IAM

5G standards and the stark divide between innovators and implementers

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- **5G offers tremendous potential and will undoubtedly transform industry landscapes and consumer life as well as the world economy**
- **However, the innovator/implementer divide remains deep - more than 70% of the technical contributions have been submitted by just 10 companies**
- **The numbers highlight why government and regulatory bodies must balance innovation stimulation with IP protection to safeguard the reinvestment cycle**

Cellular standards such as those embodied in the third generation (3G), fourth generation (4G), and fifth generation (5G) have transformed the world. The next generation – 5G – will bring this evolution even further, unlocking new potential of technologies such as AI, edge computing, and the Internet of Things (IoT).

Several studies have quantified the various economic benefits provided by cellular technologies both in the past and projected into the future. The revenue from five interrelated cellular markets has been **calculated** at $2.1 trillion in 2019 and is expected to grow to approximately $3 trillion by 2025. The total economic value (including consumer surplus) was estimated at $4.8 trillion and $7.5 trillion, respectively. For 5G, IHS **estimates** that the net contribution globally through 2035 (in net present value terms) will amount to about $2.3 trillion in constant 2016 US dollars; over the same period, global real GDP will grow at an average annual rate of 2.7%, of which 5G will contribute almost 0.2%.

Similarly, Accenture **expects** that the impact of 5G on the US economy will drive up to $2.7 trillion in additional gross output (sales) growth between 2021 and 2025 and has the potential to create or transform up to 16 million jobs across all sectors of the economy. In addition, the impact of 5G on the European economy during the same period will drive up to €2 trillion in incremental gross output, add up to €1 trillion to European GDP and create or transform up to 20 million jobs.

Cellular technologies have also provided environmental and social benefits and will do so in the future. Among others, by enabling the smart transportation system, 5G is **expected** to enable the reduction of 374 million metric tons of greenhouse gas emissions in the United States by 2025; overall, this represents an annual decrease of approximate 6% annually. Further, evidence shows that the **expansion** of mobile phones is associated with lower gender inequalities, higher contraceptive use and

lower maternal and child mortality, with bigger payoffs among the poorest countries. The same analysis further demonstrates that ownership of mobile phones has narrowed the information gap about reproductive and sexual health and empowered women to make independent decisions.

