## HORIZON 2020
## ICT - Information and Communication Technologies

## EMPOWER White Paper
### *Sustainability of EU/US collaboration*

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## Introduction

EMPOWER's mission is to develop and strengthen synergies between the European and US communities involved in the topic of Platforms for Advanced Wireless research. It relates to several key activities:

- Explore continuously the evolution of the demand and the scientific challenges to solve. This is monitored by the participation and contribution to the relevant research communities, scientific events, publications, etc.;

- Engage part of this community into the design and deployment of appropriate test platforms;

- Raise awareness from the stakeholders in order to gain their support and collect part of the necessary funding;

- Monitor appropriate test platforms on both side of the Atlantic;

- Align as much as possible the platforms in order to provide more opportunities for joint cooperation and a larger scale instrument;

- Work on the testing methodology, including open data management and reproducibility.

As a consequence, one important step forward is related to the sustainability of this effort as a multiannual engagement. This is because the design and deployment of such platforms cannot be achieved at the time scale of a project (namely 3-5 years) but rather the one of a larger initiative.

What matters is to develop incentives to align the platforms developed in Europe and in the US, regarding the vision and mission, the baseline design, the APIs, the access and the user management. This will pave the way to a more ambitious instrument that will scale-up in size and diversity. NSF and the PAWR office have been the main stakeholders to develop this dialogue on the US side, involving other actors (Fabric, Chameleon, Bridges, O-RAN, etc.). The EU ICT (17-19) have been important developments in Europe and were associated to this dialogue from the very beginning (see the first Empower workshop at Infocom 2019). The newly supported ESFRI SLICES initiative, as the first scientific instrument in Digital Sciences in Europe, provides a great opportunity to position itself as a catalyst on the EU side.

Even if their overall strategy might differ, our recommendation is to pursue and amplify the EU-US collaboration. In particular, it is observed that the academic community on both sides share similar concern, interest and motivation for joint activities. The current evolution of the domain, in particular, with the emergence of network disaggregation, cloud and AI native as well as virtualization offers many opportunities for joint activities, from design to testing. In particular, we suggest that joint activities are encouraged in the domain of open platforms for beyond-5G and 6G. Open Radio Access Network (Open RAN) constitutes a promising solution to fully transform nowadays digital infrastructures, impacting also the human capacity and skills for designing, deploying and operating such systems. This effort will help understanding, contributing and deploying these types of solutions.

## 1. EU/USA collaboration at the sight of Horizon Europe

As stated in the introduction of this White Paper, EMPOWER focuses on fostering collaboration with USA in the area of Advanced Wireless Platforms for the research of Beyond 5G and 6G. With the upcoming of the COVID pandemic, the collaboration between both geographical regions has become more difficult, not because of a lack of interest but rather as the actors were captured by the management of the emergency of the situation. The pandemic has brought to spotlight the need for Europe and USA to collaborate closely in the challenges of validating experimentally the new ideas that are appearing for B5G and 6G.

This topic was deeply debated during the discussions held between EMPOWER representatives and key researchers from Europe and USA represented on the EMPOWER's Advisory Board. The main conclusion of this dialogue is that such collaboration is needed to position both geographical regions on top of the contributors to the new wave of wireless technologies. One key aspect that was highlighted is the work performed during the recent years on establishing a wide set of infrastructures, geographically distributed (NSF GENI and EU FIRE, the Fed4Fire project, the OneLab facility or the 5tonic laboratory, and the PAWR nodes, CloudLab and Chameleon, Colosseum, Fabric and Bridges) that are not only complementary but also, for some, share some common building blocks or fundamental technologies.

The discussion around the topic on how to foster future collaboration was centered on the current status of twining and how to move forward after the lifetime of the EMPOWER project. The main problems analyzed during the discussion were:

- Sovereignty issues: Due to the pandemic there has been a major push towards gaining sovereignty over technological processes while increasing the autonomy of each region. This trend has been observed across both geographical regions. However, we are convinced that it is a mutual interest for US and EU to continue their joint efforts to cooperate on this topic;

- Transition between Horizon 2020 and Horizon Europe research programs: Currently Europe is undergoing a major switch on its funding programs for research. International cooperation is not seen as a priority at the moment as reflected in current Horizon Europe Work Programme but this situation seems to evolve positively;

- International cooperation funding in stall: Due to the above two factors, international cooperation funding is in stall at the moment. Our experience shows that aligning funding on both sides is highly challenging and that other forms of support should be considered as exemplified by previous calls.

Although these three environmental aspects are setting the pace of the current developments on international cooperation, EMPOWER sees this moment as a unique opportunity for both geographical regions to prepare and push forward the next level of EU/USA cooperation in the upcoming years. Out optimistic view comes from the following aspects, which were discussed and agreed with the EMPOWER AB:

- Horizon Europe and SNS JU phase 1 Work Programme have been recently published. International calls at the moment are only taking place within special CSA vehicles. It is expected international cooperation to be more relevant as the SNS JU Work Programme evolves towards phase 2 and 3. Unfortunately, this might be too late as important domains will have evolved until then;

- SLICES (a large-scale infrastructure, as will be presented in section 2) has been accepted as part of ESFRI. ESFRI as such does not publish solicitation to support international collaboration although this is part of the objectives of the instrument. SLICES can play a central role to foster international cooperation in the EMPOWER areas of interest. The pivotal role of SLICES for this activity allows us to be optimistic about the sustainability goals of the collaboration initiated with EMPOWER.

