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Case Statement and Proposal

International 6G R&D and Innovation Consortium

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> *It is essential that the US and its allies launch and lead an international, public-private 6G R&D and Innovation Consortium (RDIC) that can yield both economic and security/privacy benefits across the world. The core of the proposal is that several countries and multinational companies join together to develop and roll out an advanced research infrastructure (virtualized 6G tools and testbeds). This research infrastructure, and envisioned RDIC-based fundamentals research, can stitch together a critical mass of the pre-standards 6G R&D efforts already underway in US and allies' labs in academia, industry and government. Success in this endeavor will simultaneously stabilize and lead innovative development in mobile wireless networks even as it supports rapid innovation in the exploding ecosystem of commercial products and services (as well as government and civic enterprises) that depend on a functionally global, robust, and secure mobile wireless network.*

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The mobile wireless communication network is an increasingly global infrastructure of backhaul and device hardware, software, and systems integration that links a majority of humans on the planet to each other. Even more importantly, mobile wireless networks link people, autonomous and semi-autonomous machines, and computational resources and functions such as data storage and artificial intelligence as well as linking to fixed (wireline) communications. Personal data, company data, and data relevant to national security (sovereignty) flows through the mobile wireless network in tremendous and rapidly increasing volumes. Vulnerable nodes or connections in the mobile network can expose millions of individuals, tens of thousands of companies, and every nation to malign actors of every stripe.

Further, the rapidly evolving global mobile wireless network is a platform for innovation in devices and services, many provided by machine learning. Citizens and companies in the US or Germany can and do benefit from innovation on this global platform by researchers and entrepreneurs in Seoul and London. Increasingly fast and robust wireless communication networks are the heart of a host of new types of social and economic integration. As such they are a cross-border cornerstone of advances in human welfare and economic prosperity, enabling new forms of commerce, telehealth, political engagement, online education, entertainment, and community services.

As such, every individual, company, and nation has a deep and legitimate interest – for both security and economic growth reasons – in a high-performance, secure, and trustable mobile wireless network.

6G R&D and the Global Stakes in Mobile Wireless Communication

Not surprisingly, mobile wireless communications networks have become a critical new arena for global economic and geopolitical competition. The development and deployment of fifth generation (5G) wireless communication is a case in point. Global competition in 5G – with major firms in Europe, the US and Asia and very expensive investment requirements in almost every nation in the world – has unmasked a host of national economic concerns linked tightly to national, corporate and personal security vulnerabilities. These have been detailed elsewhere and are at the heart of US and other nations' global actions specifically addressing the rise of Huawei.

In virtually all liberal democracies there are laws and norms governing individual data privacy, corporate ownership of data, and legal limits on government access to personal or corporate data. The development and deployment path for 6G (from basic standards and protocols to the characteristics of devices and services integrated with, or attached to, the wireless network) will determine a wide range of societal outcomes, from data privacy for individuals and corporations to the ability of a sovereign nation to protect itself from malign actors or mount surveillance of its citizens or groups within the nation.

While some companies and nations have technological leadership roles, rapidly advancing mobile wireless network technologies are complex and inherently multinational. Interoperability, the ability of network and terminal devices and device-enabled services (such as device-level data encryption and AI, streaming video, and communication with Wi-Fi systems) to work on the global network, depends on literally hundreds of technical standards worked out among companies and governments. As a result, neither security vulnerabilities nor the R&D requirements for mobile wireless networks can be solved by a single nation, company, or group of university researchers.

The fragmentation of R&D in the wireless industry, particularly in network enabled machines and services, is a serious threat to rapid and effective technical evolution of the global mobile wireless network. In particular, the distributed and siloed nature of R&D makes it very difficult to coalesce allied nations and the mobile wireless industry around 6G standards that can ensure US and allies' national security and citizen's privacy.

The complexities multiply as settled research challenges are deployed in functioning wireless networks. Complex international standard-setting processes, global supply chains, and the importance of cross-border interoperability mean that, while a country or company can lead in aspects of the technology implementation, none can move forward in isolation.