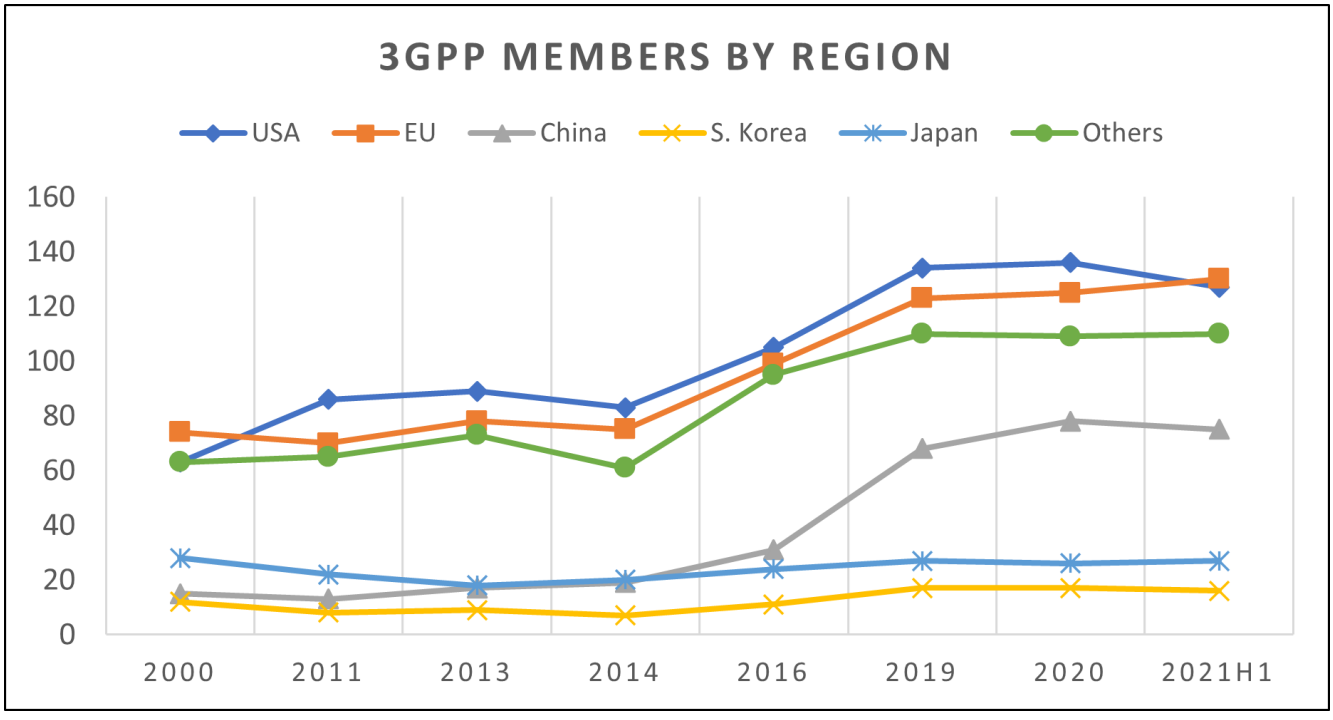
Collaborative standardisation has demonstrated significant technological achievements in the field of wireless telecommunications that foster economic prosperity and that are crucial for tech sovereignty. It is thus vital to understand how the standardisation process works and has evolved as the mobile ecosystem expands rapidly to connect much more than smartphones. **Each new generation of cellular technology has depended on countless inventions from a handful of innovators around the globe.** To conduct their costly and risky R&D activities, these few innovators employ thousands of engineers in multiple countries. Because of their commitment to R&D, these innovators continue to offer pioneering inventions to the cellular industry and drive the development and commercialisation of 3G/4G technologies, as well as the next generation 5G standard.

The development of cellular standards

Foundational cellular technologies are developed and deployed through a complex and lengthy process. Each generation of the cellular standards, from 3G to 5G, takes multiple years from R&D to the launch of standard compliant products. Private companies play an essential role in this development process, making significant investments in R&D that ultimately produce the foundational technologies that underpin the cellular ecosystem.