Finally, within the context of EMPOWER we have identified a set of key technological areas that will require a close collaboration between EU and USA. These areas are:

- Open Standards/Source projects: through the development of 5G we have witnessed a growing push towards intellectual property protection. The need for companies to protect their own results and

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development and their interest on pushing IPR into standards in the form of Standard Essential Patents, make the collaboration between companies and even between territories very complex. In addition, the evolution of 5G networks introduces architectural changes in the Radio Access Network (RAN) and the Core Network (CN) that will have adverse impact on how the digital infrastructures are designed as to support variety of use cases. An important concept that will enable next generation transport networks is disaggregation whereby networking software is separated from the switching and/or routing hardware and broken down into functional components that can be more efficiently operated. We believe the surge of Open Standards, usually linked or using Open-Source projects is a very good opportunity to build towards more collaboration across the Atlantic. Specifically, we believe collaboration between the United States and the European Union can yield to a dominant position by industry from both sides on these Open bodies, although we understand it comes at risk because of the disruptive nature of the evolution of the system. This aspect will be discussed in section 3;

- AI/ML and data analytics: next generation networks will be managed by autonomic functions realized by cognitive capabilities based on AI/ML. This statement can be demonstrated by actions initiated in ETSI and 3GPP aiming at elaborating architectures that allow the introduction of cognitive modules based on AI/ML. The development and research of the autonomic networks will require the definition of i) these cognitive modules and their open APIs to ensure portability, usability, and scale across a variety of networks ii) standardized testing and validation methods and frameworks to validate these cognitive modules and their interfaces. We believe that these two aspects can be subject of close US-EU collaboration, resulting to an acceleration of the development of AI-based Cognitive Modules and their APIs, which can again be easily tested in a plurality of platforms both in US and EU. This topic is of utmost importance and EMPOWER is preparing a monographic white paper on it, which will be available soon on the EMPOWER web page.

## 2. Next generation European research infrastructure – SLICES

The historic separation between the network and the compute has vanished. As defined by Sun microsystems long ago, "the Network is the Computer" (John Gage 1984); resources are everywhere supported by virtualization, distribution and cloud SaaS. This trend is going to impact the telecommunication and computer-based sectors, from design to products to operation. This will disqualify the multi-year planification approach based on new generations (2G/3G/4G/5G, etc.) and threat the corresponding industry. The science of Digital Infrastructures raises multiple complex challenges to the research community that already started to explore them with an agenda defined as 6G! Experimentation is becoming an even more important methodology to assess and qualify the diverse design assumptions and choices in realistic conditions. It addresses the future Internet roadmap with an ambitious agenda regarding the fundamentals and technologies for operating reliable, safe, scalable and efficient infrastructures as well as support the vertical applications that will land on these digital infrastructures. This is the motivation for developing a holistic approach where all resources (compute, storage, network) are associated to continuously design, operate and automate the full life cycle management of applications and services.

The need for a Research Infrastructure (RI) in this domain is justified by the emergence of a future Internet including beyond 5G infrastructures that require adapted and well-tailored tools for testing and developing trust and confidence regarding the design and deployment phase. Experimental platforms should be able to address the end-to-end scenario, integrating all technologies and components. SLICES ambitions to provide a European-wide test-platform, providing advanced compute, storage and network components, interconnected by dedicated high-speed links. This will be the preferred collaborative instrument for researchers at the European level, to explore and push further, the envelope of this future Internet.

SLICES will allow researcher and industry to question scientific challenges regarding the future technologies and services. They will be based on a technology roadmap that will be consolidated on the basis of the analysis of

several inputs provided by the community that are pertinent to the evolution of new radio (NR) and core network (CN) over the next decade 2020-2030.

It is important to note that the competition at the international level is already in place with ambitious projects similar to the mission defined in SLICES, in the US (NSF PAWR 2017-2022 100M$, NSF FABRIC 2019-2024 20M€, BRIDGES 2020-2023, 3M€) and China (CENI 018-2022 190M€), and efforts also developing in Japan.

A non-exhaustive list of research directions enabled by using SLICES is provided below:

- Advanced wireless networking:
  - New waveforms;
  - Higher frequencies up to THz;
  - Spectrum and wireless management;
  - Integrated sensing and communication;
  - Multiple heterogeneous radio management;
- Smart/intelligent infrastructure operation and management:
  - Advanced protocols and architecture (virtualization, softwerization, programmability)
  - AI applied to infrastructure operation and optimization at all layers;
  - Generation of data to train algorithms;
  - Distribution of intelligence into the Edge of the network;
- Design and validation of new Edge/Fog infrastructures:
  - Software and components deployment;
  - Distributed resource management;
  - Geo-distributed data management;
  - Federated deep-learning;
- Advanced functionalities:
  - Power consumption and energy efficiency;
  - Security and privacy;
  - New security issues and challenges that arise from the verticals and the ubiquitous network;
  - Interoperability, composable infrastructure services on-demand (RI as a Service). Seamless user experiences across technologies and domains.