Each successive generation of mobile wireless network (3G, 4G, 5G) is marked by a set of standards and, of course, by significant differences between "as envisioned" and "as built." The material differences between as-envisioned for 5G and for 6G are mostly technical performance improvements (moving more data with lower latency). Not surprisingly, "as built" 5G falls far short of "as envisioned" and it is important to note the current dispersed, global R&D effort in 5G[2] even as researchers and industry leaders, seeing the capacity limitations of 5G, lean toward fundamental improvements and a sixth generation of wireless performance and accompanying set of set standards. A key global challenge for 6G R&D, therefore, is to take an approach which – through early collaboration, rapid experimentation, and pre-standards resolution of interoperability challenges – can help close the gap between "as built" 5G and fully

[2] See, for example, the EU's substantial R&D investment in 5G technology and applications: https://ec.europa.eu/digital-single-market/en/policies/5G

implementing a much higher performance next generation of secure mobile wireless capability.

If the United States and its allies continue on their current trajectory of siloed wireless network R&D, they will likely lose the global wireless communications race to China, putting international security, privacy and shared economic and technological development at risk. They will run the very real risk of becoming clients of a strategic competitor with a monopolistic power advantage.

Therefore, to ensure both continued economic growth and international security the US needs to collaborate with allies on R&D for a trusted and secure sixth generation (6G) wireless communications network, and governments must do this in close collaboration with wireless commercial partners from a number of countries.

The Critical Path in 6G Leads through an International Consortium to Build and Operate a Shareable Research Infrastructure

Technical experts in different segments of the mobile wireless value chain, from US and non-US companies from Europe, Japan, and South Korea, all report something similar: there does not yet exist a shared yet secure environment where companies, as well as academic and government researchers, can come together to establish early technical baselines and pursue pre-standards convergence. The R&D challenges in wireless networks are far too complex for any one company and a fragmented R&D enterprise creates a wide range of problems, especially in interfaces/interoperability.

The very nature of the global, rapidly growing and evolving mobile wireless infrastructure makes this an unprecedented situation that requires an almost unprecedented solution: an international pre-competitive R&D consortium with demonstrable benefits to founding countries and companies as well as a vision for bringing other liberal democracies and companies “under the umbrella” as the consortium matures.

This proposal for a 6G RDIC is based on a five-year effort to create a shared, advanced research infrastructure (virtualized 6G tools and testbeds), elements of which can be rolled out for use by members even as the full set of tools and testbeds is being built out. The value of such an infrastructure is that it will support fundamental research as well as pre-standards, pre-competitive research activities aimed at 6G development for effective deployment. The goal is to drive design and pre-standards work of a 6G wireless network that fully supports the data security, privacy laws, and economic aspirations of liberal democracies.

Containerized Collaboration on Shared Virtual Testbeds

For a 6G RDIC to lead the world in developing a secure and innovation-promoting technology base, there is a pressing need to bring together a significant majority of the companies that develop and provide network hardware with an equally significant majority of providers of handsets, machines, software and services. These groups need to work out interface/interoperability rules and rub elbows during the development process as an alternative to developing technologies independently and then fighting it out later during the necessary standardization process.

Therefore, to support pre-competitive, pre-standards collaboration necessary to advance mobile wireless technology there is an immediate need for a core infrastructure investment in a number of virtual tools and testbeds[3] that allow consortium members from academia, industry and government labs to collaborate and build on each other's work.

Secure, virtualized research testbeds for 6G can provide access to researchers from member groups from around the world without the need for sustained geographical proximity. This will allow more researchers to engage and collectively break down the pre-standards R&D silos in industry and in academia. This approach can substantially increase the number of participants working on the same platform (in the same ecosystem) and, thereby, increase the pace of innovation.

The virtualized 6G R&D model empowers research teams to test, explore and get feedback on new protocols, algorithms, software, chips, and virtualized hardware early on, before the standards-making negotiations begin in earnest. This will open up opportunities for exploration of new use cases for 6G and for the secure and private transfer of data.

From a technical perspective, one of the distinguishing characteristics of 6G is that many aspects of the networks, including the workhorses called 6G Radio Access Networks (RAN) will be virtualized, meaning that software takes the place of hardware during the research phase. The role of hardware in this scenario is to evolve to reach

[3] This research infrastructure (virtualized test beds and tools) is also known as digital twinning. One use of digital twins in research, development, and design means that software models are developed to emulate physical systems – from nuclear reactors to urban transportation – and thereby create a virtual environment where researchers can test (without causing a meltdown or clogging a city's traffic) a wide range of innovations. Digital twins (simulations or direct emulations) are already a proven R&D approach in many segments of mobile wireless industry but not at the cross-functional scale envisioned for the RDIC-built infrastructure.

sufficient fidelity to its representation in the software model, whereupon the research phase is considered completed. This allows for virtualizing the pre-competitive research process in 6G, and allows it to be conducted on 4G and 5G hardware, despite their shortcomings. This strategy of creating virtualized tools for pre-competitive 6G R&D can be extended to network routing, computation, data transmission, and new ways to test automation tools across all these domains.

