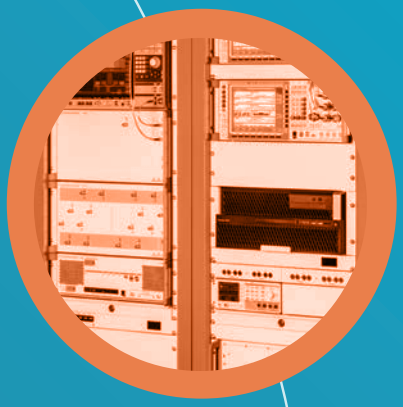
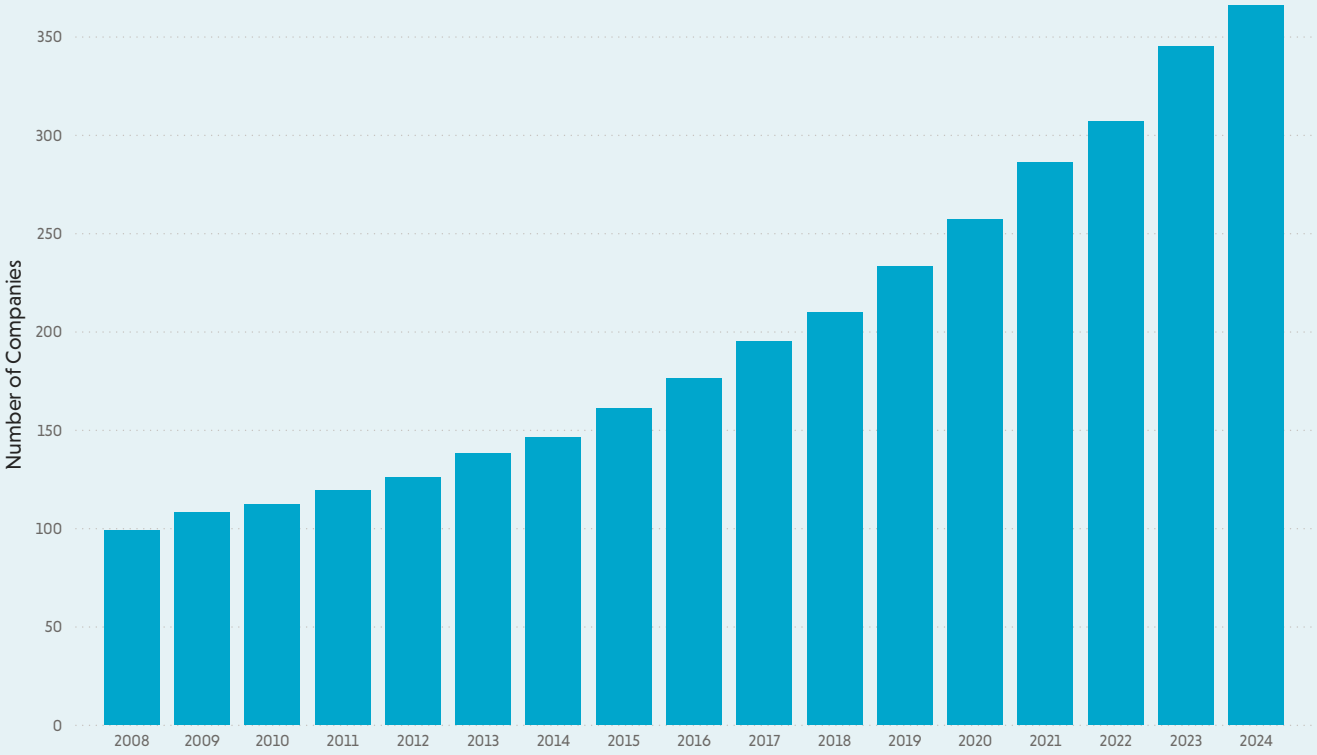


A Foundation for the Future:

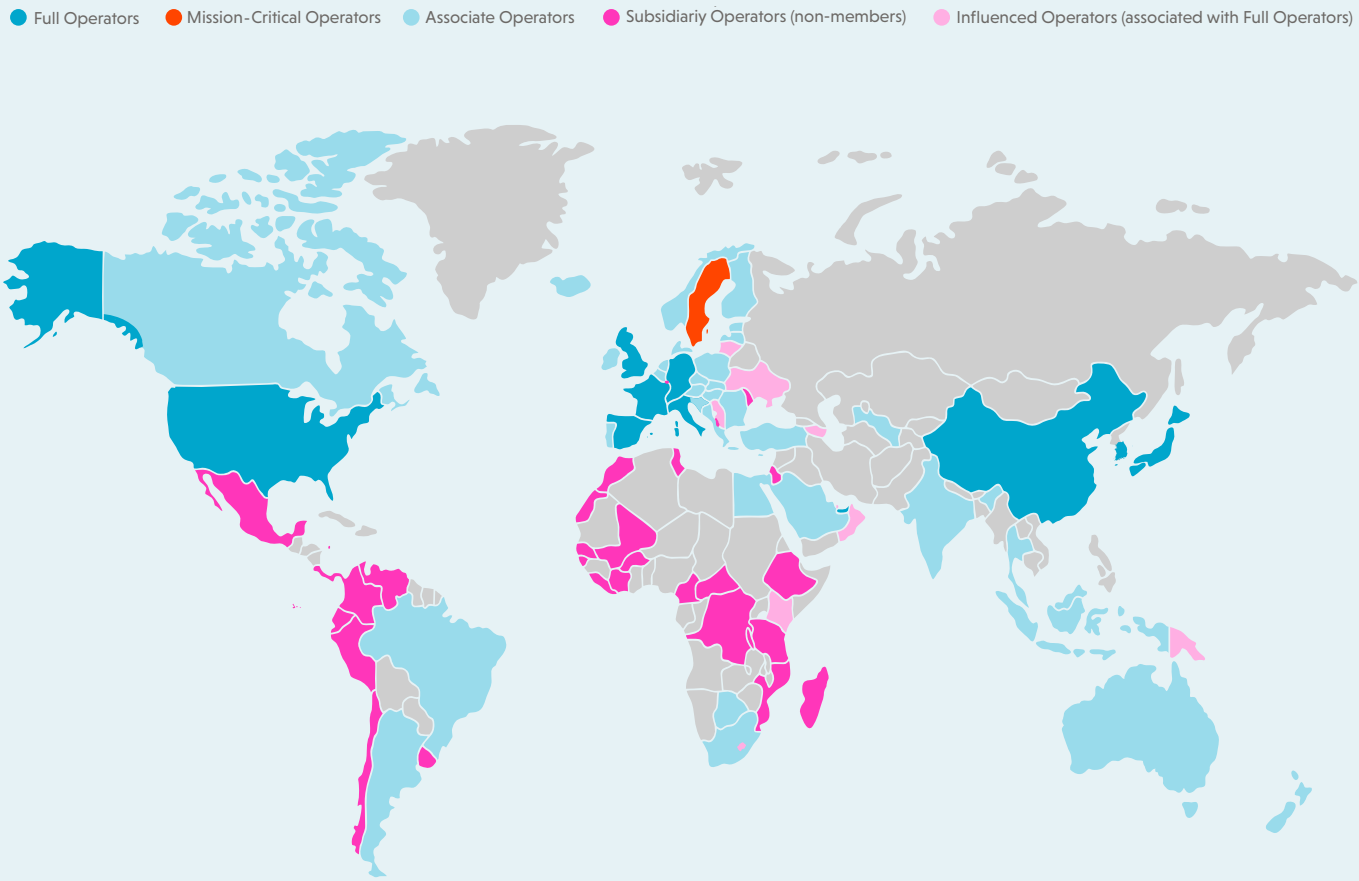
25 Years of GCF

25 GCF

GCF Membership development since 2008



GCF Worldwide Operators



AN INTRODUCTION

The Global Certification Forum (GCF) was established 25 years ago, emerging in response to growing concerns within the telecom industry about maintaining interoperability.

As EU regulatory requirements for ensuring that devices and networks worked together began to fade, particularly with the removal of the mandatory type approval regimes, operators became increasingly worried. Interoperability was vital to the success of GSM, ensuring that people could use their mobile devices seamlessly across the globe. Without a regulatory framework in place, operators felt the need for a system to replace the previous regime and maintain this global standard.

Initially, there were attempts to create an interoperability framework from within the operator communities with GSMA. However, these efforts were hindered by complexity and high costs. Eventually, the decision was made to collaborate with manufacturers on a voluntary certification scheme, leading to the creation of the GCF in 1999. After extensive discussions, this process was formalized through what became known as the 'London Agreement.' Despite some resistance from manufacturers at first, who were initially glad to be free from regulatory requirements, both parties soon realized their shared interest in ensuring interoperability, which was crucial to the success of their businesses.

The early days of GCF were not without challenges. There were frequent disagreements between operators and manufacturers, which made decision-making slow. However, the structure of the GCF, where both operators and manufacturers had equal rights and responsibilities, ultimately led to strong, effective agreements. Once consensus was reached, the certification process became a robust platform that has continued to support the mobile industry for decades.

GCF's adaptability has been a key to its continued success. As mobile technology evolved, GCF expanded to include new standards such as 4G LTE, aligning device capabilities with network deployments. This alignment ensured that new features in devices were introduced in sync with network capabilities, preventing mismatches where a feature would be available in a device but not supported by the network, or vice versa. The forum has also proven to be resilient during periods of global crisis. For example, during the 2008 financial crisis and the COVID-19 pandemic, GCF's operations and membership were minimally affected, demonstrating the robustness and necessity of the forum.

Looking ahead, GCF is well-positioned to support new sectors like mission-critical communications and satellite technologies, and further expansions of its scope. This adaptability underscores the continued relevance of GCF in ensuring global interoperability. Even as the market shifts toward more retail and internet-based device sales, reducing the reliance on operators, GCF membership continues to grow, reflecting the ongoing importance of its role in the mobile industry. The forum has not only helped ensure interoperability but also supported the implementation of global standards, bridging the gap between standard development and real-world deployment. In this way, GCF has cemented itself as a critical component of the mobile telecommunications landscape.

This publication tells GCF's 25-year story in five-year segments, complemented by testimonies from some of the people who were involved in reaching this significant milestone. We hope you enjoy reading it as much as we've enjoyed creating it.

Dr. Adriana Nugter
Chair GSMA 1999

Lars Nielsen
Director General GCF 2024

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1995-1999:
THE INCEPTION

The Global Certification Forum (GCF) was founded in 1999. However, it's valuable to look a little further back to understand its origins and purpose.

In the early days of the mobile telecom industry, it was common practice for each operator to undertake its own testing before introducing handsets or other terminals on their network. This 'type approval' approach, inherited from fixed networks (often nationwide) with many network-specific features, did not have a standard process to certify devices.

That all changed in 1995 when the European Community (EC) announced a change in telecom regulation with the Radio & Telecommunications Terminal Equipment Directive (R&TTE Directive). This directive provided a "regulatory framework for the placing on the market, free movement, and putting into service of radio equipment and telecommunications equipment," which harmonised the basic requirements for the commercialisation of devices in the member states of the EC. The directive neither mandated nor specified the management of interworking with the mobile networks, which was set to commence in 1999.

For the mobile industry leaders of the era, it was evident that a strong, well-managed device certification would soon be necessary to guarantee seamless interworking (as it was called then) or interoperability—as it's referred to today.

After the announcement of the R&TTE Directive, industry operators initiated the Certification Task Force (CTF) in 1997, which was soon joined by a wide array of leading manufacturers. The CTF then evolved into the Voluntary Certification Scheme (VCS) that held meetings over a period of several months. This culminated in the 'London Agreement' meeting on 24 August 1999, attended by eight manufacturers, ten operators, the ECTEL TMS trade group, and the GSM Association (GSMA).

At the London meeting, the foundational principles of the GCF were defined and agreed upon. A principle tenet established was that decisions would require a dual majority from both the participating operators and the device manufacturers. This established a commitment to cooperation and mutual advantage, which has since facilitated the industry's prosperity and expansion. The rest, as they say, is history. In the past quarter-century, 750 companies have participated in the GCF, and thousands of delegates have attended over 750 meetings in 28 countries across five continents.

The GCF remains strong 25 years after it was founded, with the principles agreed upon in London remaining at the core of all our activities. Here's to the next 25 years.

London Meeting Attendees

Manufacturers
Alcatel
Bosch
Ericsson
Mitsubishi
Motorola
Nokia
Panasonic
Siemens

Operators
BellSouth Mobility DCS (now part of AT&T)
BTCellnet (now part of Virgin Media O2)
Cook Inlet Western Wireless (now part of T-Mobile)
DeTeMobil (now part of Deustche Telekom)
HongKong Telecom (now part of PCCW-HKT)
Jersey Telecom
MTN
Omnipoint (now part of T-Mobile)
Swisscom
Sonera (now part of Telia)

Industry bodies and associations
GSM Association
ECTEL TMS (Association of the European Telecommunications & Professional Electronics Industry)

The foundation of interoperability

STANDARDS, TESTING, AND ACCREDITATION

***Colin Hamling,** a veteran of the mobile telephony industry, has been a leading advocate for unifying operators and manufacturers under the GCF umbrella.*

With decades of experience at BT Cellnet, O2, and Telefónica, Colin has been instrumental in the evolution of mobile technology standards. His early involvement with the British Standards Institution drafting specifications for the UK analogue TACS system, and his subsequent leadership in GSM and SIM card standards have underpinned his later achievements. In 2005, Colin joined the GCF, where he influenced the Field Trials Agreement Group (FTAG), guiding the industry towards standardised device field-testing. His subsequent involvement in GCF's steering group, as an operator representative and FTAG chair, led to him being appointed into multiple steering group chairmanships and a position on the Board of Directors.