Considerations on possible impacts of such a RI are:

- Scientific and technological impact:
  - Equip researchers and practitioners with a wide range of scientific and experimental resources and tools by deploying and operating a large-scale platform providing access to cutting-edge technologies in wireless networking, IoT, and Cloud;
  - Offer a wide variety of advanced computing and networking resources in order to respond to the needs of future dynamic systems;
  - Provide advanced test tools to ensure reproducibility through an automated data repository and support an open data approach for these communities;
  - Build the capacity by strongly contributing to the important education effort targeting both students and engineers;
  - Allow the evolution of the infrastructure following users' needs and availability of new technologies.
- Socio-economic impact:
  - Strengthening the competitiveness and growth of companies: SLICES will allow the testing of a wide range of technologies without investing in costly hardware and software platforms, reducing the risk associated with the design of new applications in the early stages of specification and design;
  - Contribution to the development of the local economy and innovation environment: SLICES will be an enabler of digital transition by reducing significantly costs of development and investment for local actors such as SMEs, startups, and local public institutions;
  - Contribution to the competitiveness of the digital ecosystem and socio-economic impacts;

- o Contribution to education, teaching and learning by the introduction and use of the RI in the educational process;
- o Contribution to European and global standards;
- o Contribution to the United Nations Sustainable Development Goals.

Digital Infrastructures as the future Internet, constitutes the cornerstone of the digital transformation of our society. As such, Innovation in this domain represents an industrial need, a sovereignty concern and a security threat. Without Digital Infrastructure, none of the advanced services envisaged for our society is feasible. They are both highly sophisticated and diverse physical systems but at the same time, they form even more complex, evolving and massive virtual systems. Their design, deployment and operation are critical. In order to research and master Digital infrastructures, the research community needs to address significant challenges regarding their efficiency, trust, availability, reliability, range, end-to-end latency, security and privacy.

Although some important work has been done on these topics, the stringent need for a scientific instrument, a test platform to support the research in this domain is an urgent concern. SLICES ambitions to provide a European-wide test-platform, providing advanced compute, storage and network components, interconnected by dedicated high-speed links. This will be the main experimental collaborative instrument for researchers at the European level, to explore and push further, the envelope of the future Internet. A strong, although fragmented expertise, exists in Europe and could be leveraged to build it. SLICES is our answer to this need. It is ambitious, practical but overall timely and necessary.

Although SLICES is centered on the research related to Digital Infrastructures, it has a strong potential for interdisciplinarity. Indeed, on the one hand, lessons learned could be advantageously exploited in other RIs where such infrastructure might be relevant in the near future. On the other hand, the digital transformation of various application domains opens an avenue for research in verticals such as smart grid, smart agriculture, autonomous vehicle, connected health etc.

The current list of partners of SLICES is:

- Centre National de la Recherche Scientifique (CNRS) – FR
- Consiglio Nazionale delle Ricerche (CNR) – IT
- Consorzio Interuniversitario Nazionale per l'Informatica (CINI) - IT
- Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT) - IT
- EBOS Technologies Ltd (EBOS) – CY
- Fundacion IMDEA Networks (IMDEA) – ES
- Institut Mines-Télécom (IMT) – FR
- Institut National de Recherche en Informatique et en Automatique (INRIA) – FR
- Instytut Chemii Bioorganicznej PAN PCSS (PSNC) – PL
- Interuniversitair Micro-Electronica Centrum (imec) – BE
- IoT Lab (IoT Lab) – CH
- Johannes Gutenberg University Mainz (JGU) – DE
- Kungliga Tekniska högskolan (KTH) – SE
- Mandat International, International Cooperation Foundation (MI) – CH
- Simula Research Laboratory (SRL) – NO
- Sorbonne Université (SU) – FR
- Számítástechnikai és Automatizálási Kutatóintézet (SZTAKI) – HU
- UCLan Cyprus (UCLAN) – CY
- Universidad del País Vasco-Euskal Herriko Unibertsitatea (UPV) – ES
- Université du Luxembourg (UL) – LU
- Université de Genève (UG) – CH
- University of Amsterdam (UvA) – NL
- University of Thessaly (UTH) – GR
- University of Oulu (UOULU) – FI
- University of Würzburg (JUM) – DE