Virtualizing various 6G hardware layers and creating digital twins will also provide valuable opportunities to iterate on the higher-level notion of "open interfaces" rather than simpler "open source" solutions that may be rife with security vulnerabilities. An open interfaces approach is a way to close down open source vulnerabilities in 6G even while maintaining both competition and collaboration critical to technological advances in the industry.

The open interfaces approach is a key advantage of virtualized testbed environments. This approach can offer "containerized" environments in which research groups from industry, academia and government can share their efforts and build on each other's advances while also retaining control and privacy of sensitive information. This is a practical solution for 6G network collaborative R&D that can maintain IP protections for consortium members and simultaneously opens the door to unprecedented pre-standards research collaborations across companies and countries.

A 6G RDIC built around virtual tools and testbeds can serve as an international and national resource for developing and testing a host of wireless network performance characteristics including the security and privacy qualities of competing 6G technologies. Testing and verifying security and privacy aspects of the network design are especially important because 6G software is going to be particularly prone to attempted hacking because of the distributed nature of the 6G network and the anticipated volume of data that will be transmitted.

In addition, given that artificial intelligence and machine learning will be incorporated into all aspects of 6G systems, creating pre-competitive sandboxes for exploring the security and privacy issues of emerging 6G technologies is especially important. A 6G R&D consortium also offers the member countries an opportunity to reclaim a position of global leadership when it comes to privacy and security of data in general. Through 6G, member countries and competitive companies will have the opportunity to become the global market leaders in industries that require deep and pervasive use of AI and machine learning.

Desirable Founding Governments and the Leadership Role of Industry

Capability in mobile wireless network technology and digital twinning is not equally distributed around the globe. There are a handful of countries that are leading candidates as founders of an international R&D consortium, built on a digital twin research infrastructure investment, which is focused on the next generation of mobile wireless. The United States, Japan, Germany, France and The United Kingdom stand out among liberal democracies as potential founding countries because of the size and research intensity of their economies.

Theoretically, any government from among these could lead in making the case, in providing start-up funding, and in recruiting other governments. As a practical matter, the US may need to lead because of its broad, if incomplete, strengths in wireless R&D, the position of US companies in wireless communications networks, and the depth of its national security relationships with allies.

For the United States government and US companies to catalyze the creation of truly internationally collaborative 6G RDIC, the government and companies must convince academic, industrial and government counterparts from a number of liberal democracies that it is in their national and commercial interest to participate (and that it is not a threat to their national sovereignty, the commercial viability of their domestic companies, or institutional independence).

In addition to the value of knowing the mobile wireless network can be trusted, there is a strong, positive economic value proposition for each of the countries listed above to be involved as founders of (and investors in) a 6G RDIC built on a digital twin research infrastructure. In particular:

1. Mobile wireless networks are key to the performance and cost of both wired and wireless telecommunications in virtually every country. Telecom service providers (public or private, national or multinational) that operate in large market economies will want to help shape R&D for the next generation of mobile wireless as it will determine their technical performance and their system investment requirements over the coming decade.
2. The digital twin research infrastructure using an open interfaces approach is inherently competitive with regard to innovation in wireless network hardware, software, and services. An international R&D consortium will likely increase competition (or at least competitive pressures) in every segment of the mobile wireless industry.
3. Advances in mobile wireless networks are driving an explosion of new products and services, creating opportunities (with very low barriers to entry) for large and

small companies. Member countries with a sufficient R&D capability (researchers and entrepreneurs who see the potential in mobile wireless) will be able to take advantage of the testbeds for early R&D on a wide range of products and services.

Countries have collaborated before to create research infrastructure. So, while this is a departure from traditional types of research infrastructure, there is an existing logic for a multinational approach to creating and running a 6G virtual testbed as a members-only R&D infrastructure.

Industry Leadership and Participation

In early discussions with US and non-US multinational companies, it has become apparent that a wide range of companies would benefit from access to testbeds and collaborations to work out the complicated technical and systems issues for 6G in an secure ecosystem in which they may interact and still trust they are not going to lose control of important intellectual property.

In the wireless industry, customer demand on wireless service providers creates “pull” on the next generation of wireless technology and capacity even as handset manufacturers, base station and backhaul providers, and cloud service providers compete to provide next generation hardware and services, many of which drive demand for higher data volumes and lower latency in networks.