The formative years of network simulators and standards

In the early 90s, Colin contributed to Cellnet and Vodafone's pioneering project (supported by test-houses and test equipment manufacturers) to develop a network simulator for testing early GSM handsets. "At that time, it was always a question of whether the handset or the network simulator had correctly interpreted the core specification when interoperability discrepancies arose – reference implementations of either entity didn't exist," Colin recalls. He played a significant role in several GSM Special Mobile Groups (SMG) and was heavily involved in the 11.10 group, tasked with creating comprehensive test scripts for all facets of mobile devices.

This specification later became integral to the work of the GSMA Terminals Group specifications, which in turn underpin many of GCF's test scenario scripts. Over time, as the number of device vendors and their products grew in volume, functionality, and complexity, operators grappled with the challenges and inefficiencies of conducting their bespoke tests on mobile devices, often tailored to their network configurations for the home market and without such robust testing on other networks in roaming scenarios.

> **By bringing together core specifications, test specifications, and a robust testing and certification process into a triangle, GCF ensures the interoperability and efficiency critical to the success of the wireless industry, while integrating conformance, field and performance testing into one harmonised unit."**

"Operators desired a unified approach to avoid each operator undertaking duplicative testing of a device across different networks, and to build confidence of interoperability. This is what GCF provided: allowing for tests to be conducted once and accepted universally," explains Colin.

While this efficiency benefitted manufacturers by eliminating the need to repeat tests for each operator, tensions arose as operators advocated for more tests under the GCF regime, while manufacturers sought to limit testing to features explicitly defined in core specifications. GCF played a crucial role in mediating discussions, discerning that test requirements were against a corresponding core specification requirement, and differentiating between conformance and performance.

GCF's Conformance, Field Trial and Performance certification testing and processes have played a key role in ensuring interoperability of a device against the varied radio and core network implementations of different network vendors.

Balancing rapid innovation with network readiness

"The drive for efficiency led operators to push for the rapid incorporation of new features into the FTAG field trials," notes Colin, "but this often clashed with the readiness of network vendors, whose networks may not have yet acquired the corresponding capabilities." Consequently, operators had to locate networks that also supported the new features in order to conduct the field trials. This led to extensive travel due to the scattered nature of these networks. Network availability was a consistent challenge in field trialling, often requiring exemption processes for certain tests until networks matched the capabilities of new devices. As GCF entered the US market, it had to integrate test specifications from beyond the Europe-focused GSMA scripts, rooted in the 11.10 group's work. This was essential to meet global standards and to include features like Near Field Communication (NFC).

This was essential to meet global standards and to include features like NFC. This was crucial not just for efficiency but also for protecting the reputation of networks, by ensuring that devices, especially when roaming, performed reliably.

The question is,

WHO NEEDS LANDLINES ANYMORE?

Valerie Townsend, *a specialist in conformity assessment and compliance, has extensive experience in the changing telecommunications landscape and continues to enjoy the challenges in and around applying industry and regulatory standards to certification schemes.*

Valerie's time as Chief Engineer at Panasonic Mobile Communications Development of Europe (PMCDE) saw her as the regulatory and industry compliance expert for 3GPP-capable (3rd Generation Partnership Project) mobile phones and connected devices.

Valerie is well-acquainted with GCF, having been on the board since its foundation. She has held elected GCF Governance and Chair positions, including the Conformance Agreement Group (CAG), chairing discussions to determine the necessary certification criteria for GCF certifications.

"Pre-GCF was a very different regulatory landscape. We're talking 2G times, with basic mobile phones – as we'd see them now. At that time, everything was covered by regulated test requirements and type approval," explains Valerie. "The arrival of the European Commission's R&TTE directive changed all that. Focused only on essential requirements, there was no longer a regulatory requirement to demonstrate network interoperability."

The deregulation of all but essential features was first greeted with concern, in particular the Mobile Operator community, represented by the GSMA organisation. This concern was swiftly followed by action as industry started to discuss and debate how a voluntary scheme could work to address this certification gap.

These discussions were the founding steps leading to the creation of GCF. At a pivotal meeting in London in August 1999, Mobile Network Operators and Mobile Device Manufacturers agreed on the core principles for an industry-led certification scheme that would meet the needs of the growing mobile industry. And the rest, as they say, is history.

The mobile manufacturing community has evolved. The initial standardisation for mobile comms was already done by ETSI (European Telecommunications Standards Institute), driven by the European industry. The establishment of the 3GPP aimed to develop and standardise the next level of mobile innovation at a global level.

GCF, with its certification framework already in place, tried and tested, simply continued "as usual", with work items referencing the 3GPP global standards from an increasingly global membership. GCF's certification framework remained workable and robust, delivering interoperability focussed certifications. GCF was now certifying for interoperability at a global level.

> **GCF is an excellent framework that has enabled the mobile industry, supporting all manufacturers with an accessible certification scheme focussed on interoperability."**

"Previously, mobile phones were restricted to their intended region. As we progressed from 2G to 3G to 4G driven by standardisation in first ETSI, then 3GPP, operators in other regions could see the interoperability that GCF was delivering and wanted to be part of it.

"GCF enabled interoperability across regions, giving consumers what they desired – phones that reliably worked," she adds. Valerie believes GCF has developed a robust and fair mechanism for introducing new requirements into the scheme, requiring industry support for new work items to ensure certifications stay relevant to the needs of the industry.

A future-forward vision

Looking to the future, Valerie is "confident that GCF and CAG will continue to serve the industry as long as members continue to sit together, discuss, and debate new requirements that align with operator needs, match manufacturer capabilities, and use the expertise of test equipment and labs."

2000-2004: PREPARING FOR 3G

Following the London Agreement in 1999, the GCF began to significantly influence the mobile telecommunications market in 2000, facilitating the deployment of handsets during a period of rapid expansion.

In the five years that followed, the number of device vendors and certified devices surged, from just two brands (Nokia and Motorola) certifying 12 devices in 2000, to more than 20 brands certifying nearly 120 devices by 2004. During this period, only 20 device vendors managed to certify devices with GCF, mostly from Europe, Japan, and a few from North America and Korea.

Five brands dominated the market: Nokia, Motorola, Sagem, Panasonic, and Ericsson, accounting for more than two-thirds of all certifications. But the dominant handset supplier was the Finnish powerhouse: Nokia.

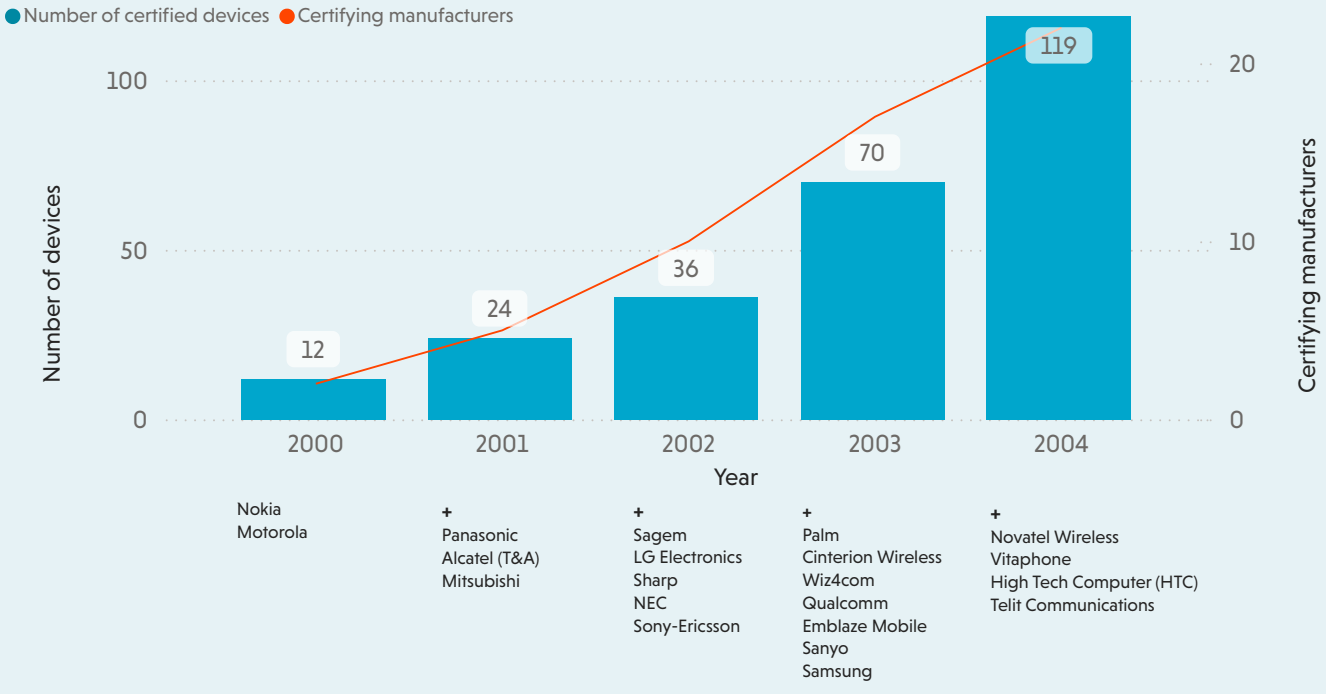
From circuit-switched to packet-switched

Mobile internet access, initially based on WAP (Wireless Application Protocol) standard, was slow and unwieldy, arguably due to the limitations of the underlying network technology rather than any inherent flaws.

Users didn't have to wait long for enhancements, as the General Packet Radio Service (GPRS) started rolling out as early as 2001. In fact, the first handset to support GPRS, the Motorola T260, was certified by GCF in November 2000.

While GPRS wasn't the first packet-switched mobile technology, it marked a surge in popularity for packet-based networks — underpinned by international standards and GCF-certified devices. The shift from circuit-switched to packet-switched

Evolution of GCF manufacturers 2000-20004



technology with GPRS was a critical evolution for the industry. GPRS provided data rates of up to 114 kbit/s. Its raw speed wasn't groundbreaking, but the efficiency of its packet-based system, along with an 'always-on' user connection, revolutionised the mobile internet experience.

Mobile internet moves on

Once GSM/GPRS networks were established and users had experienced web browsing on their mobile phones, the next step was to enhance functionality and speed. With 'always-on' connections in place, mobile email became another crucial application. An early device designed for email was the Nokia 9210 from the Nokia Communicator series, which received GCF certification in June 2001. It provided a sophisticated user experience with a colour display and a full QWERTY keyboard, powered by an ARM processor.

GPRS soon evolved into EDGE, an advanced coding and transmission technique that could triple GSM/GPRS speeds, reaching up to 384 kbit/s. Significantly, EDGE could be implemented on existing GSM/GPRS networks with minimal hardware or software changes in the core network, thus simplifying the upgrade process for operators.

Open OS arrives

The true significance of the Nokia 9210 was not immediately apparent; it was the first smartphone to operate on the Symbian OS and to be certified by GCF. While the 9210 was a pioneer, it was the Nokia 7650 that truly broke new ground as the first mass-market smartphone on the Symbian Series 60 platform. Developed from Psion's initial platform, Symbian OS led the way as an open operating system that supported third-party application downloads. It dominated as the premier smartphone OS until the end of 2010, laying the groundwork for the likes of iOS and Android. Although Symbian's app selection was not as extensive as that of its modern counterparts, it established the concept of third-party applications and an open platform for smartphones. Another notable feature of the Nokia 7650 was its built-in digital camera, which could capture top-quality 640x480 images and store them in its 4MB internal memory. In June 2003, it also became the first camera phone to be certified by GCF.

3G ahead

We cannot reflect on this era without touching on the advent of 3G. Although NTT DoCoMo in Japan commercially launched it as early as 2001, the 3G standard saw a protracted rollout by network infrastructure providers and device manufacturers, leading to delayed market entry and gradual adoption.

3G did not formally specify data rates, but the standardised UMTS (WCDMA) technology could reach up to 384 kbit/s. For megabit speeds, the industry awaited the introduction of HSDPA and HSUPA for enhanced downlink and uplink, respectively, with a subsequent evolution to evolved HSPA technologies, also called HSPA+. This led to consumer confusion, as various data rates were all marketed under the '3G' banner.

GCF certified its first 3G-capable device, the Novatel Wireless Merlin U630 PCMCIA data card for laptops, in December 2004. This certification marked the start of a trend, as 3G eventually overcame its initial slow adoption to become the dominant mobile technology in the following years.

Nokia 6210: The first certified mobile device

The first device to be certified by GCF, on 17 May 2000, was the **Nokia 6210** (pictured right), a handset released by Nokia during an exceptionally prosperous period when each new model achieved sales in the millions.

The Nokia 6210 epitomised the 2G mobile phones of its time with a monochrome 2.4" display at a resolution of 95 x 65 pixels — a stark contrast to today's smartphones, which boast displays up to nine times larger with 500 times the resolution. Beyond voice calls and SMS text messaging, it included features like a calendar, stopwatch, and three games, and was equipped with a High-Speed Circuit Switched Data (HSCSD) modem capable of speeds up to 43.2 kbit/s. Laptop connectivity options included a cable or infrared link, and Bluetooth was available as part of an optional 'connectivity pack' from Nokia.

Despite its modest speed, the Nokia 6210's internet capabilities were highly functional for business users who could often be seen in airport lounges working on laptops tethered to their mobile phones. The handset also supported the early Wireless Application Protocol (WAP) standard, a precursor to the sophisticated web browsers on modern smartphones. More significantly for the majority of users, the device was lightweight, durable, and affordable, with a battery life sufficient for up to 260 hours of standby time — more than ten days. Imagine that today!