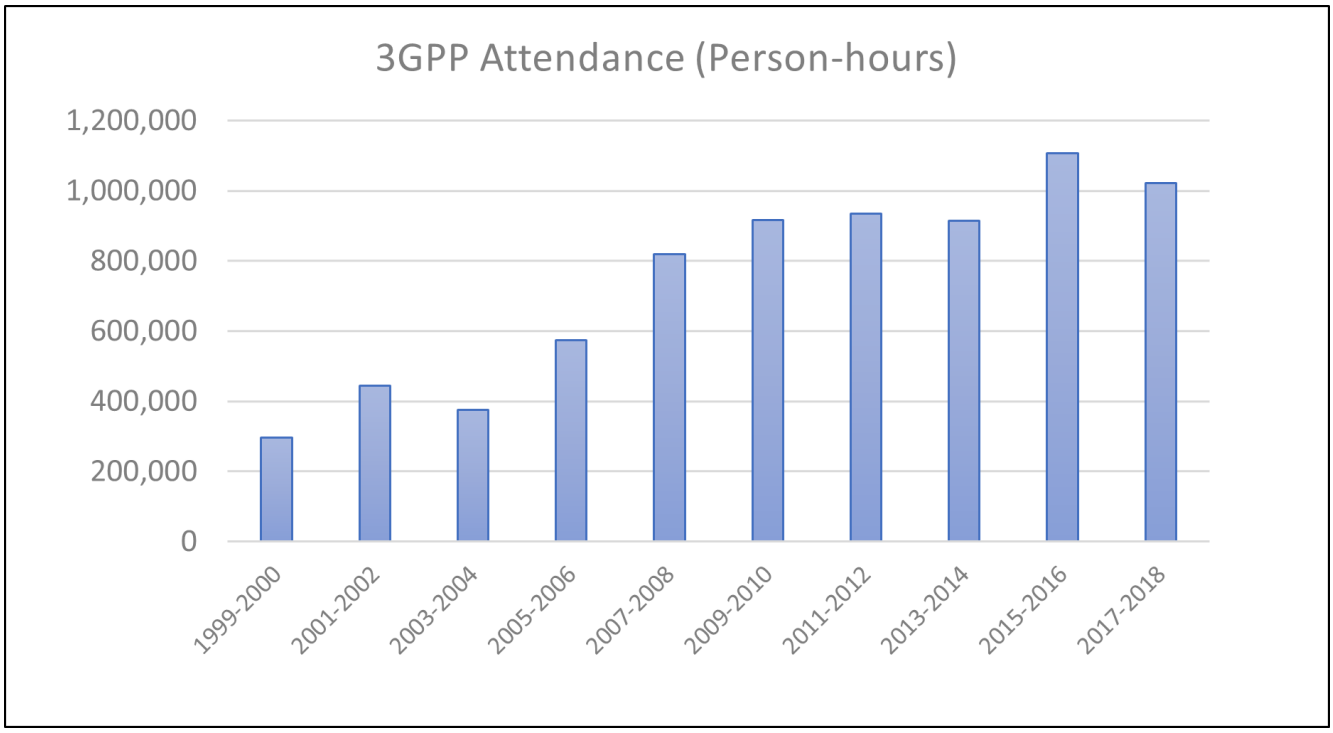
However, setting and developing global standards also requires significant coordination and cooperation among industry players. The 3rd Generation Partnership Project (**3GPP**), a partnership of seven standards-development organisations (SDOs) around the globe that develops protocols for mobile telecommunications, is a good example for understanding how the standardisation process works and has evolved. They key role of 3GPP is to develop, approve and promulgate thousands of detailed, complex technical specifications for complete end-to-end cellular systems including user equipment (or devices), radio access, core network and service framework. Over the last 20 years, hundreds of entities from the United States, European Union and Asia have been 3GPP members. Since the early 2000s, the number of 3GPP members has steadily increased, reflecting the growing importance of cellular standards across various industry verticals. Such a coordinated and global standard-development process serves the public good, establishing a common foundation for a thriving marketplace.

Figure 1: Number of 3GPP members by region between 2000 and 2021H1



Each cellular generation requires millions of person-hours in standard development by hundreds of market actors through an open, consensus standardisation process. Developing the wireless technology requires companies to invest heavily and consistently in R&D in order to drive innovation over a long-time horizon. Attendance, as measured by person-hours, has increased by more than 200% over the period 1999 to 2018, as shown in Figure 2. These numbers are a tiny fraction of the massive investments related to cellular technologies made by the innovators who engage in early R&D activities, many years before these technologies are standardised.