While many companies in the wireless network ecosystem will thrive as technology “followers,” a critical mass of companies throughout the ecosystem expect to be R&D leaders as part of their business strategy. Both groups play an essential role in defining the research focus for 6G. Therefore, for an international RDIC in mobile wireless networks to succeed, industry participation needs to include a critical mass of larger and R&D capable companies from the key sectors including chip manufacturers, handset manufacturers, software providers, service providers, base station manufacturers, and application developers.

Recruitment of these companies, including convincing them to invest as founding members of an RDIC, is a significant challenge that needs to move in parallel with the founding activities of governments.

Notes on What a Mobile Wireless RDIC Cannot Do for Governments

It is important to acknowledge the diverse politics, data policies, citizen rights and antitrust concerns in liberal democracies. While the 6G RDIC needs to be supported by multiple governments, the technical consortium should not become a forum for negotiating policy differences (in security, antitrust, or privacy rights) among countries. The goal is to advance pre-standards collaboration aimed at security and interoperability that are amenable to different legal and regulatory approaches in different countries. In general terms this means pushing technical frontiers and developing protocols for a secure system, as impervious as possible to hacking. Permissions, rights of privacy, control of corporate or national data, and standards for competition (antitrust) remain the province of national laws and international agreements.

Further, the work of 6G RDIC will be pre-standards and pre-competitive. As mentioned earlier, there are literally hundreds of technical standards governing the function of almost every aspect of mobile wireless systems. Historically, industrial standards have been established by industry groups negotiating agreement (voluntary basis) rather than by government regulation.[4] This process, while important for technical innovation, has become a battleground for a type of techno-nationalism where some governments play an increasingly active role in coordinating domestic companies and promoting particular standards for international adoption. The economic and security challenges this creates must be dealt with by governments in government-to-government negotiation, before or during standard setting processes. The 6G RDIC will founder if it is pulled, by companies or governments, into standards process and government-to-government disputes about appropriate roles for government.

Consortium Principles and the Path Forward

International commercially oriented pre-competitive R&D consortia are rare but there is broad and deep experience in many countries with public-private pre-competitive R&D consortia, including those involving companies headquartered in several countries. There are also many successful examples of international co-investment in shared research infrastructure. Drawing on those examples, it is possible to outline a proposed

[4] The voluntary approach to standards was a major contribution of US President Herbert Hoover, made when he was US Secretary of Commerce. Hoover, seeing standards as oiling all the processes of commerce, insisted that the process be voluntary and declared success in 1924 when he announced, "Now the half-inch nut screws onto all the half-inch bolts." Following World War II the US voluntary approach to standards setting became the international standard for industrial standards setting.

6G RDIC, independently governed, seeded by government investment, supported in part by private funds, and fully engaging researchers and students from universities.

In general terms, there are six principles for such consortia:

1. Industry (or the client for new knowledge) has a lead role in defining the problem/research focus and makes a material investment in the research program.
2. Governments invest in relatively long-lived R&D infrastructure to enable pre-competitive research by collaborating companies and related fundamental research.
3. Governments support related fundamental research, often for open publication and relying on university researchers, that contributes to knowledge and society.
4. Universities bear responsibility for solution-enabling fundamental research and for development of human capital needed to capture societal value from science and engineering advances.
5. Independence, governance and management of consortia/institutes are critical to performance and should reflect the approach of successful public-private R&D collaborations.
6. Securing participation of companies, universities and governments requires clear policies and practices with regard to intellectual property (IP) ownership, licensing, and publication.

Assuming the United States has the will to assume a first-mover role, the process begins by immediately establishing a cabinet-level agency-led or interagency group within the US Federal government (if interagency, it can be convened by the White House Office of Science and Technology Policy) that can help launch, and adhere to, an international start-up body.

The international start-up group – which will need to include research leaders from companies, universities, and national labs – should have responsibility for developing a broad consortium plan and quickly initiating discussions with both companies and corresponding agencies or groups in the government of countries that have a shared interest in a 6G system that is an alternative to Huawei and Chinese government efforts.

To effectively pursue this goal, the group should – working with identified founding members of the consortium as necessary – assume responsibility for those charter actions and filings to avoid falling afoul of antitrust laws in prospective participant countries. In general terms this involves demonstrating how shared virtual testbeds using open interfaces do not limit competition, but rather allow a more complete and varied set of competing technologies to be considered in international standards processes, and ultimately in market competition. In specific terms, consortium structures and processes need to demonstrably allow or promote pre- and post-standards competition. In the US, the consortium should register under the National Cooperative Research and Production Act (NCRPA).