Taming the Wild West of MOBILE CERTIFICATION

Bjarke Nielsen, *a seasoned expert in the telecommunications industry, offers invaluable insights into the pivotal role of chipset companies during the 2000s.*

Bjarke Nielsen, particularly during his tenure as Director of Technical Standards at Qualcomm, played a pivotal role in the evolution of mobile standards. As the inaugural chairman of the 3rd Generation Partnership Project (3GPP) T1 group, he was instrumental in bridging the gap between emerging test cases and their market applicability. His efforts in the early 2000s laid the foundations for GCF, where he subsequently served as a member of the GCF Board of Directors.

> **GCF catapulted the industry from a mere collection of regional technical specifications to a globally streamlined set of technologies that are now seamlessly integrated into the daily lives of millions of people globally."**

The mobile industry's shift to 3G presented a formidable challenge. "At that time, test cases were a cacophony of interpretations and implementations, with each testing company speaking its own dialect of programming languages and protocols," Bjarke recalls. "This lack of coherence led to a fragmented approach to device development, where quirks and workarounds became the norm, and the certainty of device performance in the field was elusive. It was a time reminiscent of the Wild West, where the industry desperately needed a sheriff to bring order."

Defying expectations

US manufacturers such as Qualcomm were keen to extend their reach beyond the Eurocentric GSM standards and introduce their own technologies, like Code Division Multiple Access (CDMA), to the global stage. Bjarke was at the forefront of these efforts, championing a more inclusive approach. "The industry was on the brink of a significant shift, and it was imperative that all players, regardless of their geographic or corporate origins, had a voice in shaping the future," he reflects. It was within this context that the test and certification standardisation efforts grew from a European initiative into a worldwide endeavour, transcending regional boundaries to unite the industry under the shared objective of interoperability and streamlined certification processes.

It was not until 2002 that Bjarke succeeded in securing Qualcomm's acceptance as a full member of GCF. Qualcomm's membership proved to be a strategic advantage. By aligning with GCF's certification processes, Qualcomm was able to demonstrate global interoperability, a critical factor in reducing time to market for its devices. "Having a clear set of specifications meant we could develop with efficiency and precision, knowing exactly when a device met market standards," Bjarke explains.

This clarity and efficiency not only accelerated product development but also instilled confidence in the technology, making it a compelling proposition for investors. The guarantee that devices would operate seamlessly across diverse markets without necessitating modifications was instrumental in attracting investment and propelling the industry's growth. "It was about scaling, technological confidence, and a clear path to market – all of which were facilitated by GCF's certification framework," he adds.

Chipset paradigm shift

During the early 2000s, chipset companies such as Qualcomm began to assume a crucial role in the development of mobile devices. As the knowledge base shifted from device manufacturers to chipset producers, these companies emerged as the guardians of essential mobile functionalities, embedding them directly into their chips. Consequently, chipset companies bore the responsibility for implementing the standards and specifications set forth by organisations like GCF, ensuring that devices were compliant and capable of operating within the international telecommunications ecosystem.

Today, Bjarke views GCF as a well-oiled machine that delivers immense value to the industry through its efficient certification processes. With the integration of AI into devices and 3GPP technology into drones, the necessity for streamlining certification continues to advance – Bjarke believes GCF is in the perfect position to offer a certification framework for those related industries.

Managing the ART OF THE COMPROMISE

Claus Andre Madsen, *a former Nokia executive, has been a key figure in fostering unity within GCF throughout its 25-year history.*

If Claus were to attribute one word to GCF's 25-year history, it would be 'unity.' Having had a lengthy career at Nokia from the mid-90s to 2011, he has a unique understanding of standardisation and certification from device manufacturer and network operator perspectives. This experience helped him fully appreciate GCF's role in uniting organisations with differing interests and agendas.

"At that time, the mobile industry was in clear need of strong, well-managed certification of devices to ensure problem-free interworking," says Claus. "This was in the interest of the device manufacturers and the network operators. However, establishing mobile standards-based certifications was easier said than done. It required tremendous effort from the GCF to give equal weight to the opinions and concerns of different groups. It did an excellent job of unifying the sector."

The 110-Day rule

He cites the "110-day rule" as an example of this compromise. When GCF introduces new testing criteria or updates existing ones, there is no defined transition period before these changes become mandatory for certification. A certification scheme where testing changes from day to day and during a certification process was not feasible for the industry.

Therefore, a transition rule was needed, allowing manufacturers, test houses, and other stakeholders to prepare for and implement the new requirements.

The rule is designed to strike a balance between the rapid evolution of mobile technologies and the need for industry stakeholders to adapt to changes without causing significant disruption to the certification and release of new devices.

"It was a real challenge to get all parties in the telecommunications industry to agree to the 110-day limit," recalls Claus. "In fact, I remember Nokia hosting a meeting with the GCF in Helsinki where the details were agreed upon. The device manufacturers were looking at six months, while the network operators wanted two weeks. In the end, the 110-day compromise was agreed."

The Nokia 6210 and beyond

Claus speaks fondly of his experiences in the telecommunications industry. In 2000, he was involved in the certification of the Nokia 6210, a GSM single-band handset and the first device certified by GCF. This triggered a wave of similar certifications with devices from Nokia and other manufactures.

> **The first round of validation of test cases meant a lot of work on the fly. There were some problems, with surprising behaviours from devices and test equipment that needed to be solved. But we got there in the end."**

"It was a period of intense activity," he says. "The first round of validation of test cases meant a lot of work on the fly. There were some problems, with surprising behaviours from devices and test equipment that needed to be solved. But we got there in the end. And this was proved by the success of the Nokia 6210 over a long period."

Looking to the future, Claus is confident that GCF will continue to unify the telecommunications sector, including sectors beyond telecommunication. He points to the need for GCF to focus on certifying devices with advanced 5G features to enable the introduction of new revenue-generating opportunities and needs for the industry.

He also says there is a role to play in curbing the rising costs of certification due to the increasing complexity of technology, especially as the industry moves towards 6G. "GCF sets a good principle for cooperation, and I believe it will continue to do so over the next 25 years," he concludes.

2005-2009: DATA SPEED RACE: MOBILE INTERNET'S EARLY YEARS

The previous few years had been characterised by the anticipation of 3G technology, which soon became adopted by most network operators and manufacturers.

However, despite providing always-on connectivity, 3G networks were initially relatively slow. It was not until the introduction of HSPA and its evolution to HSPA+ technologies that users could genuinely perceive mobile broadband as comparable to their domestic or office internet connections, with data rates in the megabit range revolutionising the experience of browsing the web or watching video on a mobile phone.

The enhanced speed of 3G gave rise to new applications, with consumer devices offering more sophisticated cameras, stylish designs, and a fresh wave of professional and prosumer handsets that included features such as keyboards and styluses.

Consumer handsets set the trend

While GCF had already certified its first 3G device — a data card in 2004 — the first GCF-certified 3G mobile phone was the Panasonic VS70 in 2006. All the major manufacturers of the era, including Nokia, Motorola, Samsung, Alcatel, Panasonic, and Sony Ericsson, launched consumer-targeted camera phones supporting 3G and HSPA. Noteworthy models included the

Motorola RAZR V3xx (pictured left) had a dramatic clamshell design and slender aluminium body, becoming soon the mobile phone everyone aspired to own, and establishing a new trend for premium, fashionable handsets. The V3xx model was larger and heavier than Motorola's original RAZR V3, but the inclusion of 3G and a 2-megapixel camera significantly enhanced its functionality.

The N95 was Nokia's inaugural handset to include features that have since become standard in smartphones nowadays: a GPS receiver for mapping and turn-by-turn navigation, as well as an accelerometer.

Global Certification Forum initial founders (2008)

Upon its inception, the administrative functions of GCF had been initially managed within GSM Association (nowadays GSMA)-that had formed in 1995. In 2008, GCF attained full independence through its incorporation as a UK company, with the following companies fully engaged in its creation.

The organisation soon reached 160 active members, including 37 full members, 40 observers, and over 80 associate operators.

Manufacturers
Motorola
NEC
Nokia
Panasonic
RIM
Sony Ericsson

Operators
NTT DoCoMo
Orange France
Telecom Italia
Telefónica Móviles España S.A.
TeliaSonera
Vodafone D2

Network infrastructure supplier
Ericsson

Device technology supplier
Qualcomm

Test houses
Cetecom GmbH
IOT & Approval Solutions Ltd.
Flander OY
TesTime
P3 Solutions GmbH

iconic Motorola RAZR V3xx, launched in 2006 or the Nokia N95 in 2007, the first GCF-certified HSDPA handset.

Professionals go mobile

As mobile phones became internet-connected, it was a natural progression for them to incorporate email functionality. The company that arguably pioneered the efficient mobile email experience was Research In Motion (RIM), and, in 2006, their BlackBerry 8700 became the first email-centric device to be certified by GCF — still a GPRS device.

Featuring a physical QWERTY keyboard and a convenient thumbwheel, the 8700 catered specifically to professionals who needed to send and receive text-based messages. It was supported by a secure, business-focused infrastructure that operated through BlackBerry's own servers. Other professional-oriented handsets were alternatives to BlackBerry, including those based on Windows CE and Windows Mobile, which sought to extend Microsoft's dominance from personal computers to mobile phones. Between 2003 and 2010, multiple companies released devices powered by Windows CE or Mobile, such as HP, Motorola, HTC, and LG, among many others.

For professionals who required the functionality of their laptops while remaining connected on the move, the solution came in the form of HSPA data cards and USB modems. In 2006, the GCF certified its first HSDPA USB modem: the Huawei E220.

Emerging technology trends

During this period, the radio network technologies and standards were predominantly centred around the WCDMA air interface — the most widespread implementation of 3G, standardised by 3GPP as UTRA and soon incorporated in GCF certification. This encompassed HSDPA, HSUPA, and DC-HSPA, all of which provided significantly increased bandwidth compared to the initial releases.

GCF developed the capability to certify every year hundreds of devices across these technologies and beyond, including legacy 2G devices utilising GSM, GPRS, and EDGE. By monitoring the number of devices certified with each technology, GCF tapped into a valuable source of industry trends.

In addition to the technologies undergoing active certification, GCF was also preparing its support for the next major advancement: LTE, introduced in the 3GPP Release 8 and frozen in December 2008. However, that's a story for another time...

A new era in the making

Although it appeared that 3G had only recently emerged, the mobile internet was already on the cusp of transforming our lives permanently. Two new products provided a glimpse into the direction the industry was poised to take in the years ahead.

Initially, in 2007, the modern smartphone era was kickstarted by a launch that had been eagerly anticipated for years: the iPhone. With its innovative multi-touch screen, the iPhone was set to revolutionise the mobile phone industry for the foreseeable future. Somewhat unexpectedly, it did not support 3G upon its debut, instead relying on quad-band GPRS / EDGE connectivity.

Subsequently, although it may not have garnered as much attention as the iPhone at the time, another significant milestone was achieved in 2008 with GCF's certification of the HTC Dream, the inaugural Android smartphone.

How mobile internet TRANSFORMED OUR LIVES

Hajo Schulze, *the longest-serving Director of the Global Certification Forum Board since its incorporation in 2008, has consistently represented the interests of operators within the organisation.*

Mobile broadband services first became available to consumers just over two decades ago. For the first time, a mobile device like a laptop could quickly connect to the internet virtually anywhere in the world.

The first truly useful mobile data standard was 3G, introduced in 2003, when radio technology enabled more than calls and text messages. Early 3G mobile broadband modems utilised Personal Computer Memory Card International Association (PCMCIA) slots, commonly found on laptops for connecting peripherals like extended memory.

Operators could provide data services through these PC card modems with speeds reaching up to 384 kbit/s per second, which were enhanced over time using High-Speed Circuit-Switched Data (HSCSD) in the network. With the advent of USB connectivity, the obsolete PCMCIA standard gave way to USB modems.

"Around this time, 3G-enabled mobile phones were by no means 'smart' – they mostly had a keypad and a display," Hajo recalls. "However, for those with a camera, the so-called 'killer application' touted by phone manufacturers was video telephony, which didn't take off as expected because the video quality wasn't great.

"Moreover, for the consumer, video calls cost considerably more than voice calls. It was only with the launch of 4G smartphones that people could download video calling apps, and video calling became popular."

The first terrestrial system (TS), known as Freedom of Mobile Multimedia Access (FOMA), represented an early iteration of the Universal Mobile Telecommunications System (UMTS), or 3G, developed and maintained by the 3rd Generation Partnership Project (3GPP). However, FOMA was incompatible with subsequent releases.

"GCF's role was to define the stages from which version of the standards 3G would be applicable, validated, and usable," says Hajo. "We, therefore, created a technical working group called the Universal Terrestrial Radio Access (UTRA) Agreement Group, or UAG. Within UAG, we collated all the features, requirements, validation reports, and so on to make it happen.

"For example, voice and video connection trials were performed on system simulators, which are clean artificial environments, but we also conducted field trials. That means we checked the devices against the system simulator and in the live network – so-called 'dirty environments.'

> **Today, there are more IoT devices on our networks than smartphones, and GCF's role will evolve to ensure compatibility."**

"Now, the GCF is focusing on the non-traditional smartphone industry – the Internet of Things," says Hajo.

"The industry, as it currently stands, mainly comprises small start-ups producing much lower quantities of IoT devices compared to smartphone manufacturers, but the car industry is also a significant player. Today, there are more IoT devices on our networks than smartphones, and GCF's role will evolve to ensure compatibility."

Managing complexity amid

SMARTPHONE INNOVATION PEAK

***Leif Mattisson,** a former Ericsson Standardisation Manager, says that GCF served as a catalyst for collaboration and cooperation during a period of remarkable creativity and innovation.*

Leif Mattisson recognises the importance of collaboration within the wireless and mobile community. With over 25 years of experience, including his tenure as Standardisation Manager at Ericsson and active participation in 3GPP and GCF working groups, he has contributed to the development of device conformance and performance test specifications throughout the evolution from 2G to 5G.