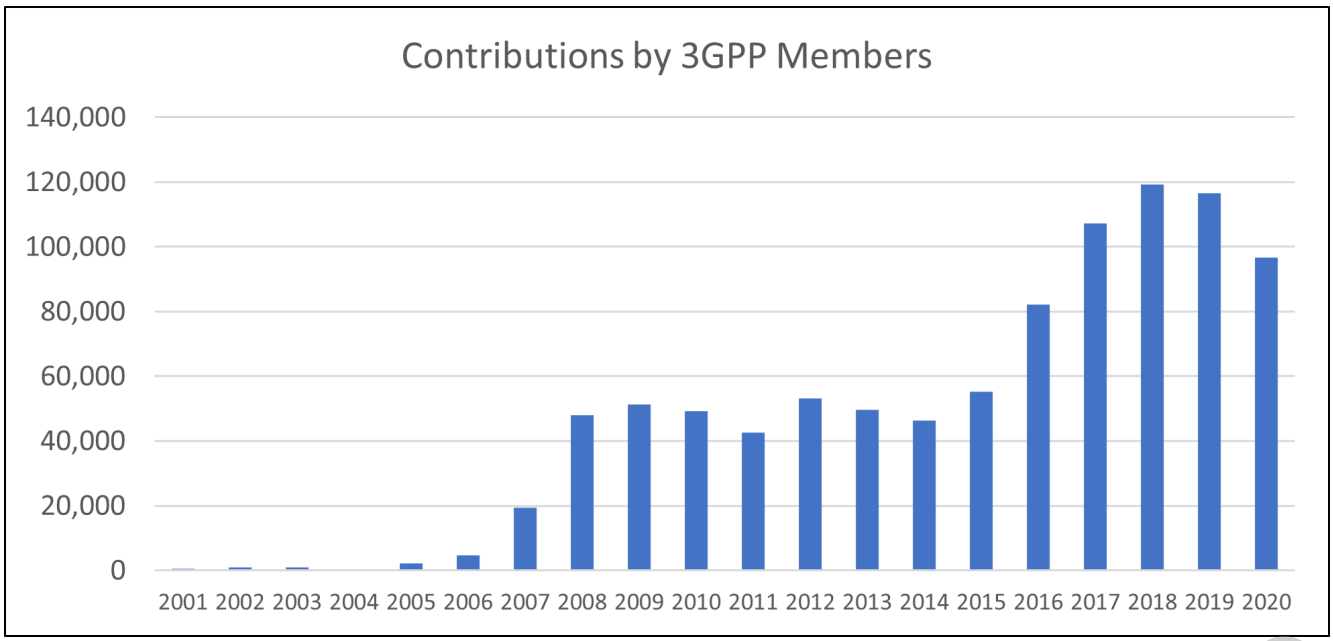
Figure 2: Number of person-hours and total compensation of delegates over the period 1999-2018



Contributions to 3GPP represent a fundamental data point in the understanding of the standards development process and the development of technical specifications. Member organisations submit technical documents, called contributions, that address various technical issues and propose solutions for how to address them. These contributions are then reviewed and discussed among all the members in the working group meetings. The 3GPP, for example, follows a consensus building or a majority voting governing rule for selecting between competing proposed solutions.

Between 2001 and 2020, 3GPP members made 946,374 contributions in total, with a significant uptick in the number of contributions after 2016. While quantity is not a measure of quality, the rise in the number of submitted contributions is directly related to the complexity, scope and the level of effort that goes into developing 5G. 3GPP offers an open standardisation ecosystem within which entities of all sizes can successfully contribute their innovative technologies. Past empirical research has **revealed** that 3GPP has rules and processes that attract the participation of SMEs and start-ups, giving them as fair a chance of success in contributing to the development of next-generation technology standards as any other participant.

Figure 3: Number of submitted contributions by 3GPP members over the period 2001-2020 (Note: The number of contributions prior to 2008 is severely underestimated, given that 3GPP does not provide the full list of submitted contributions)