It is worth noting that item 5 and, especially item 6 above – governance/control and IP arrangements – are difficult to resolve and time consuming in any multiparty R&D and innovation enterprise. In large part, management and governance, along with intellectual property arrangements, determine the benefits that members/participants can derive from participation. Many multiparty R&D consortia concepts founder on IP and control issues and these issues are likely to be doubly challenging when the consortium involves national governments as well as companies. Therefore, an important role for the start-up group is to quickly plumb the experience of successful R&D consortia and reach agreement on the broad outlines of control and IP issues.

Appendix 2 is provided as an example IP rights structure for a 6G RDIC that is consistent with the proposed virtual test bed and tools described above. This is provided only as an example, of course, as the IP structure must be negotiated and settled by the founding members of the RDIC.

As soon as practical, the reins should be turned over to RDIC Governing Board with representation (negotiated by the start-up group of governments) from governments, research institutions, and companies. As the Board takes responsibility for the RDIC it will need to quickly settle both policy and operational questions critical to the launch.

The 6G RDIC, while organizationally separate from existing institutions, should be geographically located within an existing hotbed for both wireless industry and academic wireless R&D. That said, the Consortium must be organized to immediately transcend that location through secure, international access to a robust suite of virtual tools. Geography must not be a barrier to deep member collaboration. In short, the Consortium needs to scale its virtual tools and testbeds to capture the potential of the wireless researchers across the entire set of nations that are working together from academia, industry and government labs.

As negotiations begin over the size, scope and eventual full-scale operation of the RDIC, it will be important to develop target 5-year budgets for different functions of the consortia:

1. Virtual testbeds and tools (infrastructure investment).

2. Annual minimum research funding requirements for short term/road-mapped technical questions (with, perhaps, different timescales for execution matched to different budget levels).
3. Annual minimum research funding for fundamentals research (with, perhaps, different timescales for execution matched to different budget levels).
4. Budget (and providers) for 6G human capital development (education and training of the full range of talent necessary, from technicians and technical staff to research capable graduates of MS and PhD programs).
5. Overhead expenses.

These uses of funds need to be matched to sources of funds (governments and companies) during the process of careful definition of member benefits, control and IP issues, and setting member's contribution plan/requirements for both countries and companies.

The Global Value of Collaboration with Competition in Wireless Networks

Mobile wireless communications networks have become a critical arena for global economic and geopolitical competition. At the same time, mobile wireless communication is quickly becoming critical infrastructure in nearly all aspects of society. Therefore, the stakes could not be higher for getting 6G right even as rapid evolution in wireless technology makes it clear that speed is essential.

An International 6G RDIC would be a grand public-private partnership, unique in that companies, as well as academic and government researchers, will be able to build a common foundation while also maintaining control of their intellectual property through "containerized" virtual 6G ecosystems. The outcome of these pre-standards research collaborations will be interoperable 6G commercial offerings that are built for security and privacy consistent with the policies, practices, and values of the world's liberal democracies.

A 6G RDIC would lay the groundwork for a global wireless communications system that encourages continuous improvement, transparency as well as competition for "disruption from within". The open interfaces and "plug and play" structure of the virtualized hardware and software tools means that experimental hardware, software or algorithms from one participating company can be integrated into the network alongside that of another participating company or lab. This will encourage ongoing innovation during the pre-competitive research stage that can translate to an environment of continual innovation and improvement in real 6G networks once they are rolled out.

Appendix 1

Advanced Mobile Wireless Innovation Workforce Development

In addition to mounting an effective competitive challenge to potential 6G hegemony by Chinese firms working in collaboration with the Chinese government, an international 6G R&D and Innovation Consortium would have a further direct and concrete benefit for the US and its allies and commercial partners: a 6G innovation workforce. Research centers frequently include large numbers of students and postdocs as part of their organizational human capital, and the 6G RDIC would be no exception.

Establishing a functional 6G RDIC means that the very next generation of graduated students and postdocs will enter the workforce with both specific technical training and more expansive practical perspectives — thanks to their experiences working in the 6G Innovation Consortium. These early career researchers will quickly become a powerful innovation workforce empowered to integrate the innovations they have been trained to make into the fabric of the industries that hire them. This is about leveraging as many breakthroughs and insights as possible. It is about graduating students who have deep technical skills and the awareness of what will be needed to successfully make the jump to industry in order to weave innovations into the industrial fabric.