That journey required intense efforts around test case development to ensure industry standards were accurately translated into certification processes that guaranteed interoperability and conformance. Leif collaborated with industry experts to create comprehensive test plans encompassing device compatibility, network performance, and security protocols.

"There were a lot of competing interests – from network operators to device vendors – but there was a common aim: to manage technical complexity and ensure the best outcomes for end users," Leif says. "GCF was at the heart of those efforts, bringing people from across the industry together and overseeing open and transparent conversations. Ultimately, that resulted in fewer device issues, like dropped calls and other network problems, which was crucial for customer satisfaction."

Beyond the 4G revolution

Leif reflects with special fondness on the transformative years from 2010 to 2014. During this period, the 3rd Generation Partnership Project (3GPP) had introduced 4G LTE, which was rapidly gaining global adoption. At the same time, smartphones were experiencing unprecedented innovation, ushering in a host of new features and capabilities. It was an exciting time for the wireless and mobile community.

"But it was also a challenging time," Leif recalls. "We were already thinking about the transition from 4G to 5G and the need to manage complexity and deliver flexibility for communication protocols. GCF was central to this activity, helping the industry focus its efforts and fully understand the benefits and services that 5G could deliver. This collaboration and cooperation was handled well and got everyone working towards common goals."

> **"Supporting and encouraging global harmonised testing is a key example of how the industry has benefitted from GCF's collaborative approach."**

Global expansion of telecom services

GCF achieved a major milestone by expanding its reach to include a diverse range of operators, particularly in Asia. This global expansion, fuelled by persistent networking efforts, fostered a more unified and cohesive telecommunications industry.

GCF's facilitation of testing standards empowered network operators, covering different equipment providers and device manufacturers from around the globe to conduct interoperability tests. This ensured seamless integration of devices from various vendors, reducing redundancy, enhancing cost efficiency, and accelerating time-to-market.

"Supporting and encouraging global harmonised testing is a key example of how the industry has benefitted from GCF's collaborative approach," Leif says.

Shaping the future of innovation

Leif is optimistic about the industry's capacity to embrace emerging technologies like 6G. He envisions GCF guiding the navigation of 6G devices and services complexities, while ensuring certification costs remain manageable.

"GCF will remain a results-focused organisation," Leif concludes. "It will continue to support interoperability and conformance across the mobile and wireless community." He foresees GCF driving a surge in component certification, including chips, chipsets, and modules. By pre-qualifying these components against industry standards, GCF will streamline the overall certification process for devices, reducing complexity and costs.

2010-2014: THE SMARTPHONE ERA

The 2010s marked the era when smartphones became the dominant force in the mobile market, although their ascent was gradual. In 2010, mobile device sales to end users increased by 32% from the previous year to 1.6 billion units, and despite the rapid growth of smartphone sales, they constituted just 19% of the total. Nokia was still the market leader, but its reign was drawing to a close.

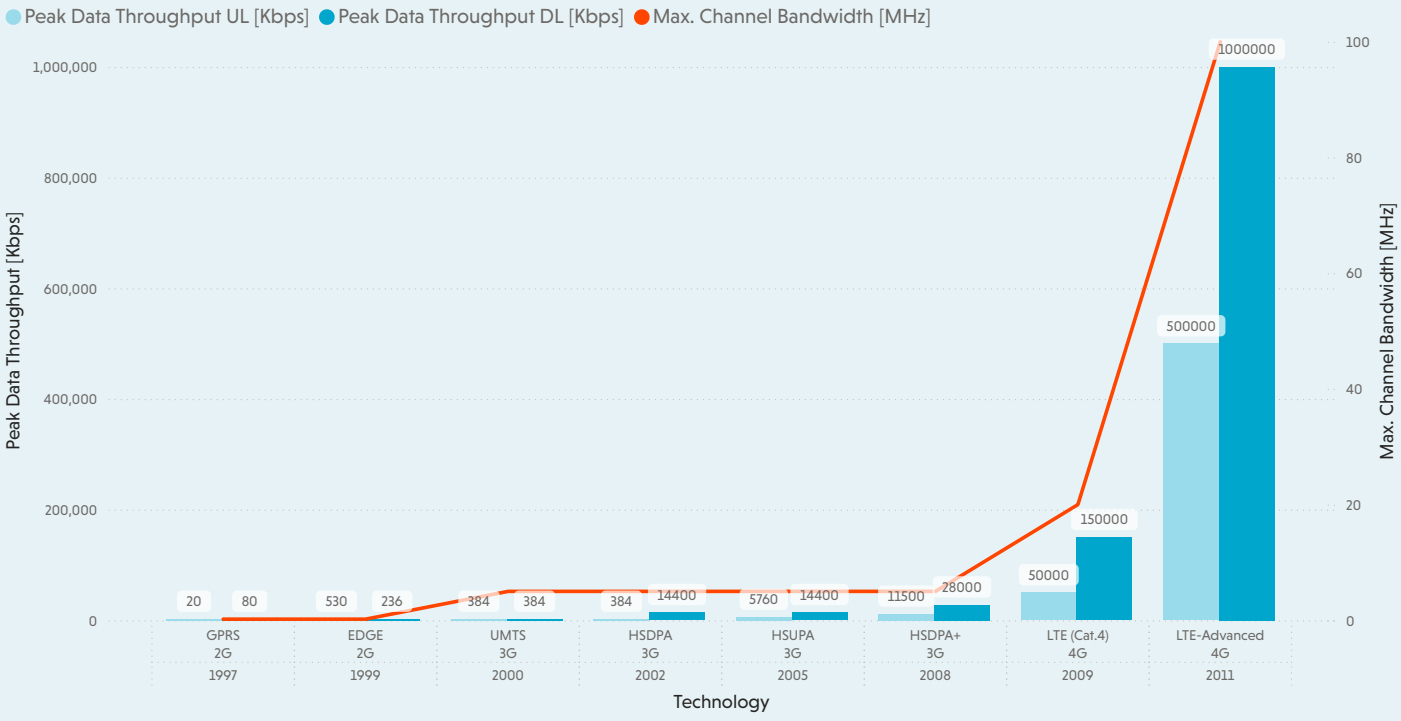
By 2014, smartphones had surged to represent two-thirds of global mobile handset sales. With 1.2 billion smartphones sold to end-users, Samsung had established a commanding lead, selling over twice as many phones as Apple, which held second place — followed by Microsoft, Lenovo, Huawei, and LG. However, when considering only smartphone sales, Samsung and Apple were in a tight race.

Technology enables smartphone boom

So, how did smartphones take over so quickly? Numerous factors contributed to the smartphone revolution, including superior operating system software (Android and iOS), open application stores brimming with useful apps, and user-friendly multi-touch screens.

However, these software and user interface advancements also depended on robust network connectivity, with fast and reliable mobile broadband, and interoperability guaranteed by GCF's certification efforts and the widespread adoption of standards. The arrival of 4G technology marked a significant shift. In 2011, GCF certified its first 4G data device, a USB modem developed by Samsung that supported Long Term Evolution (LTE), which is

Evolution of Data Throughput



a term 3GPP used for Evolved UTRA or E-UTRA technology. Later that year, LG certified the first LTE wireless router, the LG FM300, which Vodafone commercially launched as the LTE Turbobox. LTE mobile broadband routers, both portable and stationary, were also introduced by Novatel Wireless, Huawei, ZTE, and others, offering fast wireless connectivity.

While modems and routers led the introduction and certification of new radio access technologies, handsets were quick to follow. GCF certified its first 4G smartphone, the HTC One, in 2012, preceding Apple's first 4G-supported iPhone 5, which debuted later that year. The HTC One operated on Android 4 with a Qualcomm Snapdragon chipset, delivering performance that satisfied consumers. It boasted a 4.7-inch screen (considered small by current standards), a 4-megapixel camera, GPS support, and an FM radio.

Technology advances: LTE and more

The HTC One was compatible with 4G LTE as well as legacy GSM/EDGE and UMTS/HSPA standards. 3GPP finalised the initial release of the LTE standard in December 2008, which provided peak download rates of approximately 100 Mbps, reduced latency, enhanced mobility support, and improved voice call quality. The LTE standard progressed to incorporate Multiple Input Multiple Output (MIMO) technology, utilising multiple antennas to boost signal performance and throughput.

In addition to LTE, smartphones from leading brands — including HTC, Samsung, Sony Ericsson, Microsoft, and Huawei — supported another standard: Dual Carrier High-Speed Packet Access (DC-HSPA). DC-HSPA optimised the use of available resources by multiplexing carriers, offering operators who were behind in 4G deployment the ability to provide commendable data speeds.

During this time, LTE transitioned towards LTE Advanced (LTE-A), introducing new capabilities such as carrier aggregation, which enabled significantly higher data rates and enhanced performance. LTE-A could achieve download speeds peaking at up to 1 Gbps and uplink speeds of up to 500 Mbps. In 2014, GCF certified its first LTE-A device, an LTE-A variant of the Samsung Galaxy S5, which was exclusively launched in South Korea. As wireless technology advanced by leaps and bounds, GCF kept pace by broadening its certification remit. Field trials, based on the GSMA TSG TS.11 specification, became compulsory for LTE devices in 2010. In 2011, performance items were incorporated, addressing areas that were relevant but not obligatory for GCF certification, such as acoustics, battery life, and antenna performance. Furthermore, 2014 marked the inclusion of CDMA technology, continuing the efforts initiated by the CDMA Certification Forum (CCF).

The rise of the app economy

App stores were not an invention of Apple and Google, but these tech giants transformed them into an unprecedented force in the mobile industry. Apple launched its App Store in 2008 with an initial offering of 500 applications, a figure that rapidly escalated to tens of thousands and more. The Google Play Store, initially named Android Market, debuted the same year and experienced similar exponential growth.

New companies across various sectors successfully launched their services on these app stores, bypassing traditional routes to market, thereby expanding their customer base and revenues in tandem with the burgeoning smartphone market. For instance, Uber, which started in 2010, now boasts annual revenues exceeding $37 billion. Mobile gaming also saw rapid growth, with the Apple and Google Play app stores significantly boosting the industry. By 2010, popular titles like Angry Birds were generating millions of dollars monthly, propelled by the novel concept of in-app purchases.

Market changes

As Android and iOS surged in popularity, other once-prominent players were in decline. Nokia, previously a titan in mobile handsets, had lost its edge. Microsoft's various mobile operating systems, while somewhat successful, never attained the dominance in the smartphone market that the company enjoyed in the PC sector. Windows Mobile's market share peaked at nearly 50% of all smartphone sales in Q2 2007, but rapidly dwindled to single digits as consumers shifted to Android and iOS.

In 2014, Microsoft and Nokia joined forces when Microsoft acquired Nokia's handset division for $7.2 billion. However, the merger came too late to mount a serious challenge against Apple, Samsung, and the burgeoning touchscreen smartphone market. Similarly, RIM's BlackBerry OS experienced a dramatic decline in market share.

With Samsung and Apple at the forefront, the mobile industry — and GCF — were gearing up for the next major shift: the advent of 5G.

GCF had certified its first Android touch-only smartphone, the HTC Magic, in 2009. This was closely followed by the **Samsung Galaxy S** (pictured left) in 2010, which became a massive success in the market, accelerating the shift of many handset manufacturers towards Android, and the decline of other alternative Operating Systems that had once dominated the market.

Verizon's leap to LTE: A GCF-CERTIFIED SUCCESS

***Chris Schmidt,** a telecom veteran, reflects on the transformative journey from CDMA to LTE and Verizon's strategic partnership with the GCF.*

With over three decades in the telecommunications industry, Chris Schmidt has made significant contributions across multiple sectors, including public safety, military, and consumer wireless products. His tenure at Verizon was marked by his involvement in the launch of 4G and 5G technologies, as well as his role as a board member of the GCF from 2012 to 2016. Chris' expertise spans both wireless and wireline products.

When Chris joined Verizon in 2008, he brought his wealth of knowledge from previous years at Motorola, Thales, and Ericsson. By 2011, he was instrumental in Verizon's decision to become the first US operator to join the GCF.

At the time, the US telecommunications industry was undergoing a significant technology transition from the previously dominant CDMA technology, more prevalent in the US, to LTE technology. This shift required significant changes in network infrastructure and testing protocols, and there was a push to unify the fragmented certification landscape.

LTE and GCF helped Verizon to scale

"Alignment with the GCF was a strategic move for Verizon, driven by the adoption of LTE as a global standard that offered significant economies of scale for both our operations and customers. GCF's governance structure, particularly its by-laws, provided a clear and organised framework we found lacking elsewhere," says Chris, reflecting on Verizon's decision to partner with the GCF.

Historically, operators like Verizon had their own stringent certification processes, which often required devices to be tested in their labs regardless of any prior testing by other operators or bodies. As a customer-first company, Verizon needed to ensure devices would work seamlessly across different network configurations and with other operators' networks internationally.

By adopting global standards and GCF's certification program, Verizon was able to significantly lower certification costs while maintaining the high-quality standards essential for a superior network experience.

This approach provided a balanced solution to the dichotomy of ensuring device quality and broadening customer access to the network, achieving the ideal combination of quality assurance and scalability.

> **"The GCF mantra of 'test once, use anywhere' is a game-changer, offering immense benefits to consumers and manufacturers alike by enabling economies of scale and a truly global product reach."**

A key quality: remaining humble

"GCF's democratic approach, where operators and manufacturers have equal voting rights and all parties in the ecosystem are represented, ensures that even when there's friction, it ultimately benefits all stakeholders, most importantly the customer, which aligns with our core values at Verizon," explains Chris. In his view, one of the most distinctive qualities of the GCF is its lack of airs and graces, and its willingness to collaborate broadly across the industry.