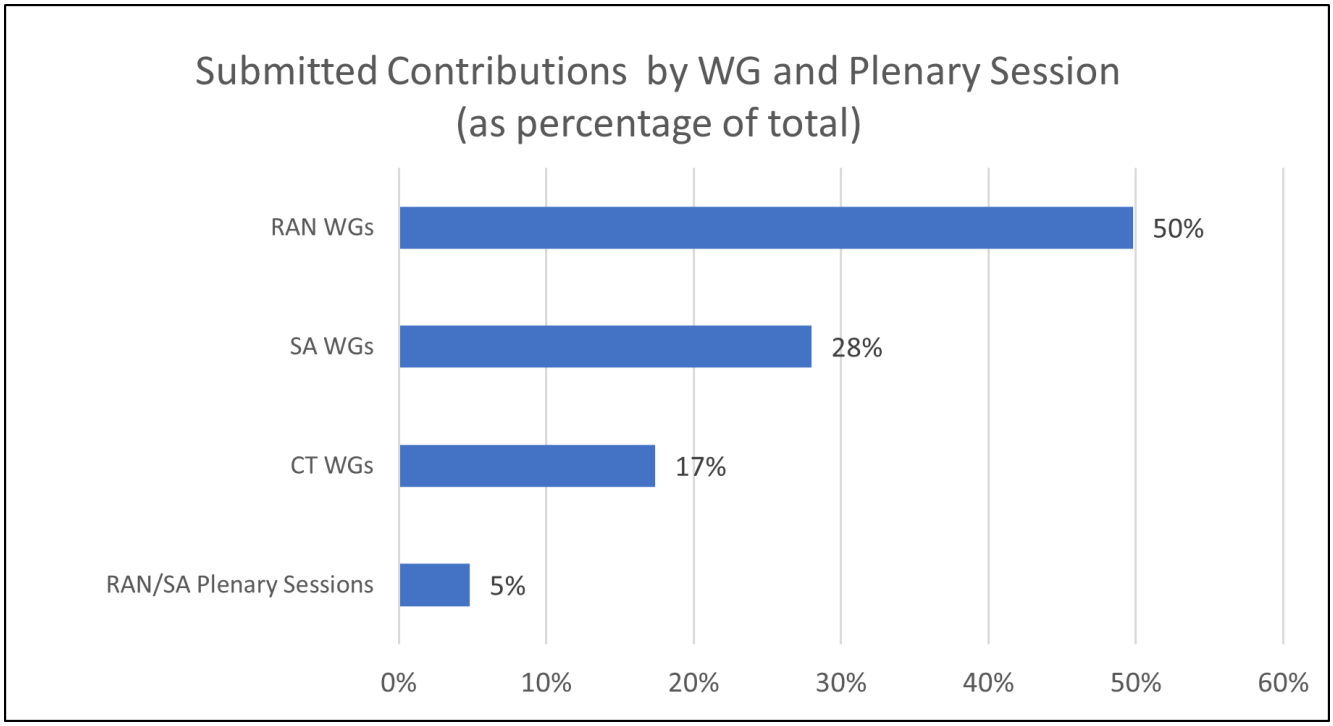


3GPP is organised into 16 various specialised working groups (WGs):

- six radio access network (RAN) WGs (RAN1-RAN6), which define the radio communication between user equipment and core networks;
- six service/systems aspects (SA) WGs (SA1-SA6), which is responsible for overall architecture and service capabilities; and
- four core terminal and network (CT) WGs (CT1, CT3, CT4, CT6), which are responsible for core network and define terminal interfaces and capabilities.