SLICES, already received expression of interest from 98 international organizations (government, research and academia, industry, clusters and networks, NRENs). The supports are shown in are listed in Figure 1.
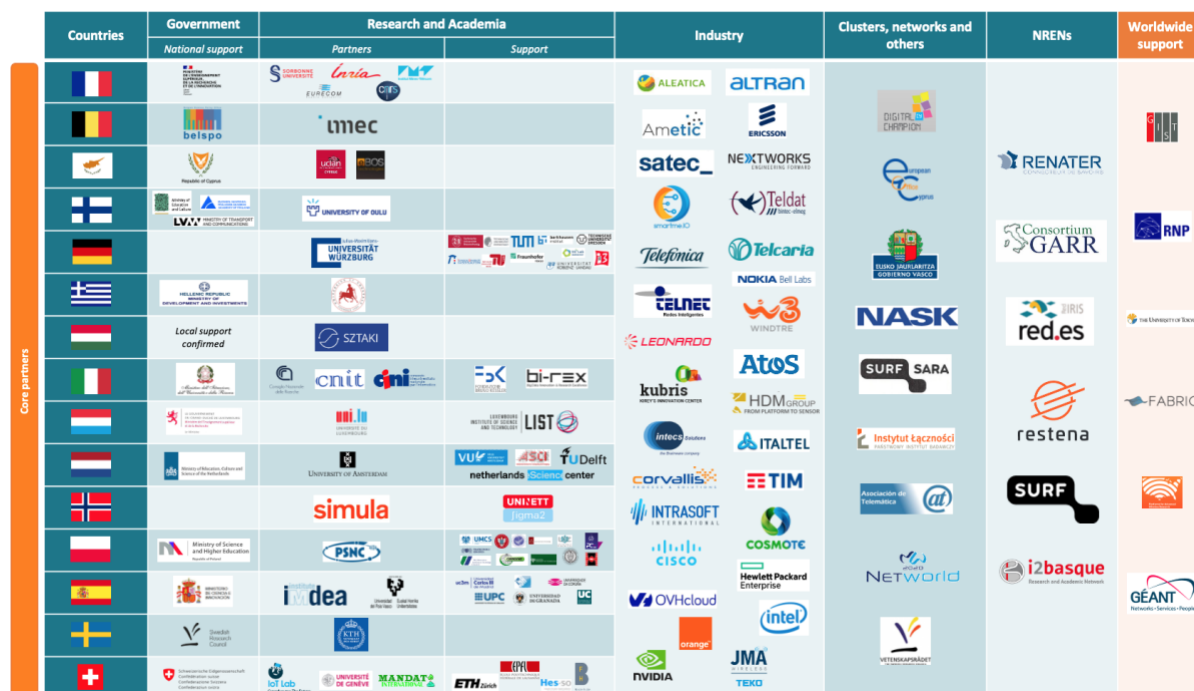


*Figure 1: Expression of interest on SLICES per country*

In summary, SLICES has the potential to play a catalyst role regarding the development, deployment and operation of test platforms in the domains covered by EMPOWER. It is well identified at the international level and SLICES received already expression of interest from international partners to develop joint cooperation. In particular, SLICES is positioning itself as supporting the open-source effort regarding the deployment of the disaggregation approach of the future digital infrastructures.


# 3. Open Source and Mutualization of tools

### 3.1. Mutualization of Software, Equipment and Human Resources

One of EMPOWER's main objectives is to stimulate mutualization of platform components and software and to demonstrate the joint developments and proof-of-concept activities at high-profile venues such as the Mobile World Congress and Linux Foundation events. Specifically, EMPOWER members now have ongoing engagements with several entities in the USA, in particular the PAWR facilities and associated testbeds as well as Linux foundation MAGMA and OPNFV-VCO3/5G Cloud-Native projects as well as joint activities with the Open Networking Foundation (ONF). These collaborations aim firstly to reduce fragmentation by producing common software toolsets and coordinating joint development efforts.

A key step in this direction was to provide a single core network solution for the 4G/5GNSA mobility-management entity (MME) between EU-based OpenAirInterface (OAI) and USA-based MAGMA. This serves both academic and industrial use-cases on both ends of the Atlantic.

A similar endeavor is now underway with teams from OAI in Europe and US colleagues from PAWR through the OpenAirX-Labs initiative, which targets accelerated development of 5G RAN and Core Network open-source software components through community-based development. The software tools are primarily of EU origin. The latter primarily targets knowledge exchange and establishing a strong academic development

community in the USA to assist EU developers. Today two full-time engineers are working in the USA aiming at supporting OpenAirX-Labs researchers with deployment and testing of 5G RAN and Core software tools for academic research purposes.

Steps were taken to harmonize software deployment methodologies in order to join forces on testbed computing resource management. This objective aims at providing common blueprints that can be used to deploy containerized versions of radio-access, core network software, mobile-edge computing functions and mobile service frameworks, including but not limited to OAI, Mosaic5G and Magma. These targets both Kubernetes-based and bare-metal computing clusters.

### 3.2. Distributed Testing Procedures

EMPOWER contributes to aggregating testing procedures across multiple platforms. Testing is a key component for ensuring software-integrity, in particular for community-based development, when new features are added to a software package. Because of differences in infrastructure at different sites (different computing platforms and radio equipment) testing of common software packages should firstly be automated by a continuous-integration (CI) and continuous-delivery (CD) system and secondly adapted to the specific needs of the experimental sites. These needs are expressed in terms of features, deployment environments (static, highly-mobile, over-the-air or with test and measurement equipment) and require a high-level of coordination between the various parties.

EU-labs such as EURECOM, INRIA-R2Lab are working closely with the OpenAirX Labs in the USA on defining and implementing a multi-site testing architecture for the OAI, Mosaic5g and MAGMA software packages using the various academic sites at its disposal. The framework will also make use of other similar EU software components such as srsLTE, Amarisoft and commercial testing hardware and software. To this end, hooks for the OAI Jenkins-based CI/CD framework are being added for COLOSSEUM in the USA. As a result, COLOSSEUM will provide a significant increase of computing resources to the main testing site at EURECOM to handle the merge requests to the OAI codebases that are increasing very quickly, in particular for the 5G components. This will reduce the amount of time for testing community merge requests and encourage more developers from the USA to contribute to the codebases that are largely led by EU developers. In a similar vein, through national initiatives such as the France Relance Engage5G project in France, efforts are being made to extend this open tooling approach for testing open-source radio and core network software components on these experimental networks derived from 5G-EVE which now comprise elements from industry-led communities such as O-RAN and ONAP. A similar effort is being implemented with the Magma Foundation and the Open Core Network (OCN) project.