This collaborative spirit, whether with the CCF (CDMA Certification Forum) or the PTCRB (PCS Type Certification Review Board), is rooted in a practical and humble approach to certification, questioning the need for duplicative processes and advocating for partnerships that streamline the path to market for manufacturers.

Looking ahead, Chris points out GCF's role in fostering innovation and ensuring the highest standards of interoperability remains more critical than ever. With new technologies on the horizon and the ever-increasing demand for seamless global communication, GCF's commitment to 'test once, use anywhere' will continue to underpin the success and expansion of the wireless industry.

Quality assurance in mobile

TECHNOLOGY TESTING

Kevin Spalding, *a former Ericsson Standardisation Manager, says that GCF served as a catalyst for collaboration and cooperation during a period of remarkable creativity and innovation.*

Kevin Spalding understands the importance of quality in testing, having recognised the need for a dedicated testing house to conduct the field testing promoted by GCF as early as 2003.

"The GCF was on a mission to simplify and centralise the certification process, but there simply weren't any accreditation houses offering the test services, which was a barrier to wider adoption," says Kevin. He decided to solve the problem by establishing a testing company of his own, dedicated to offering GCF field testing – and, so, IoT & Approval Solutions Ltd. (IoTAS) was born.

Initially based in the UK, then expanding into Australia and Japan, the company encountered logistical hurdles in dispatching test engineers to GCF member sites worldwide.

To overcome this, they forged strategic partnerships locally across the globe, significantly simplifying business operations, reducing travel expenses, and lessening their carbon footprint. However, when other accreditation bodies began offering GCF certification, it became apparent that testing methodologies differed in some instances.

"We realised that test regimes were not always aligned, which in turn could cause inconsistencies with GCF testing being completed," says Kevin.

IoTAS actively engaged within GCF to tackle this quality issue and the GCF also tasked an independent consultant with assessing the variability in global testing practices. The findings provided GCF with a compelling business case to appoint a full-time Quality Manager, a role established in 2019. IoTAS is still contributing to improving GCF processes by writing and validating MCX field test cases.

"GCF works by consensus and we had many debates and some disagreements over quality and testing processes, but achieving buy-in is what makes the organisation stronger," says Kevin.

Tactics included formal meetings where member attendance was compulsory and closely monitored, as well as informal discussions designed to build trust between the different interested parties.

"Lots of organisations don't stand the test of time because they can't or won't evolve. GCF provides a genuine forum for everyone to feel their views have been heard. This gives the organisation the agility to remain relevant as the mobile sector evolves. That early effort to ensure quality is fully embedded into GCF testing processes is a good example: it's given the organisation a strong foundation from which to build and the agility to embrace new technologies as they emerge."

The road ahead is filled with new challenges. Mission Critical Services technology, which integrates broadband, big data, video, and cellular technology, is entering GCF's realm for certification and compliance. The health and fitness sector, too, depends on GCF's accreditation of embedded modules and chipsets. Additionally, Non-Terrestrial Networks (NTN) are poised to become a key area of focus for GCF in this decade.

> **Lots of organisations don't stand the test of time because they don't evolve: GCF adapts and stays relevant."**

"When IoTAS and GCF started, the focus was all on smartphones," recalls Kevin. "It's incredible to think we are now testing modules, chipsets, plus network and IoT devices. Whatever comes next, GCF is well-placed to provide the accreditation and quality framework required to deliver commercial compatibility."

2015-2019

INTERNET EVERYWHERE

By 2015, smartphones were everywhere. Wide availability, strong competition, and affordable prices, coupled with the widespread adoption of LTE networks, flat data plans, and Wi-Fi hotspots, meant smartphones became increasingly accessible. This democratisation of technology meant access to the internet had become more prevalent than ever.

Over a billion people worldwide had adopted smartphones, and over 60% of internet traffic came from mobile devices, surpassing desktops. This unprecedented access empowered users in nearly every country to tap into an almost limitless supply of information and transformative services, such as banking and payment systems.

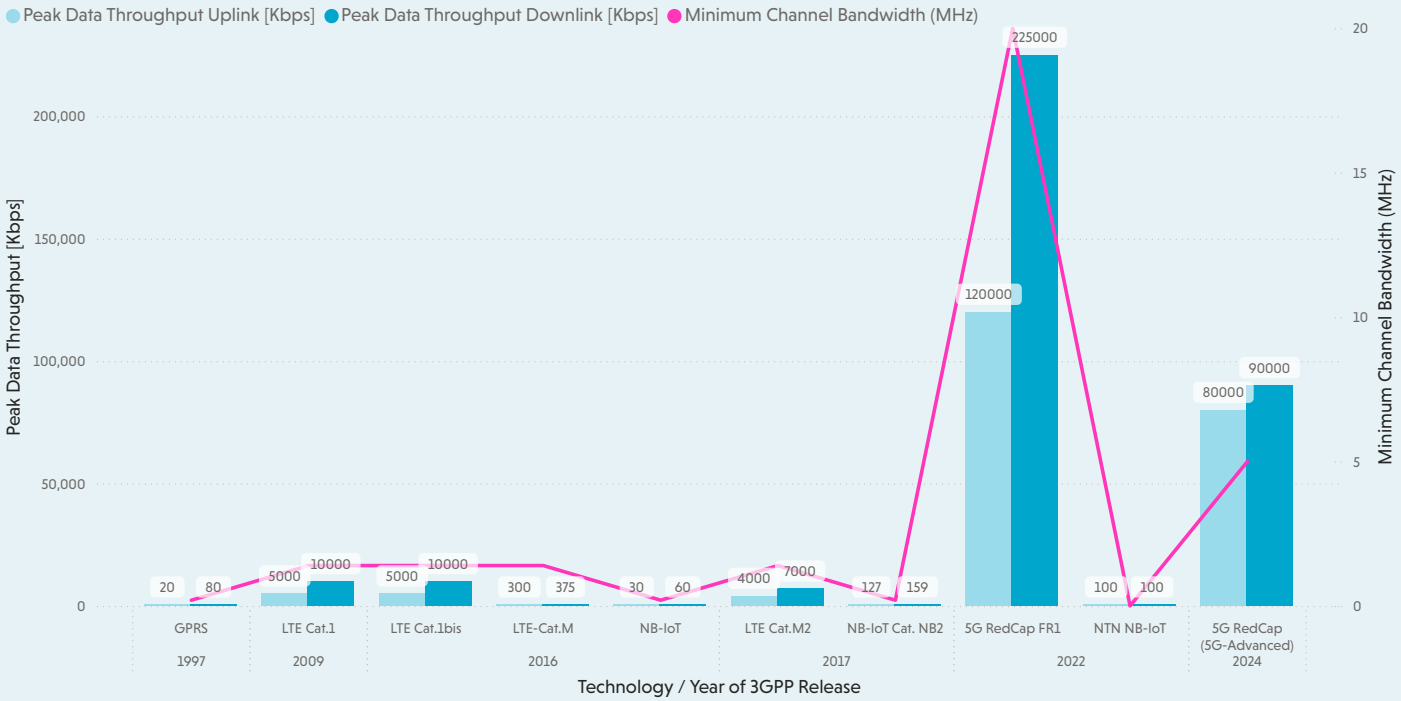
LPWA and the Internet of Things

Of course, the mobile world wasn't just about phones. Machine-to-machine (M2M) communications had led to the concept of the Internet of Things (IoT), where different wired and wireless technologies were used to connect a myriad of devices, such as sensors, smart metres, street lights, and more. Many of these devices required mobility and adherence to standardised cellular wireless protocols.

Many IoT applications faced challenges due to high power consumption and cost associated with traditional cellular networks like GPRS, WCDMA, and early 4G. To address these limitations, the cellular wireless industry developed low-power wide-area (LPWA) technologies that offer low power consumption, wide coverage, and sufficient throughput for most IoT applications, making them ideal for battery-powered devices.

Multiple proprietary LPWA technologies, like Sigfox and LoRa, initially dominated the market. However, a significant

Evolution of Data Throughput - IoT/M2M technologies



breakthrough occurred in 2016 when 3GPP standardised NB-IoT (narrowband IoT) and LTE Cat-M (also commonly known as LTE Category M or LTE-M). These technologies, based on simplified 4G standards, aimed to provide more efficient and cost-effective mobile connectivity for replacing outdated GPRS modules.

For service providers, the decision between NB-IoT and LTE-M hinges on the specific needs of their applications. LTE-M is better suited for applications requiring higher data rates and mobility, such as asset tracking or smart metres in dynamic environments. In contrast, NB-IoT is ideal for static, low-power devices with minimal data requirements, like environmental sensors or smart parking solutions.

In 2017, GCF certified its first NB-IoT device, the Quectel BC95-B8. This was a compact module aimed at IoT applications such as smart metering, white goods, street lighting, smart parking, and smoke alarms. 2017 also saw GCF certifying its first multi-mode IoT module, the Sierra Wireless AirPrime HL6528RD, and its first LTE-M module, the SIMCom SIM7000A.

LTE supports innovation

In the consumer market, LTE (and LTE-A) was now a mature, widely adopted technology. As fast and reliable connectivity became standard, industry giants focused on innovation to stand out.

Samsung achieved a double-first with its Galaxy Watch LTE, certified by GCF in 2018 — this was the first LTE smartwatch and also the first device certified with a GSMA consumer eSIM. With LTE, a smartwatch can connect to the cellular network without needing to communicate via a phone, so that users can text or call independently, or, for example, can leave their phone at home when they go for a run and still stream music from the internet.

Samsung followed suit in 2018 with the Galaxy Watch LTE, the first smartwatch and first device certified with a GSMA consumer eSIM and able to support LTE connectivity. This breakthrough enabled users to make calls, send texts, and stream music independently, without needing a phone nearby.

The Consumer eSIM standard was first published by the GSMA in 2016, evolving from a previous implementation for M2M devices. An eSIM, a small secure element embedded in a device, could replace or coexist with the traditional removable SIM cards that had been a familiar part of our phones for years.

GCF worked actively with GSMA to introduce a certification program for Remote SIM Provisioning capabilities for Consumer eSIM in devices, from smartphones, to wearables and connected PCs. The eSIM's compact size, embedded design, and remote reprogrammability made it ideal for smartphones and wearable devices, especially those requiring water and dust resistance.

By the end of the decade, most smartphones had a similar form factor: a rectangular slab with very few or no physical keys and a display measuring between 4.5 and 7 inches. In 2019, Samsung introduced a significant innovation with the Galaxy Fold, the first foldable smartphone certified by GCF.

When folded, it looked like a typical smartphone with a 4.6-inch display. However, it could be opened to reveal a 7.5-inch display that was more like a tablet, nearly as big as the iPad Mini's 7.9-inch screen.

The arrival of 5G

If LTE was mature yet innovative, the newest kid on the block was 5G. Long heralded, the first 5G networks started to be rolled out in 2019. 'The first mobile phone certified by GCF supporting 5G, the Oppo Reno 5G, arrived in the same year. Launched in Switzerland in May 2019, this was the first 5G mobile phone commercially available in Europe.

When 5G was first deployed, most 5G networks were non-standalone (NSA), which means that they relied on a 4G core network to operate. The transition from 4G LTE to 5G was also smoothed by 5G NR EN-DC (new radio, dual connectivity), which enables devices to use 5G and 4G LTE simultaneously.

Over the years, the industry has been moving increasingly to the full-fledged 5G standalone (SA) networks that operate independently with no need for a 4G core. These 5G SA networks promise better performance and energy efficiency for both operators and users. The first smartphone tested with 5G technology, the Huawei Mate20 X 5G, was certified by GCF in 2019, and also became the first smartphone certified with 5G SA.

But 5G isn't just for smartphones. Also in 2019, GCF certified its first 5G CPE (consumer premises equipment) device, the Huawei 5G CPE Pro. This was a 5G home router that enabled mobile carriers to offer consumers a home broadband service over the 5G network. These types of devices have evolved significantly and are nowadays one of the most successful use cases for 5G technology.

One example of this was the **Microsoft Surface 3 LTE** (pictured right), certified by GCF in 2015. This portable 2-in-1 device ran a full version of Windows OS, providing the experience of a standard Windows PC on a smaller, portable form factor — a lightweight tablet with built-in LTE connectivity.

Conformance testing:

EVOLUTION IN THE 5G ERA

Amy Tao, *Vice Chair of the GCF Conformance Agreement Group (CAG) and Project Manager at Bureau Veritas Consumer Products Service division, is a seasoned engineer who has provided technical support for conformance testing since the early days of GSM.*

Since joining Bureau Veritas in 2015, Amy has been an active participant in all 3GPP (3rd Generation Partnership Project), GCF, and PTCRB Working Group meetings. Collaborating with project managers within the test lab, Amy uses these meetings to address technological issues and challenges in the conformance criteria certification area.

"It's important to understand that when 3GPP initiated work on 5G, this technology was distinct from legacy GSM, UTRA, and even E-UTRA technologies, due to its use of very high frequencies and the requirement for vertical products," says Amy.

"Before the GCF began to adopt the work item and continue contributions from 3GPP – a process that spanned many meetings between 2017 and 2019 – we had to navigate the different structure, including Frequency Range 1 and Frequency Range 2 with New Radio, and establish how it should be integrated into the CAG. During that period, I recall extensive travel solely to discuss 5G, the creation of specifications, and the separation of the overarching items from the sub-work items."

Concurrently, with E-UTRA, there was an array of carrier aggregation (CA) configurations, where multiple carrier components (CCs) across different frequency bands merged to enhance mobile data speeds. For LTE CA, various band combinations were encountered, including two-carrier components (2CCs), 3CCs, 4CCs, and even 5CCs, which were introduced to the industry.