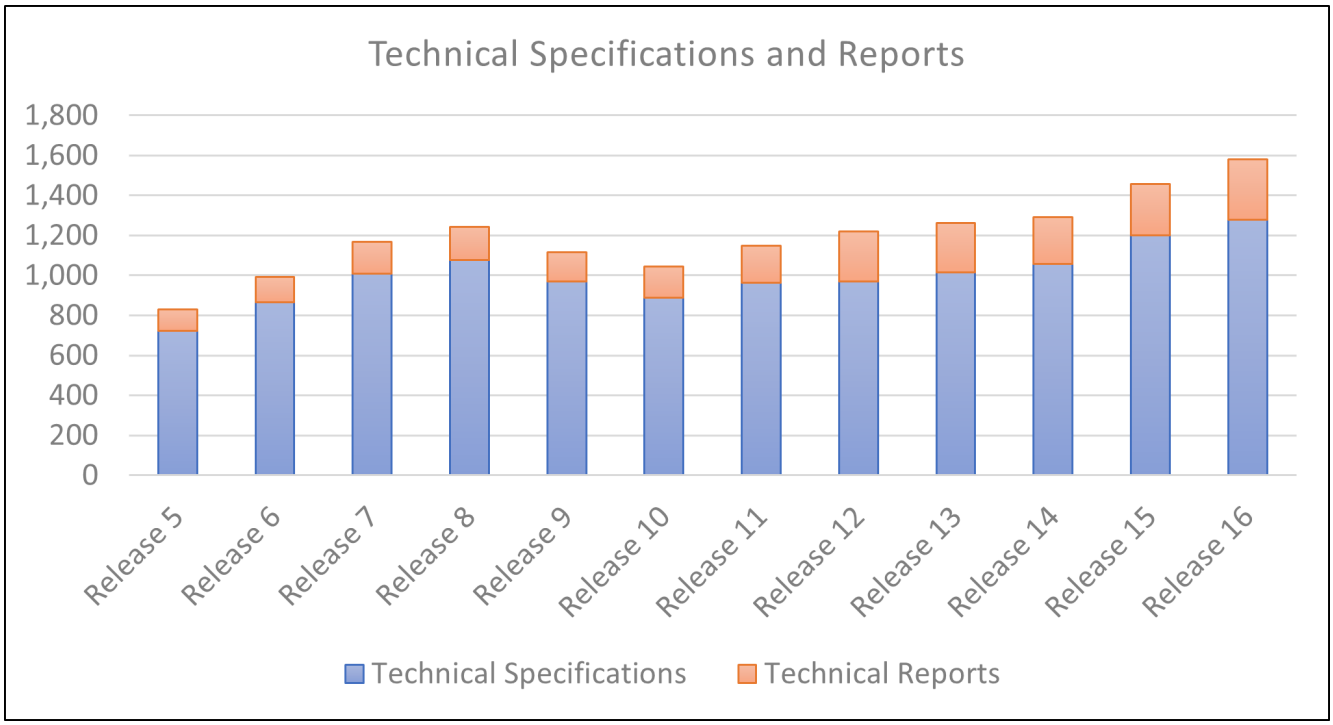
As Figure 4 shows, RAN WGs account for 50% of submitted contributions, followed by SA WGs and CT WGs, which are responsible for 28% and 17%, respectively. The remaining 5% of contributions have been submitted to RAN and SA plenary sessions.

Figure 4: Submitted contributions by WG and Plenary Session (as percentage of total)



Each generation of the standard itself is developed over years and iteratively, with new versions of each standard launched as specific releases. Technical specifications represent the ultimate output of the work completed in 3GPP. These technical specifications are published by 3GPP after each standards release and used by downstream manufacturers to provide guidance on the development of devices that practice the cellular standards. The next figure shows the timing and number of technical specifications/reports included in each cellular standard release, covering the evolution from 3G to 5G. Each new release of technical specifications and standards can be directly tied to new and improved features, which can be credited with important developments in the wireless industry.

Figure 5: Number of technical specifications and reports by release



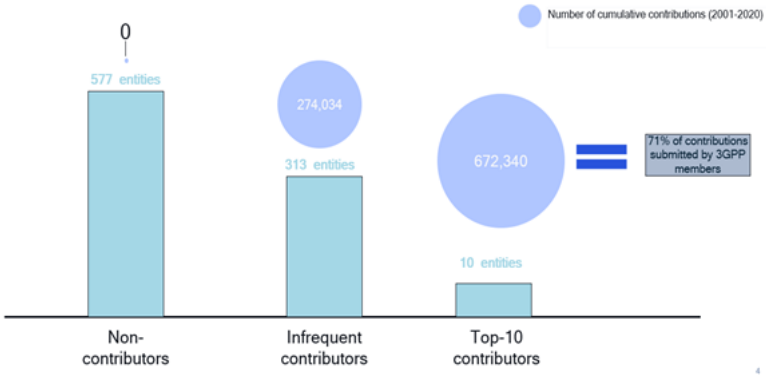
Understandably, the development of technically advanced standards, such as 5G, renders the standardisation process more complex. There is a higher number of participants, there are more technical contributions and there is a higher number of technical specifications and reports.