The PAWR AERPAW site has provided remote access to a Keysight real-time MIMO channel emulator, high-end servers and 4G/5G radio platforms for EURECOM and COLOSSEUM team members to improve the functionality of OAI for aerial platforms. EURECOM is currently working with Northeastern and North Carolina State University on building the test-platform and deploying both OAI RAN and Core functions for testing with the channel emulator. This is a very beneficial activity for both sides. EURECOM does not have access to such equipment in its 5G-EVE facility in Sophia Antipolis and the resulting collaboration will help improve the quality of the radio software immensely.

### 3.3. Funding Open-Source Telecommunications Software Development in the 5G-era

Funding grass-roots open-source initiatives often begins with seed funding from institutes developing the software and, in the EU, support from publicly-funded collaborative project initiatives. If we take the example of OAI 4G and 5G software, the development early on was primarily carried out by EURECOM through involvement in national and EU projects. The open-source model allowed for simpler collaboration means to share prototyping software between partners. The model has proven to be solid for supporting research and prototyping in the 5G-era. As a result, a French non-profit entity, the OpenAirInterface Software Alliance (*Fond de Dotation OpenAirInterface*) was created to federate a budding international community and collect donations to increase OAI's level of quality, awareness, and global monetary contributions. Contributions and participation

in the governance of OAI is today largely-dominated by US corporations as is the case for many open-source software foundations today. Despite the fact that extreme care was taken to ensure that the majority of OAI's 4G and 5G software components use licensing, which is compatible with 3GPP intellectual property policy, major EU corporations in telecommunications are hesitant to embrace the open-source model for components in the vicinity of the radio-access.
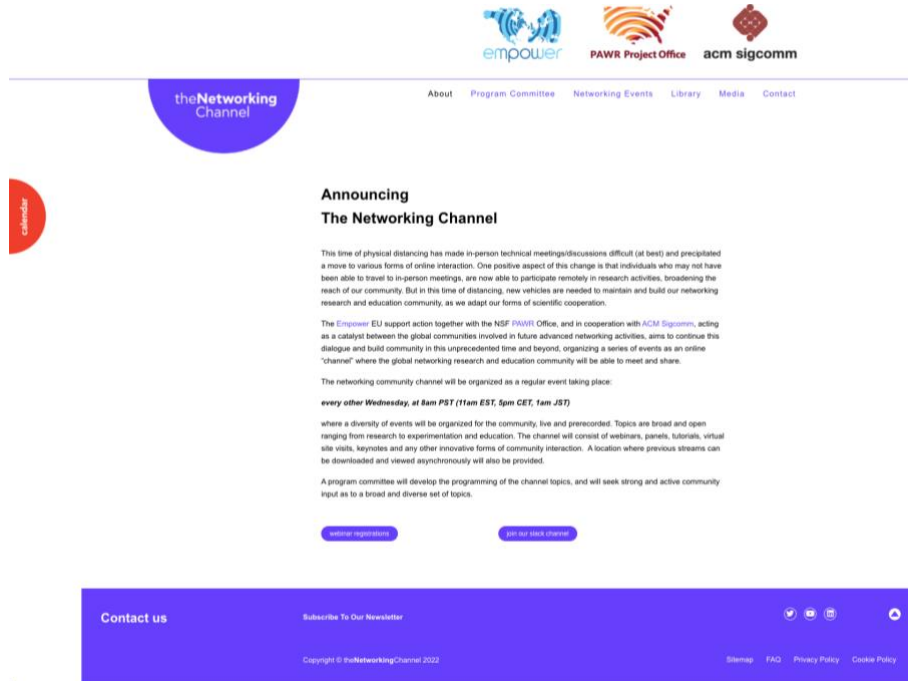

*Figure 2: The Networking Channel main web page*

## 4. The Networking Channel

As a consequence of the Covid Pandemic and its effects on the physical barriers and difficulties to cooperate, EMPOWER took the initiative to launch together with the NSF PAWR Office, and in cooperation with ACM Sigcomm, the Networking Channel (https://networkingchannel.eu, see Figure 2), acting as a catalyst between the global communities involved in future advanced networking activities. It aims at continuing the dialogue and build community in this unprecedented time and beyond, organizing a series of events as an online "channel" where the global networking research and education community will be able to meet and share.

The networking community channel is organized as a regular event, taking place *every other Wednesday, at 8am PST (11am EST, 5pm CET, 1am JST)*, where a diversity of events is organized for the community, live and pre-recorded. Topics are broad and open ranging from research to experimentation and education. The channel consists of webinars, panels, tutorials, virtual site visits, keynotes and any other innovative forms of community interaction. A YouTube Channel (https://www.youtube.com/channel/UCAtFAG5JdQrHac6ArIWJ-hw) is available where previous streams can be downloaded and viewed asynchronously.

The Programme Committee co-chairs are:

- Matthew Caesar, University of Illinois, USA;
- Serge Fdida, Sorbonne Université, France;
- Abhimanyu Gosain, Northeastern University, USA;
- Jim Kurose, University of Massachusetts, USA;
- Stavroula Maglavera (communication/administration).