CA supported types of inter-band, intra-band contiguous, and intra-band non-contiguous configurations, enabling devices to support more bands.

"From a test lab's perspective, we were required to test nearly everything. Even though 3GPP, which sometimes defined redundant tests, allowed us to test the CA combinations with highest CCs supported and skip fallback CA combinations, the specifications were not always clear by the industry. For certain CA combinations, finding a validated test platform was challenging," adds Amy. "Consequently, we sometimes had to seek exemptions for specific bands / band combinations or scrutinise the specifications more closely to determine potential redundancy. At that time, some devices supported hundreds or thousands of bands / band combinations, presenting a substantial task for labs to execute, particularly with modules or smartphones."

With the advent of 5G, the number of bands / band combinations have significantly grown. 5G not only adapts CA structure from E-UTRA, but also includes the feature of Dual Connectivity (DC) to allow devices to simultaneously connect to E-UTRA and 5G networks.

> **Attending GCF meetings in person, rather than remotely, is not just a preference but a necessity to actively engage in conformance discussions, improving the GCF certification scheme as part of the wireless industry."**

"It becomes a challenge for labs since we had to ensure that all relevant bands / band combination could be tested and certified in our labs. Understandably, device manufacturers desire one-stop-shop testing, which places additional pressure on the lab industry and necessitates considerable investment."

In the meantime, smartphone manufacturers may introduce one or two new devices annually, and the booming IoT sector – with its cost-competitive nature and where swift market entry is a significant advantage – is influencing the lab industry. The number of IoT devices integrating a GCF-Certified Module increase each year; it leads to demands for less comprehensive, more affordable conformance certification testing. Yet, this can only be realised if manufacturers, operators, and test labs actively participate as GCF members and attend meetings in person.

"To resolve this issue, physical attendance at GCF meetings is important and necessary for active engagement in conformance discussions. New certification tests hinge on forging strong, personal connections with operators and manufacturers. Human interaction during these meetings is not just advantageous - it's essential; it enables members to openly discuss issues, stay updated on ongoing projects, and reach consensus on future directions," concludes Amy.

Mastering the

MAZE OF CONNECTIVITY

***Howard Benn,** a telecommunications standards architect, examines the complex intricacies of advanced connectivity and the vital role of the GCF.*

Howard Benn has played a pivotal role in shaping mobile communication standards, particularly during his tenure at Motorola and Samsung, where he contributed significantly to the development of Global System for Mobile Communications (GSM) and 3rd Generation Partnership Project (3GPP) specifications. His involvement with GCF was crucial in prioritising test cases for certification.

Today, as an Honorary Professor and active contributor to the European Telecommunications Standards Institute (ETSI), Howard continues to influence the future of telecommunications through his educational and standardisation efforts.

Forging a path to universal connectivity

Since 2010, GCF has emerged as a key entity in managing the increasing complexity of mobile industry standards. Whilst the 3GPP Technical Specification Group Radio Access Network (TSG RAN) Working Group RAN4 has concentrated on defining performance requirements, Working Group RAN5 has been responsible for creating the test cases. GCF has played a pivotal role in the certification process, ensuring that these standards are met.

"In the dawn of mobile connectivity, manufacturers aspired to craft a universal phone, one that would meet the needs of operators worldwide and ensure a level playing field in the industry – a vision that underscored the essence of global interoperability," remembers Howard. "As we navigated the complexities of evolving 3G standards, we were at the forefront of introducing breakthrough technologies like HSDPA (High-Speed Downlink Packet Access), transforming the mobile landscape from a voice-centric realm into a data-driven world, despite the original design for high-capacity voice communication."

The collaboration between manufacturers and operators, facilitated by GCF, has been instrumental in determining which features are implemented in networks around the world. "The impact of GCF has been most evident in its ability to drive network performance by ensuring that each individual device on the network functions optimally, thereby securing the overall health and efficiency of mobile communication systems worldwide," Howard asserts.

Inflated complexity

As the industry transitioned to 4G, it faced critical decisions regarding the evolution of mobile standards due to fundamental changes in technology.

Discussions, for instance, centred on whether to continue with the established Code Division Multiple Access (CDMA) based system or transition to Orthogonal Frequency Division Multiplexing (OFDM). During this period, GCF played a critical role by rigorously ensuring that the emerging 4G standards were robust and fully equipped to usher in a new era of mobile internet access.
The focus was on achieving high-speed, high-efficiency connectivity while integrating thousands of new features, particularly in the rapidly expanding Internet of Things (IoT) space.

With 5G, GCF faced an enormous challenge due to the sheer complexity and volume of test cases required for the ever-expanding range of features and frequency bands. "The task was not just to test, but to prioritise and harmonise, ensuring a common set of features across devices in an industry where specifications ballooned," says Howard. "In terms of numbers, this meant that the test specifications in 3GPP Release 15 spanned 645 pages, rising to a staggering 5,294 pages for Release 17."

GCF overcame this challenge by fostering a collaborative space where industry experts could tackle the growing complexity of mobile standards. Its structured environment facilitated clear communication between operators and manufacturers, ensuring that testing priorities were aligned with network requirements, all the while complying with competition laws in a competitive landscape.

As mobile standards progress towards 6G, the role of GCF will become even more essential in meeting the industry's intricate and harmonised requirements, says Howard.

> **"GCF's expertise in navigating the complexities of certification has been pivotal in ensuring that the global march towards 6G is characterised by seamless interoperability and strict adherence to standards, transcending political boundaries to maintain unity in technological development."**

2020-2024

PANDEMIC POWERHOUSES: LTE & 5G

As the 2020s began, the world came to a standstill. The COVID-19 pandemic led to millions of deaths, prompted countries worldwide to impose lockdowns and halt travel, and caused unprecedented disruption across nearly all industries.

Mobile technology became crucial in controlling the spread of COVID-19, enabling millions to work from home and stay connected while physically distanced from colleagues, family, and friends. Simultaneously, the widespread availability of LTE and 5G networks facilitated the rapid and effective dissemination of news to the public, influencing behaviour and providing essential health information.

Bigger, better 5G smartphones

Despite COVID-19 lockdowns, the mobile industry persevered and GCF maintained operations, albeit without in-person meetings for over two years.

Smartphones improved, boasting larger, brighter high-resolution displays and superior camera sensors that eclipsed earlier models. They also became more intelligent, offering a wider array of connectivity options and technologies.

In 2020, GCF certified its first 5G mmWave device, the Samsung Galaxy S20 5G UW (Ultra Wideband), which was capable of accessing the millimetre wave (mmWave or FR2) frequency bands. Although mmWave offers exceptionally fast speeds, its limited range meant that the more common sub-6 GHz (FR1) frequency bands gained greater popularity in practice.

The initial 5G networks were non-standalone (NSA), dependent on a 4G core network, but standalone (SA) 5G soon emerged, offering higher speeds and lower latency. GCF certified the Oppo Find X3 Pro in 2021, the sole handset available at the

Samsung continued to push new innovations with the Galaxy Flip, certified by GCF in 2020. This was the first foldable smartphone with a glass display, whereas previous models from Samsung and Motorola had plastic ones. Samsung's second-generation folding phone, the **Galaxy Z Fold 2** (pictured left), followed closely behind and was certified by GCF in 2021.

Motorola wasn't to be left behind, and its Razr 5G hit the market in 2020 (after being certified by GCF). This brought the clamshell design of the original Razr up to date, with 5G connectivity and a folding screen.

launch of Europe's first commercial 5G SA network, which at the time covered only three cities in Germany.

5G adoption has continued to surge. By the end of 2023, 38% of all devices certified by GCF, and 60.5% of all smartphones certified, incorporated 5G technology. Over 96% of 5G devices certified in 2023 supported 5G SA operations.

To support the increasing certification activity, GCF established the Device Conformance Criteria (DCC) tool in 2007, which has evolved continuously. While GCF initially managed with a relatively manual process, the DCC tool now facilitates the tracking of work items, test platforms, and test case validations across industries. In 2021, GCF updated to a new version to manage the growing complexity of certification criteria driven by the advancements in LTE and 5G. Today, the DCC stands as the most comprehensive database of test information for devices implementing 3GPP standards.

IoT everywhere

Since 2015, IoT has become an integral part of GCF's activities. By 2023, GCF's IoT activities reached a new milestone: the number of wireless modules, designed for IoT and mobile broadband applications, exceeded consumer-oriented mobile phones (primarily smartphones) for the first time.

The first IoT chipset to be certified by GCF (in 2020), not specifically as a module or device, was the u-blox UBX-R5. This 5G-ready, multi-band chipset supported both LTE-M and NB-IoT and featured hardware-based security. It could then be implemented and easily certified across a range of devices.

5G also entered the IoT arena with its reduced capability (RedCap) variant, introduced in 3GPP Release 17. In 2023, GCF launched its 5G RedCap certification, with the first product, the Quectel RG255C-GL module, being certified in September 2024.

5G RedCap (also known as 5G NR-Light) is designed to broaden the application of 5G to use cases not well-served by conventional 5G but that could still benefit from the advanced features and spectral efficiency of 5G NR. It does so by offering lower bandwidth and fewer features at a reduced cost. 5G RedCap is particularly suitable for IoT and industrial applications that need higher data throughput than other LPWA technologies can provide, such as video surveillance, industrial sensors, and wearables.

Beyond handsets

GCF's work predominantly revolves around mobile handsets, modules, and IoT. As previously noted, 2023 marked the first year when more modules than smartphones were certified (35.6% versus 33.2% of all devices certified).

However, certifications extend to multiple other technologies and markets. For instance, in 2021, GCF launched its C-V2X Automotive programme. Collaborating with the 5G Automotive Association (5GAA), GCF has crafted an innovative programme for certifying the radio layer of C-V2X. Direct wireless connections based on C-V2X (starting with LTE-V2X and progressing towards 5G NR-V2X) between vehicles and between vehicles and infrastructure will enhance the safety and efficiency of transportation systems. The first C-V2X-capable device was certified in November 2022.

In the mission-critical sector, while TETRA currently prevails, the next generation of mission-critical services (MCS) is being deployed over LTE cellular networks and is advancing towards 5G. These newer technologies, governed by 3GPP standards, provide the necessary bandwidth for robust voice and data communication with first responders, public safety services, transportation, and beyond.

GCF and The Critical Communications Association (TCCA) have collaborated for several years on a joint initiative to establish a certification programme for Mission-Critical Services, aiming to certify MCS clients and devices that support MCS services. The first MCS client, the MissionX Android SDK from Frequentis, was certified in July 2024.

Additionally, in 2024, GCF's certification programme reached new milestones with the introduction of NB-IoT support for Non-Terrestrial Networks (NTN). With the adoption of standards-based satellite connectivity, manufacturers can now certify their devices for direct connection to various satellite operators. This facilitates the rapid launch of satellite-connected devices with guaranteed interoperability, enabling satellite communications in regions beyond the reach of terrestrial networks.

Looking back on 25 years of history, GCF has the heritage, expertise, and knowledge to support the mobile industry, coupled with an inquisitive spirit to continue driving innovation into the future.

A window on the MOBILE WORLD

***Danni Song**, 宋丹 being her Chinese name — is an experienced engineer who uses her position as a board member of GCF to champion the needs of the mobile industry in Asia. She first joined the organisation in 2011 as a member of the CCSA working group and in 2018 as a member of the 3GPP working group.*

The evolution of wireless and mobile networks has revolutionised global communication, but technological priorities can vary widely depending on where you are in the world. This variation is something that Danni Song is keen to address as Principal Researcher for China Mobile, the leading ICT services provider in mainland China.

China Mobile has the world's largest network and customer base, with more than one billion mobile customers (as of August 2024). Developing new features to retain their world-leading position requires considerable investment in research, field trials, and testing.

"It's very important for us to communicate our feature requirements to the supply chain as early as possible so manufacturers and testing houses know what's in the pipeline. Equally, we want our route to market to be as cost-efficient as possible," says Danni. "The GCF helps vendors to prepare and support new features, centralises certification, and makes commercialisation easier."

Danni particularly values the global perspective the GCF offers through its membership, which gives China Mobile important feedback on the new features being proposed. It also enables vendors to raise questions and clarify requirements more efficiently.

GCF's global perspective also fosters a better understanding of how priorities in Asia may benefit mobile developments in other parts of the world, and vice versa — one example Danni highlights is the importance of mobile connectivity and high-speed trains.

"The ability to use mobile devices reliably on high-speed trains was really important in China and Japan, but not such a priority in Europe and North America," Danni recalls. "Through the GCF, we were able to explain how certain features, such as roaming, would bring benefits to mobile network operators globally, not just in Asia. These features have since been commercialised and validated, allowing everyone to use their mobiles and laptops on the train."

Despite this type of success, accommodating different priorities in different markets can sometimes be a frustrating process. Network slicing — the ability for multiple independent networks to exist on the same physical network using different 'slices' of the same spectrum band — is still a work in progress.

"Development of the ecosystems in some parts of the world (including Asia) is quite far advanced, but some other global operators just aren't there yet, so we're waiting for new partners to emerge," says Danni.

> **"GCF's global membership fosters a better understanding of how priorities in Asia may benefit mobile developments in other parts of the world, and vice versa."**

In the meantime, there are other challenges to overcome. GCF certification is not yet mandatory in Asia, although the three leading Chinese operators are already aware of its benefits. Manufacturers in Asia are also coming on board, realising that GCF certification is a key requirement if they wish to expand into global export markets.

"It would be good to see GCF adopted as the de facto certification standard across Asia in the near future," says Danni. "And, who knows, maybe one day we'll have a branch office here in China! One world, one certification."