The innovator-implementer divide

The development of cellular standards builds upon a substantial effort and collaboration across hundreds of stakeholders with diverse interests and incentives. Every major advance in the mobile ecosystem has been enabled by the evolution and interplay of a diverse set of entities.

However, there is a discrepancy in who is making the risky investments and who is profiting from them. It is the companies that have specialised in technology creation, that are investing more than any other segment of the value chain. Although many participate in the standards development process, only a small share of participants contribute technologies. Specifically, around 900 entities have participated in the 3GPP. However, a startling 10 companies are collectively responsible for submitting 71% of all contributions made to the 3GPP over the last 20 years – more than 50% of members made no contributions at all (see Figure 6).

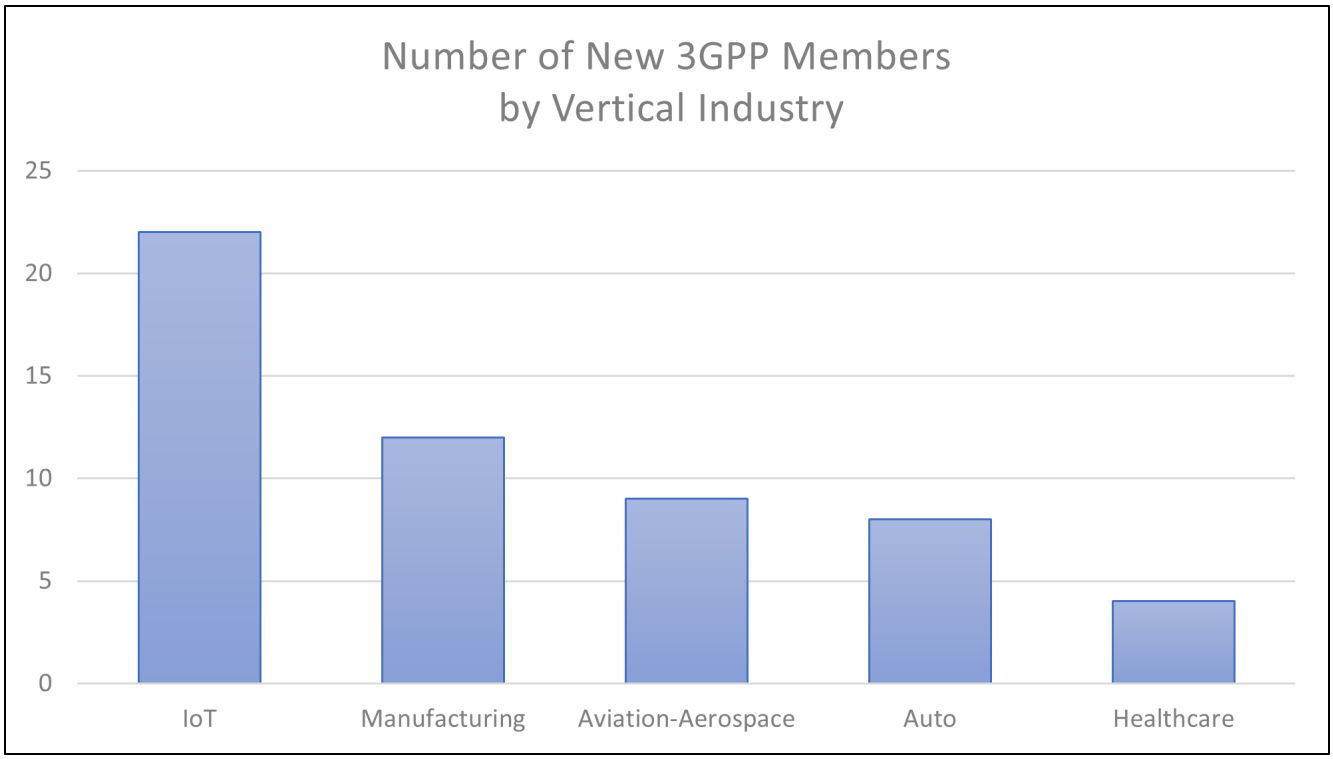
Figure 6: Cumulative number of submitted contributions by 3GPP members over the period 2001-2020