The Networking Channel started its operation on 24/3/2021 and organized the following events:

- 24/3/2021: The Network will be programmed by many, operated by a few - Nick McKeown – Professor of Computer Science and Electrical Engineering, Stanford University. With a panel of graduate student discussans from around the world (https://networkingchannel.eu/the-network-will-be-programmed-by-many/); Registrations: 480; Attendees: 268;

- 7/4/2021: A Journey with mmWave research - Joerg Widmer – Research Professor and Research Director of IMDEA Networks; Sundeep Rangan – Associate Director, NYU WIRELESS; Michele Zorzi – University of Padova, Italy; Xinyu Zhang – Associate Professor, Department of Electrical and Computer Engineering, University of California San Diego (https://networkingchannel.eu/a-journey-with-mmwave-research/); Reegistrations: 256; Attendees: 147;

- 21/4/2021: 5G and Next G Innovation Opportunities and Challenges: Enabled by Disaggregation, SDN and Open Source - Guru Parulkar – Executive Director of Open Networking Foundation (ONF) and Executive Director of Stanford Platform Lab; Sachin Katti – Assistant Professor of Electrical Engineering and Computer Science at Stanford University, Co-Chair of O-RAN Alliance; Christian Maciocco – Principal Engineer and Director Telecom Systems Research, Intel Labs; Florian Kaltenberger – EURECOM (https://networkingchannel.eu/5g-and-next-g-innovation-opportunities-and-challenges/); Registrations: 342; Attendees: 174;

- 5/5/2021: Advice on how to succeed in grad school - Jennifer Rexford – Professor of the Computer Science Department at Princeton University; Edmundo de Souza e Silva – Federal University of Rio De Janeiro, Brazil; David Patterson – Berkeley, USA; Anja Feldmann – Max Planck Institute for Informatics. With a panel of graduate student discussans from around the world (https://networkingchannel.eu/advice-on-how-to-succeed-in-grad-school/); Registrations: 939; Attendees: 575;

- 19/5/2021: Emerging Trends in AI/ML and Implications for Networking Research- Dr Sujata Banerjee – Sr. Director of Research, VMware, USA; Dr. Somdeb Majumdar – Intel's AI Lab, USA; Dr Dario Rossi – Huawei, France; Dr Dan Pei – Tsinghua University, China (https://networkingchannel.eu/emerging-trends-in-ai-ml-and-implications-for-networking-research/): Registrations: 386; Attendees: 182;

- 2/6/2021: Challenges at Layer 8: Network neutrality, the digital divide and spectrum - Scott Marcus – Senior Fellow at Bruegel, Belgium; Eric Burger – Professor of Computer Science, Georgetown University, USA; Chris Marsden – Professor of Internet Law, University of Sussex, UK; Sonia Jorge – Executive Director, A4AI, Head of Digital Inclusion, Web Foundation; Paul Brooks – Consulting CTO and Chair of Internet Australia, Australia(https://networkingchannel.eu/challenges-at-layer-8-network-neutrality-the-digital-divide-and-spectrum/); Registrations: 162; Attendees: 69;

- 15/9/2021: Google Networking: Infrastructure and Selected Challenges - Christophe Diot – Principal Engineer at Network Operations team, Google; Paulie Germano – Senior Staff Network Engineer, Google (https://networkingchannel.eu/google-networking-infrastructure-and-selected-challenges/); Registrations: 625; Attendees: 292;

- 29/9/2021: Demonstrating Advanced 5G and Edge Services on the 5G-VINNI platform - Andrés Gonzalez – Senior Researcher, Telenor Research, Norway; Johan Morten Tetlie – Solution Architect, Ericsson Norway; Antonios Dimitriadis – Lead Telco Cloud Infrastructure and Automation Solution Architect, Nokia; Tirthankar Ghosh – Solution Architect, Service Orchestration, Nokia; Kennet Nomeland – Radio System Architect, Norwegian Defence Material Agency (https://networkingchannel.eu/demonstrating-advanced-5g-and-edge-services-on-the-5g-vinni-platform/); registrations: 175; Attendees: 96;

- 19/10/2021: Networking Education During and After the Pandemic - Bamba Gueye – Université Cheikh Anta Diop, Senegal; Jörg Liebeherr – University of Toronto, Canada; Koojana Kuladinithi – Hamburg University of Technology, Germany; Luciano Paschoal Gaspary – Federal University of Rio Grande do Sul; Prométhée Spathis – Sorbonne Université, France. With a panel of student discussans from around

the world (https://networkingchannel.eu/networking-education-during-and-after-the-pandemic/); Registrations: 90; Attendees: 76;

- 27/10/2021: Experiments in the Edge to Cloud Continuum - Kate Keahey – University of Chicago; Jason Anderson – University of Chicago (https://networkingchannel.eu/experiments-in-the-edge-to-cloud-continuum/); Registrations: 172; Attendees: 83;

- 10/11/2021: A day in the life of Netflix Streaming: A conversation about Netflix Adaptive Streaming and more - Te-Yuan Huang– Streaming Algorithm team, Netflix; Renata Teixeira – Streaming Algorithms team, Netflix (https://networkingchannel.eu/a-day-in-the-life-of-netflix-streaming-a-conversation-about-netflix-adaptive-streaming-and-more/); Registrations: 299; Attendees: 175;