A pivotal role in mobile INTEROPERABILITY

Adrian Scrase, *an ETSI veteran, reflects on his extensive collaboration with GCF and its impact on the wireless and mobile sector.*

Adrian Scrase is well familiar with GCF. His tenure as Chief Technical Officer at the European Telecommunications Standards Institute (ETSI) involved close cooperation with GCF, aligning ETSI's standards with device certification for the wireless and mobile community. This partnership proved invaluable, ensuring new devices were market-ready and globally interoperable.

"Historically, there was a lengthy delay from the completion of a standard to having products available in the marketplace — sometimes years," Adrian recalls. "GCF added real value by providing a one-stop-shop approach to the certification process, ensuring tests were in place as soon as possible after standards completion. Closing the gap between standards completion and product availability was crucial for industry progress."

GCF's international scope has simplified device certification, replacing the cumbersome country-by-country approach with a unified system. This approach required a complete rethink about the process, plus vast amounts of time and money.

"GCF's global certification framework, with its rigorous processes and tests, has been pivotal," Adrian states. "It's the most influential and recognised body of its type, instilling confidence in vendors and operators alike."

The catalyst for industry progress

Adrian's illustrious career at ETSI was long and distinguished, including a key role in the 3rd Generation Partnership Project (3GPP), a collaboration between groups of telecommunications standards associations. Established in the 1990s, this project set out to create universally accepted system specifications for third-generation (3G) mobile based on the evolved Global System for Mobile Communication (GSM) core networks — a significant milestone in the evolution of the modern mobile sector.

Looking back, Adrian remembers the introduction of 3G as challenging. The standards were rushed, and various other factors were at play. However, the transition from 3G to 4G was different. Here, the industry under-promised and over-delivered, and much credit can be attributed to GCF.

"The transition from 3G to 4G was expertly managed, with GCF playing a fundamental role. Their well-developed certification process prioritised essential tests and had a positive impact on device availability. That successful period laid the groundwork for the transition to 5G."

From 6G research to machine-readable standards

Now retired, Adrian Scrase remains an influential and knowledgeable figure in the mobile and wireless sector. He has recently been appointed as a Visiting Professor at the University of Surrey in the UK, driving research into 6G. This work will precede standards and certification development, and he expects to continue his close collaboration with ETSI and GCF.

"There is so much more to do," he asserts. "For instance, when I look back over the last 30 years, there has not been much change in how we write standards. They are still mostly text-based prose, whereas I think we should move more towards machine-readable standards. This process will inevitably involve GCF, as changes to standards need to be closely aligned with certification. I look forward to our ongoing relationship."

> **"GCF is the most influential and recognised body of its type worldwide, and that provided confidence for the vendor and operator communities."**

2025+ AND BEYOND:

AI, GLOBAL CONNECTIVITY, & THE RISE OF 6G

The past 25 years have been a remarkable journey for the mobile industry, with GCF playing an active role throughout. Looking ahead, what will the next 25 years bring?

While we can't predict the distant future, some near-term trends are discernible.

Mobile technology trends and innovations

AI is likely to continue its rapid ascent, driven by increasingly swift processors and the management of vast data volumes.

Mobile communications will be crucial in this landscape, facilitating the transfer of information from sensors and IoT devices, and connecting smartphones and wearables to the cloud with advanced radio access technologies. We can expect AI capabilities at both the device and access network levels to undergo significant evolution in the coming years, revolutionising user experiences and network operations.

Smartphones, smartwatches, and smart glasses will become faster, lighter, and more sophisticated, offering new AI-driven features to users, often with cloud support. At the market's opposite end, ultra-affordable smartphones will further democratise global communication.

As society becomes increasingly reliant on connected services and devices, cybersecurity for consumer and IoT devices will grow in importance.

Evolving mobile networks

Our mobile handsets will increasingly offer direct satellite connections, with non-terrestrial standards-based wireless communication such as NTN 5G NR.

Initially, smartphones are expected to be certified with this technology for basic messaging and emergency services in areas beyond terrestrial network coverage. As the number of satellites grows and costs decrease, we anticipate broader applications for this technology.

Innovations like folding and rollable form factors will continue to fuel the demand for new smartphones. This will coincide with 5G solidifying its status as the leading wireless technology, complemented by the expansion of 5G RedCap into cost-effective modules and IoT applications.

Beyond smartphones, there is an anticipated increase in the use of standards-based mobile communications in mission-critical services — from two-way radios to body-worn cameras and vehicle-mounted devices. The continued deployment of automotive connectivity is expected, although the timeline for widespread adoption of C-V2X technologies in vehicles and the advent of fully autonomous cars remains uncertain.

Our connected future

As technology evolves, GCF remains sharply focused on introducing new innovations, such as self-powered Ambient IoT, advanced 5G features, and additional frequency bands and combinations. Concurrently, GCF will continue to manage the phasing out of older Radio Access Technologies, such as 3G/WCDMA and 2G/GSM, as operators decommission these services and repurpose the frequencies.

GCF has consistently adapted over time and will persist in doing so. We keep pace with ever-changing markets, thanks to the contributions of our members and partners, and the availability of standards and test specifications developed by standards developing organisations (SDOs), with 3GPP (for which GCF is a market representation partner) and GSMA being the most significant.

As the sixth generation of mobile communications (6G) is being defined, with an expected launch in the early 2030s, GCF is ready to deliver certification programmes for the forthcoming generations of mobile technology, just as it has since the era of 2G.

GCF delegates and guests celebrating GCF 25th Anniversary at IET London, 25 September 2024.

GCF in Figures

Membership (Active)

366 Members

131 Operator Members

6 Test Platform Vendors

175 Manufacturer Members

60 Test Industry Members

63 Test Laboratories (RTOs)

108 Countries Impacted

64 Countries Represented

Other

~2000 Active Delegates

337 Agreement Group Meetings
**Includes SG, CAG, FTAG and IAG meetings.

17 Partner Organizations

Certification Activity

9960 Devices Certified

5982 Handsets Certfied (including Smartphones)

2537 Smartphones Certified

1920 Modules Certified

257 Certifying Companies

17 Technology Areas Covered

1540 Work Items active

9060 Unique test cases validated and active

111 Test Platforms active

15 Test Platform Vendors active

*GCF figures based on end October 2024 data

A guiding hand through TESTING TIMES

***Alexander Pabst** talks about the positive impact of the GCF on the test environment and how it will continue to make a difference in years to come.*

Few people know test and measurement like Alexander Pabst. With a 27-year career at Rohde & Schwarz, ending up as wireless communications segment lead, this industry leader has played a critical role in ensuring device-network interoperability.

During this time, Alexander worked closely with GCF, ensuring the certification programs it developed fed through into reliable systems and equipment that fully met end-user expectations. "Rohde & Schwarz embraced GCF right from the start, and I was part of the first GCF steering group," he recalls.

"Even today, it's still the most relevant organisation because it unifies the requirements of network operators and device vendors. And that has always been really important for us because GCF has also helped simplify and streamline the test environment."

Test requirements are growing with each generation of wireless connectivity as new systems and technologies are introduced. For Alexander, it's essential that the industry is not overloaded with test requirements, as it can become costly and cumbersome. He says the GCF has successfully trimmed down the complexity of some testing without impacting conformance and product quality.

For example, ten years ago, GCF played a pivotal role in optimising the protocol test cases, which are essential for ensuring communication between the base station and the mobile device. It recognised that the fundamental 'language' of communication remained consistent across different radio frequencies.

Consequently, GCF's guidance meant that repetitive testing across every frequency band was unnecessary. Alexander says this approach prevented redundant efforts and contributed to a more efficient testing process within the industry.

Navigating the technical challenges of the future

What next, though? The wireless and mobile sector is set to embrace unprecedented innovation, with the race for AI-powered, cloud-assisted, ultra-fast devices with longer battery life and connection from any point on earth.

This will require the adoption of a range of technologies such as Non-Terrestrial Networks 5G New Radio (NTN 5G NR), LTE direct-to-satellite, 5G Reduced Capability (RedCap), and Mission-Critical Broadband (MCX Broadband). Collectively, these technologies will enhance connectivity, reliability, and accessibility of wireless communication worldwide.

> **"GCF has a well-proven track record. I like that it is a lean and mean organisation run cost-efficiently, making it affordable to everyone."**

Alexander thinks GCF will help navigate this complexity, delivering value for all. "The ecosystem is changing, and having ubiquitous connectivity is a cool thing – not only for people who enjoy hiking in the Alps but also for other industries and applications, such as the automotive sector for fully autonomous driving," he says. "This is undoubtedly going to happen, and we see the first instances with narrowband NTN right now, evolving to NTN NR and to 6G.

"There will no longer be any differentiation between satellite or terrestrial-based networks – it will all be integrated."

Looking to the future, Alexander believes GCF will continue to welcome more members of different sizes and disciplines, such as satellite operators, widening its ecosystem and making it even more relevant for the future.

He reckons this will expand its reach worldwide, securing its position for the next 25 years. "GCF has a well-proven track record. I like that it is a lean and mean organisation run cost-efficiently, making it affordable to everyone."

Certification enables INNOVATION

Sabine Dickhut, *a well-established engineer with considerable experience of the wireless industry, cellular testing, and industry certifications, has been a valuable contributor to GCF for two decades. She has actively participated in various steering committees and working groups.*

Qualcomm is a global connected processor company whose technology underpins wireless connectivity, RF front-end, high-performance, low-power computing, multimedia, and on-device intelligence. They are dedicated to the standardisation of many key technologies that will transform the world, encompassing wireless – Wi-Fi, Bluetooth, 4G, 5G – to multimedia, which includes video codecs. Furthermore, they participate in over 200 global standards and industry organisations.

Sabine Dickhut is part of Qualcomm's Technical Standards team, and as the GCF Certification Manager is charged with the responsibility of ensuring that their leading-edge products comply with GCF's certification criteria. With so many individual operators and other stakeholders in the mobile technology market today, she recognises the role of GCF as a central certification body to be of immeasurable value.

"Centralised certification provides huge benefits," Sabine asserts. "Most mobile operators recognise GCF-certified products, thereby reducing the complexity involved in the testing and certification process. This is commercially significant, as it reduces time to market."

Sabine also recognises the value of GCF as a forum for the exchange of ideas and the discussion of industry challenges. "It's crucial that all stakeholders – manufacturers, test houses, operators, and others – have the opportunity to come together and discuss future direction.

"GCF gives everyone a voice, a place where we can agree on the certification requirements we all need to work towards. It gives confidence that new products meet industry standards, ensuring interoperability and performance."

The wireless industry faces significant challenges in the future. The current emphasis lies on the delivery of 5G-Advanced features, which entails the enhancements of Non-Terrestrial Networks (NTN) as well as artificial intelligence (AI) and machine learning (ML) to enhance network performance, optimise resource allocation, and improve user experience.

Beyond these developments, there is the task of scoping and evolving 6G. "Determining continued compliance of a product which evolves through the self-teaching phases throughout its lifecycle is going to be interesting," observes Sabine.

There are also some ongoing fundamental challenges to address. Consumers and end-users expect that new technological devices will be more feature-rich and increasingly energy-efficient. These (occasionally conflicting) imperatives contribute to the growing complexity of devices, which can lead to more costly certification processes.

These challenges cannot be resolved in isolation, making global industry organisations like GCF more important than ever.

"The wireless industry is a fast-paced environment, and the speed of innovation is increasing all the time," says Sabine. "It's so important for the future of the industry that we have consensus between stakeholders, so product development, feature deployment, and certification requirements are fully aligned. GCF enables this conversation and encourages the early buy-in that's required globally to adopt the mobile technologies of the future."

> **GCF achieves consensus between all mobile industry stakeholders, which enables the adoption of the mobile technologies of the future."**

The test industry: ENABLING GCF SUCCESS

Over the last 25 years, GCF has made significant strides thanks to the unwavering support and expertise of our partners, colleagues, and the test industry – which has been the consistent backbone of our activities since the beginning.

Three types of organisations

GCF certification was once limited to a few qualified test laboratories able to certify conformance and RF test cases over a reduced number of work items and validated test platforms. Now, GCF certification involves over 65 accredited Recognised Test Organisations (RTOs) in 11 countries.

Device testing associated with GCF certification must be undertaken by these organisations, which are further accredited by ISO or an equivalent quality accreditation process, to conduct device testing that ensures compliance with GCF standards.

GCF introduced real-world network testing in 2007, following specifications set by GSMA Terminal Steering Group and executed on 'Field Trial Qualified' networks designated by network operators. This practice has expanded globally, with nearly 40 field trial laboratories now operating across 10 countries.

To complement RTOs, GCF established the concept of third-party Assessment Capable Entities (ACEs). These ACEs are subject matter experts who assist manufacturers in certifying their devices. Affiliated with accredited organisations, ACEs possess the expertise to determine the necessary test range for device certification and evaluate test results, thereby ensuring that products meet GCF's certification standards.

Of course, we must highlight the role of test equipment vendors. When GCF started, we worked with just a few across Europe. Today, we operate alongside major test equipment vendors such as Rohde & Schwarz, Keysight, Anritsu, Comprion, Beijing StarPoint, CICT, Spirent, FIME, UL, SinanMonde, DEKRA, and HEAD Acoustics.

These companies have been instrumental in supplying RTOs with validated test platforms, certified for various accreditation scopes, that effectively evaluate GCF Conformance Criteria across different work items and frequency bands for certified devices and products.

For conformance testing, these platforms rely on the development, verification, and release of 3GPP TTCN-3 Protocol Conformance Test Suites, developed by 3GPP TF160. These suites, based on 3GPP RAN5 Group's test cases, are crucial for conformance testing.