5G is the most ambitious generation to date. It not only aims to deliver new levels of performance and efficiency to enhance today's mobile broadband services, but also to expand mobile networks to become a unifying connectivity fabric for a wide range of use cases. It is the foundational technology that will affect every industry by creating new products and revenue streams (eg, virtual care and connected vehicles), delivering cost and productivity benefits (eg, fewer collisions and more efficient traffic management) and supporting sustainability and resiliency (eg, smart factories and energy grids).

The vast impact that 5G is expected to have across the entire economy is reflected in the number of entities and the wide range of industries that have participated in the development of cellular standards since 2016 when 3GPP began work on defining 5G global standards.

Figure 7: Number of new 3GPP members by vertical from 2016 onwards



For example, several major car makers have joined 3GPP as members: Volkswagen in 2016, Daimler and Ford in 2019. In fact, the automotive sector alone is **expected** to earn an additional 30% in revenue, or up to $1.5 trillion, by 2030 thanks to cellular standards. Further, two big players in the aerospace industry joined 3GPP in 2019: SpaceX and the European Space Agency. 5G technology will also enable new precision agriculture capabilities on farm equipment leveraging real-time connectivity; John Deere, a world leader in providing advanced products, technology and services for customers whose work is revolutionising agriculture and construction, joined 3GPP in 2019. Finally, Sectra AB, a Swedish company that develops and sells cutting-edge solutions in the expanding niche spaces of medical IT and cybersecurity, joined 3GPP in 2020.

In fact, all these companies are pure implementers of cellular standards, as they make very few contributions (if any) toward their development.

Looking ahead

5G offers tremendous potential and will undoubtedly transform industry landscapes and consumer life as well as the world economy – increasing productivity, creating new industries and disrupting others. It will spawn next-level innovation for industries like healthcare, auto, manufacturing, agriculture, to mention a few.

The development and incorporation of innovative cellular communications technologies in standards is a collaborative effort among hundreds of different entities with potentially diverse interests/incentives. It is a huge endeavour that expands significantly as it proceeds. The broad and increasing participation in the development of cellular standards reflects many factors, including widening interest across many different industries, as communications capabilities are increasingly included in a much wider range of devices than mobile phones.

However, the data clearly shows that most cellular technology contributions to 3GPP standards come from a relatively small number of major companies: more than 70% of the technical contributions have been submitted by just 10 companies. The interpretation of this empirical finding is that many individuals participate in the latter stages of the standardisation process on behalf of companies that are seeking to innovate with applications and services outside of the standards, while using 4G and 5G cellular communications as a platform, rather than participating as innovators in standard-essential cellular technologies themselves.

IP rights protection is essential to maintaining the ecosystem of wireless activity that is founded on the reliable connectivity enabled by cellular technologies. Companies that have developed the cellular standards have taken on substantial risk to enable an ecosystem that took years to come to fruition and must therefore be encouraged with a supportive regulatory

framework. In other words, the need to encourage investments in cellular-enabled devices must be balanced with the need to protect that inventors who have made these breakthrough technologies possible.

Efficient licensing is crucial for achieving broad and rapid diffusion of technology standards – in the context of standards, it ensures that the highest quality of technology is being contributed and accepted. Licensing also helps to create a level playing field for all types of contributing companies from large multinationals to start-ups. Government and regulatory bodies need to balance innovation stimulation with IP protection to ensure that the reinvestment cycle continues.

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