- 24/11/2021: Quantum Networks - Frédéric Grosshans – Sorbonne Université; Rodney Van Meter – Keio University; Donald F. Towsley – University of Massachusetts Amherst (https://networkingchannel.eu/quantum-networks/); Registrations: 239; Attendees: 134;

- 8/12/2021: Human-centered Networking - Ellen Zegura – Georgia Tech (https://networkingchannel.eu/human-centered-networking/); Registrations: 136; Attendees: 80;

- 19/1/2022: QUIC and its impact on secured transport layer management in SATCOM systems - Nicolas Kuhn – Project Manager Technical Lead at Centre National d'Études Spatiales; Christian Huitema – Private Octopus Inc; Emile Stephan – Orange Labs; Alexandre Ferrieux – Orange Labs; Isabelle Hamchaoui – Orange Labs; John Border – Hughes Network Systems; Chi-Jiun Su – Hughes Network Systems; Marie-José Montpetit – Telecom Paris Sud (https://networkingchannel.eu/quic-and-its-impact-on-secured-transport-layer-management-in-satcom-systems/); Registrations: 174; Attendees: 132;

- 2/2/2022: How can we improve diversity and inclusion in the systems and networking community? Margaret Martonosi – NSF; Tracy Camp – Colorado School of Mines; Mythili Vutukuru – IIT Bombay; Ahmed Elmokashfi – Simula Research; Craig Partridge – Colorado State University; Manuel Perez Quinones – University of North Carolina at Charlotte (https://networkingchannel.eu/how-can-we-improve-diversity-and-inclusion-in-the-systems-and-networking-community/); Registrations: 130; Attendees: 87;

- 16/2/2022: Kanchana Kanchanasut – Asian Institute of Technology, Randy Bush – Arrcus (https://networkingchannel.eu/deploying-networking-in-developing-regions/); Registrations: 137; Attendees: 71;

- 2/3/2022: David Boswarthick, ETSI; Mikko Uusitalo, Nokia Bell Labs, Douglas Castor, InterDigital Research and Innovation for 6G (https://networkingchannel.eu/transatlantic-perspectives-on-6g-vision-roadmap-and-development-model/); Registrations: 212; Attendees: 97;
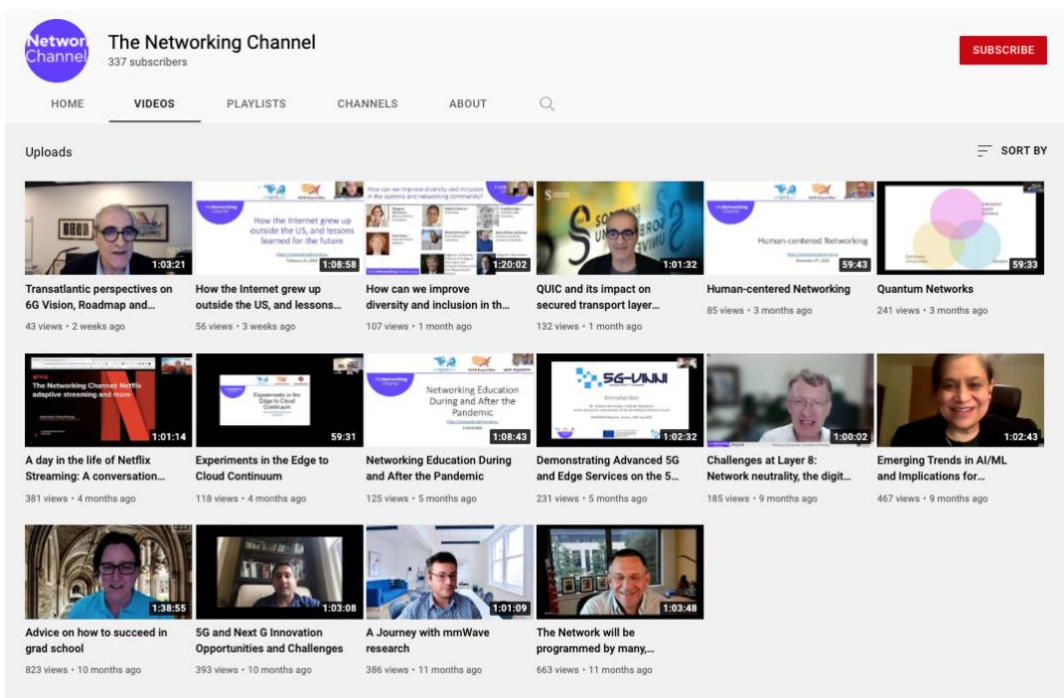
*Figure 3: The Networking Channel YouTube site*

Figure 3 presents the YouTube channel where the different talks are being stored for future audience. There are currently (March 22) more than 337 subscribers in the YouTube Channel and the recordings of the events have been viewed hundred times.