While 3GPP provides the foundational suites, some manufacturers and operators, like Motorola Mobility and Verizon Communications, have developed their own proprietary test platforms. Additionally, many manufacturers have established in-house RTO capabilities for testing their products.

As the mobile industry and its standards have evolved, GCF has adapted. Our test partners have mirrored this growth, ensuring healthy competition through a rigorous process. This process now focuses on various verticals, including automotive, mission-critical services (MCS), non-terrestrial access, and the Internet of Things (IoT). Many of these verticals are driven by specific industry or interest groups, which are also GCF partners.

GCF's activities have expanded significantly, now enabling more than 2,000 unique work items, over 9,000 unique test cases, and almost 75,000 validated and active test cases on specific frequency bands or band combinations. We now rely on 111 active test platforms from 15 different test equipment vendors, covering up to 17 different, relevant technologies.

Throughout our 25-year history, the test industry has been instrumental to GCF's success. We couldn't have achieved this without your valuable contributions.

Working together to build a SAFER FUTURE

***Tero Pesonen** has been involved in professional mobile radio communication development since 1997, with extensive expertise in public safety applications. He is Board vice-chair of The Critical Communications Association (TCCA) and has chaired TCCA's Critical Communications Broadband Group (CCBG) for more than a decade.*

Tero is committed to making mission-critical communications more robust, secure, and affordable. As a longstanding member of TCCA, he works with mission-critical users worldwide to increase the safety and efficiency of today's TETRA and forthcoming critical broadband communications technologies.

"Mission-critical communication is basically anything where there is a major risk to life or the state," Tero explains. "Users can be first responders, such as the police, fire, and rescue, but applications extend from the military and civil defence through to social services, from public utilities to private industries. All face circumstances where communication must be successful to save lives or avert disaster."

TCCA aims to bring all the stakeholders from across the mission-critical communication value chain together, including the public network operators, industry, applications developers and regulators providing a forum to consider current and future needs and drive the development of solutions that will deliver benefits to all.

The baseline standard for mission-critical mobile broadband communications is 3GPP, but TCCA faced challenges around developing suitable certification standards. Collaboration with GCF gave them a working framework and access to the wider communications community.

"A multivendor market doesn't happen by itself, and we recognised that certification was going to be key," says Tero. "GCF already had established industry connections and certification processes, which saved TCCA a lot of time and effort. Through collaboration with GCF, we have gained a voice and market relevance."

The Critical Communications World 2019 conference in Kuala Lumpur marked a turning point, where GCF was first able to participate and join TCCA's vision for mission-critical communication. The event helped their respective members to have confidence that 3GPP mission-critical communications was imminent, and worth investing in. Equally, TCCA demonstrated its clear commitment to certification, which brought a new set of vendors to GCF.

The big challenge for TCCA and GCF was persuading test houses to invest in developing suitable equipment for testing 3GPP mission-critical products at a time when all their resources had been allocated to 5G.

Tero recalls: "When you call 112 or triple zero or 911 or 999, you want help to arrive as soon as possible so, on a personal level, it's easy to convince people that mission-critical communication is important. But when one is looking at Excel sheets and finite budgets, it's much more challenging. Thankfully, GCF were on the same page as us."

> **We need to encourage continuous development and collaborative ways of working to provide the safety and security that society needs to keep functioning, in a way that we as taxpayers can afford. Working with GCF and other stakeholders will help us to achieve greater understanding and visibility of the importance of open standards, interoperability and certification in critical communications."**

Together, GCF and TCCA were able to demonstrate the business case, and once one test house was on board, the others quickly followed.

Future ambitions

According to Tero, the mission-critical future will expand into 3GPP conformant device-to-device and satellite communications, which raises a whole new set of challenges around ensuring and verifying interoperability. The need for certification becomes even more important. This presents GCF with some key strategic questions as it continues to evolve, including whether to expand its remit to cover umbrella services certification, such as the applications layer above 3GPP standards, and not just MCX product certification.

"As we move into a more and more connected world," Tero adds, "I would argue that there is a continuously increasing need for certification beyond the product layer to ensure open, interoperable services. If GCF doesn't do it, then somebody else needs to step up."

BUILDING ON THE PAST, INSPIRED FOR THE FUTURE

Over the past quarter-century, we have played a vital role in the wireless industry by ensuring device interoperability, fostering collaboration, and driving innovation. Since our inception in 1999, GCF has expanded from a small, dedicated group of manufacturers and operators to a global forum that unites over 350 companies. What began with the founding principles of certification and testing has developed into a world-renowned organisation that sets the benchmark for mobile and wireless device certification.

Originating from the London Agreement, where industry leaders acknowledged the necessity for a unified certification process, our commitment to interoperability has remained the cornerstone of GCF's mission. The outcome? Thousands of devices have undergone GCF's stringent certification process, guaranteeing they meet the required global standards and function seamlessly across networks worldwide. Today, over 700 companies have engaged with GCF, with members hailing from every corner of the globe.

At the core of GCF's success lies its role as a collaborative forum. As technology progresses, the GCF provides a platform where manufacturers, operators, and test houses can converge to exchange ideas, tackle challenges, and reach consensus on future technological standards. This model of industry-wide cooperation has been essential in managing the increasingly intricate mobile landscape.

Adaptability is another key factor. Over the years, GCF has evolved alongside the industry, adapting to shifts in technology and market needs. From the initial days of 2G certification, GCF has broadened its remit to include 3G, 4G, and now 5G, while also anticipating the advent of 6G. The task of certifying increasingly complex devices, which incorporate AI, machine learning, and sophisticated connectivity solutions, will no doubt call for the same spirit of collaboration and innovation that has characterised GCF's first 25 years.

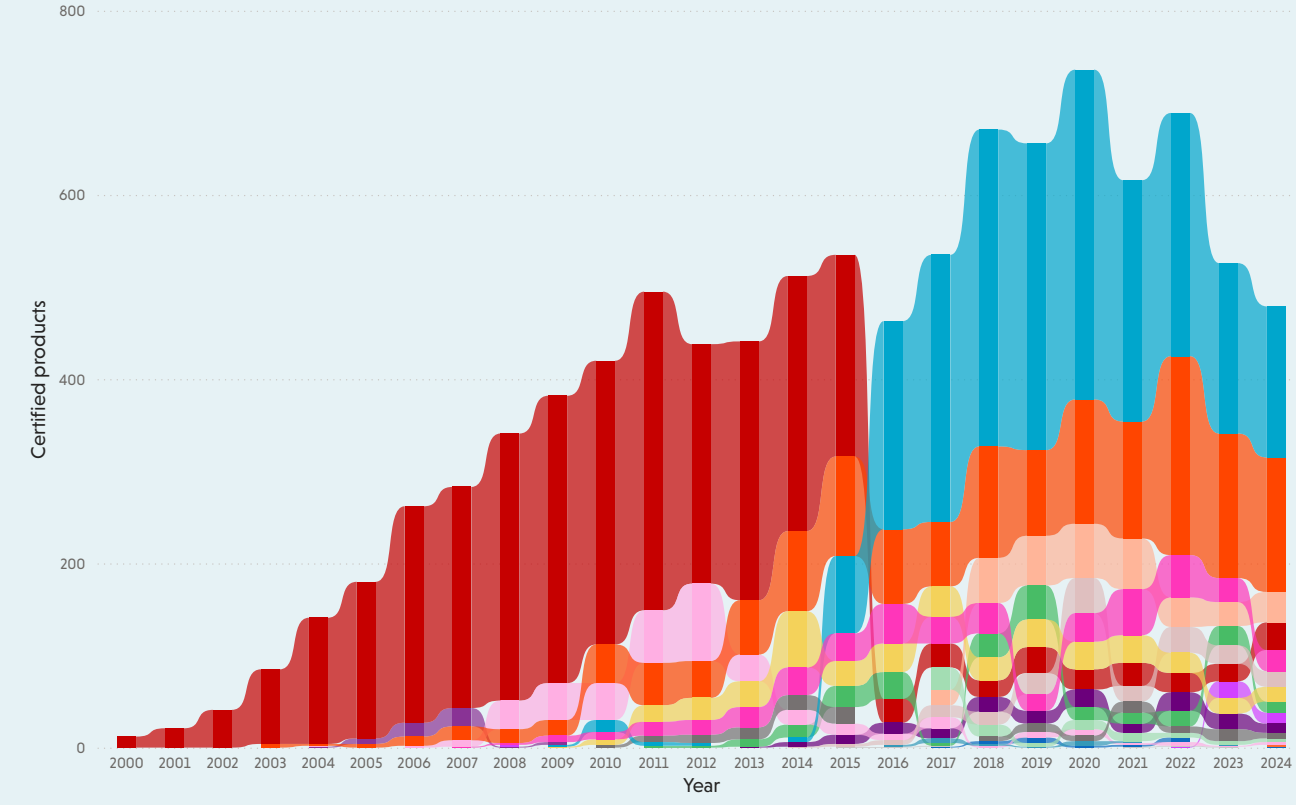
As the industry ventures into new technological realms, GCF's continued efforts to enable seamless global communication will become ever more vital. With a solid foundation and a progressive outlook, the GCF is well-equipped to guide the mobile industry into the forthcoming era of connectivity.

We're grateful for your support

We extend our heartfelt thanks to all our members, partners, and contributors who have supported the GCF over the past 25 years. Our deepest gratitude goes to the device manufacturers, operators, test industry, industry bodies, and regulatory organisations that have played an instrumental role in shaping GCF's success. Special appreciation is due to those who contributed to this book—from all the named interviewees to our agency partners at Publitek—and to the steering committees, working groups, and technical standards teams whose dedication and teamwork have established GCF as the esteemed institution it is today. Together, you have all been pivotal in driving innovation, ensuring global interoperability, and propelling the mobile industry forward.

Here's to the next quarter-century of certification, collaboration, and innovation.

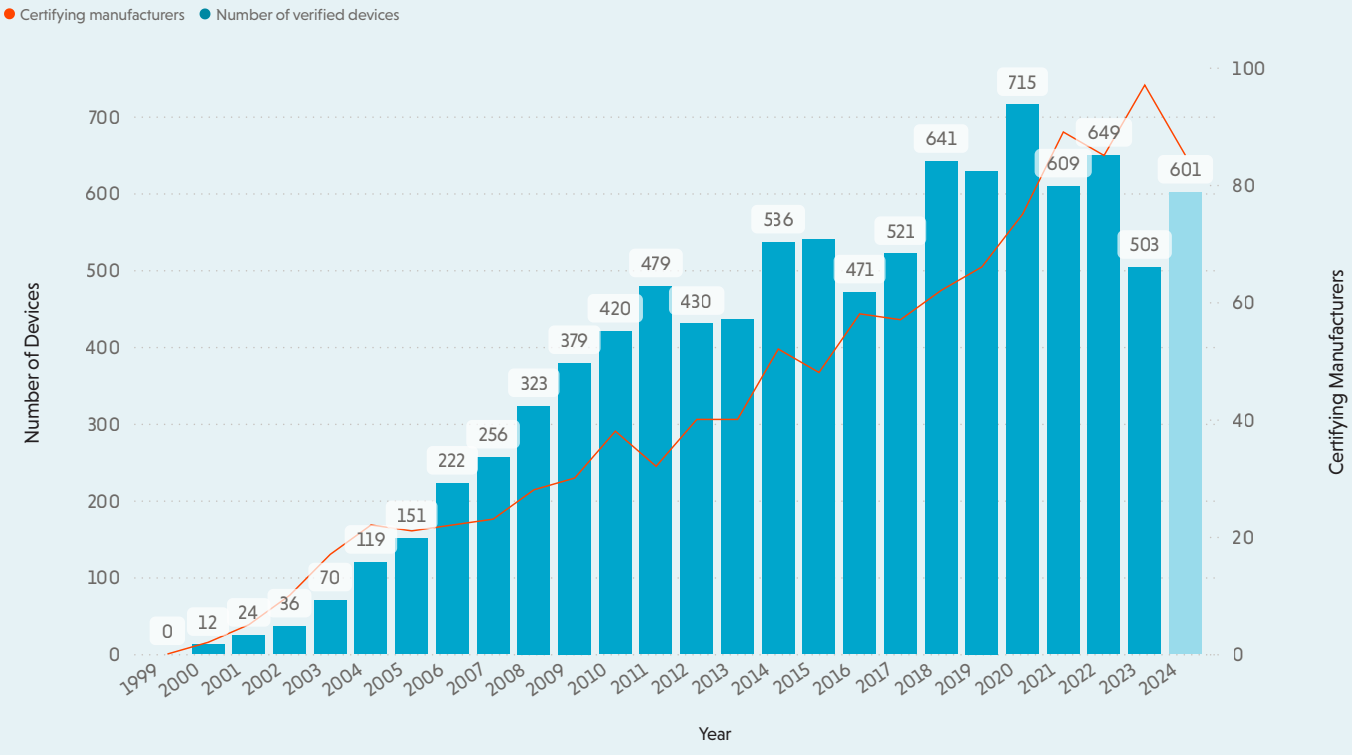
Evolution of Product Types in Certified Devices



Primary function

- Data Card
- IoT Module
- Medical Device
- Other (Consumer)
- Tablet / 2-in-1 Notebook
- Fixed Wireless Access Device
- IoT/M2M Device
- Modem / USB Modem / Dongle
- Other (Personal Communication)
- Wearable device
- Handset/Feature phone
- Laptop / Notebook / Netbook
- Module
- Smartphone
- WLAN Router
- IoT Automotive / Vehicular device
- MCS Client Platform
- Other
- SoC / Chipset / Platform

GCF Certified Devices & Certifying Manufacturers 2000-2024



2024 Values estimated based on available certification data up to 31 August 2024

GCF
Test Certify Connect

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