In the 6G virtual environment, for example, software writers and application creators will be largely freed from the constraints imposed by specifying where and how computations occur and data flows. It is critical to engage creative technical people in the United States and allies and commercial partners right now, at the early stages of the 6G development project. In network industries, companies at the ends of the value chain, entrepreneurs, and students are too often left out of early-stage innovation conversations.

Appendix 2

Example Outline
Property Rights Agreement for Infrastructure-Based 6G RDIC

Protection and control of intellectual property (IP) rights for multi-party collaboratives and consortia can be challenging. Fortunately, IP sharing models have been developed that can serve as a starting point for this proposed multi-country, university, company collaboration (footnote to reference the AMRC would be good here).

The key to structuring a successful IP agreement across a multi-party collaborative is to separate items including the following:

1. IP ownership vs. IP access.
2. Shared (pre-competitive) IP vs. specific project (closely held) IP.
3. Background IP for R&D use vs. commercialization
4. IP for open publication vs. restricted IP intended for commercialization.
5. Project infrastructure IP vs. IP not directly connected to the project infrastructure.

When tackling any large problem there is a significant volume of pre-competitive IP developed that represents progress towards the program's goals but the technology readiness level (TRL) is too low for direct application to an industry participant's product or service.

This body of pre-competitive IP is best owned by a neutral non-profit driven participant such as a university. Other collaborative members gain access to this IP through their participation and buy-in in the project which could include cash or in-kind contributions. This approach also paints a positive story for participating governments since commonly accessed IP is collected and owned by higher education institutions in their countries. It further provides tangible returns on government financial support.

As this body of pre-competitive IP grows and matures, participating companies are able to identify components of the IP that can be applied to their specific product or service needs. When this occurs, the company independently or in combination with other parties can structure a specific project to progress the TRL level of the IP and drive innovation in their business. These specific projects include financial and in-kind contributions by the sponsoring company beyond their recurring membership fees required by the collaborative.

With this commitment to fund development work beyond the base membership fee, the company enjoys the opportunity to define IP ownership rights for the specific project results that are held exclusively with the sponsoring company. This transition from university owned and jointly accessed IP to company owned IP is the primary vehicle for extracting IP from the collaborative for commercial exploitation. Again, the countries involved are able to book a "win" as their companies take advantage of the innovation taking place in the collaborative and leverage that innovation to improve their products and services.

This model has proven successful for collaboratives that involve a single university and government and multiple industry participants. Extending the model to involve multiple governments and universities will require creative multi-national thinking and will be a key enabler for a successful multi-country, university, company collaborative.

Table 1: Example IP Access Model.

Intellectual Property Type	Category	IP Ownership	IP Access	Examples
Pre-competitive (shared) Infrastructure IP	*Category 1. Consortium owned and shared*	University or non-commercial entity	All members may use the IP, and may not use or generate their own IP to restrict other members.	The consortium owns the IP to plug-and-play open-interface test hardware and software; any improvements to the hardware and software are shared among members.
Member Owned Infrastructure IP	*Category 2. Member owned and shared*	Individual member companies	All members may use the IP, and may not use or generate their own IP to restrict other members.	A member owns the IP to plug-and-play open-interface test hardware and software; any improvements to the hardware and software are owned by the member company, with all interface-level improvements shared with other members.

Project (New) IP Publication	*Category 2. Member owned and shared*	Individual member companies	Members will provide other members with early access to non-patent literature; other members may use the IP for purposes of developing their own IP but not to commercially practice the IP as published.	Members will share working papers and pre-prints with other members in advance of publication. Other members may create their own products and improvements accordingly, but do not receive a commercial license to the IP described in the literature.
Background IP	*Category 3. Member owned and shared with limitations*	Individual member companies	Members will provide other members with access for R&D purposes; other members may use the IP for purposes of developing their own IP for but must compensate the background IP owner if a commercial product or service is taken to market	In a 6G consortium, members will share IP related to 5G and earlier technologies – other members can use the IP for purposes of developing their own 6G technologies but must compensate the owner of the background IP if a commercial product or service is taken to market
Specific Project (closely held) IP Commercialization	*Category 4. Member owned and restricted*	Individual member companies	Members are not required to share new commercial IP, and other members may not access or use the IP except through partnerships with the IP owner.	Members do not need to share new commercial know-how, or patent filings in advance of patent office open publication. Members have no expectation of access to new commercial IP from other members.