Some statistics regarding the attendance of theNetworkingChannel events depicted in the next figures:
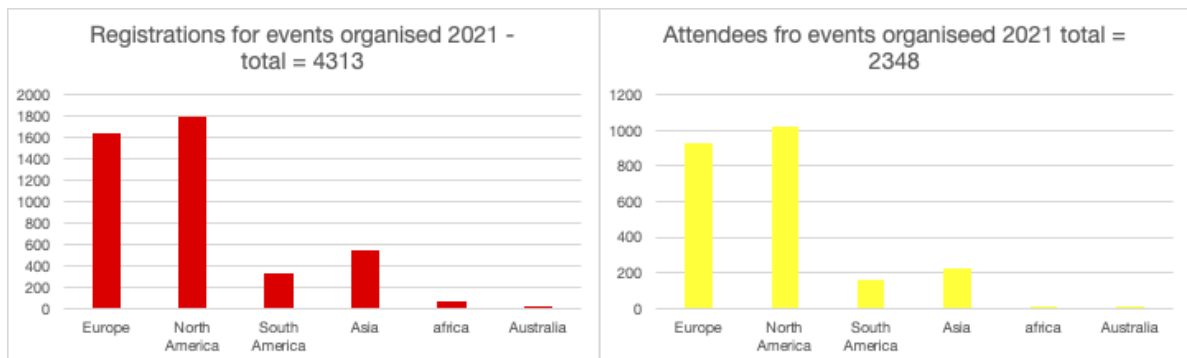


*Figure 4: Statistics of the total registrations and attendees for the events organised in 2021*

## Google Analytics Behaviors Overview

| Continent ▼ | Region ▼ | Channel ▼ | Device ▼ | Mar 27, 2021 - Nov 30, 2021 ▼ |

**Overview of your user behaviors**

| Pageviews | Unique Pageviews | Avg. Time on Page | | Bounce Rate | % Exit | Pages / Session |
|---|---|---|---|---|---|---|
| 25,179 | 20,980 | 00:01:40 | | 53.05% | 53.37% | 1.86 |

*Figure 5: Total visitors of the website*

**What do users see when they are in your website?**



Which page is the most popular?

- / (17.7%)
- /advice-on-how-to-succeed-in-grad-school/
- /networking-events/ (34.5%)
- /registration-list/
- /library/ (13.5%)
- /google-networking-infrastructure-and-selected-challenges/
- /quantum-networks/ (10.8%)
- /emerging-trends-in-ai-ml-and-im...
- /networking-events-page-1/ (9%)
- others

| | Page | Pageviews |
|---|---|---|
| 1. | / | 4,446 |
| 2. | /advice-on-how-to-succeed-in-grad-school/ | 3,388 |
| 3. | /networking-events/ | 2,727 |
| 4. | /registration-list/ | 2,262 |
| 5. | /library/ | 801 |
| 6. | /google-networking-infrastructure-and-sel... | 748 |
| 7. | /quantum-networks/ | 737 |
| 8. | /emerging-trends-in-ai-ml-and-implicatio... | 705 |
| 9. | /networking-events-page-1/ | 669 |
| 10. | /a-day-in-the-life-of-netflix-streaming-a-co... | 659 |
| 11. | /committees/ | 638 |
| 12. | /5g-and-next-g-innovation-opportunities-... | 509 |
| 13. | /experiments-in-the-edge-to-cloud-contin... | 489 |
| 14. | /a-journey-with-mmwave-research/ | 487 |
| 15. | /networking-education-during-and-after-t... | 430 |
| 16. | /demonstrating-advanced-5g-and-edge-s... | 387 |

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*Figure 6: Top pages visited*

**Total users per country**

| | Country | Users ▼ |
|---|---|---|
| 1. | United States | 4,021 |
| 2. | Brazil | 507 |
| 3. | China | 365 |
| 4. | France | 360 |
| 5. | India | 359 |
| 6. | Germany | 257 |
| 7. | Spain | 222 |
| 8. | United Kingdom | 221 |
| 9. | Italy | 194 |
| 10. | Netherlands | 171 |
| 11. | Greece | 168 |
| 12. | Canada | 165 |
| 13. | Pakistan | 146 |
| 14. | Finland | 133 |
| 15. | Norway | 115 |
| 16. | Thailand | 112 |
| 17. | Japan | 82 |
| 18. | Turkey | 70 |
| 19. | Switzerland | 69 |
| 20. | Austria | 68 |
| 21. | Hong Kong | 64 |
| 22. | Sweden | 55 |
| 23. | Belgium | 54 |
| 24. | Jordan | 51 |
| 25. | Portugal | 46 |

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*Figure 7: Top countries*

**EMPOWER ■ Grant Agreement 824994**
**EMPOWER White Paper ■ March, 2022**
H2020 ■ Research and Innovation project
H2020-ICT-2018-21 ■ EU-US Collaboration for advanced wireless platforms■

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## 5.  EMPOWER EU/USA collaboration recommendations for next phase of SNS JU

EMPOWER has been working on fostering the relationship and collaboration between USA and EU in the area of Advance Wireless Infrastructure for the last 3 years. During this time, a deep understanding on the best way of promoting joint activities has been developed together with a strong trust relationship among the partners. In this document, the EMPOWER project presents the devised recommendations for the EU to develop join programs and activities with the USA.

The main USA forum promoting USA Leadership on 6G is the ATIS Next Generation Alliance[1] launched in 2020. This alliance mirrors the European 6G-IA industry association and includes key USA industry stakeholders on 6G including members of EMPOWER such as Nokia and InterDigital. The NGA work structured includes 6 working groups so far including National 6G Roadmap, Green Generation, Spectrum, Technology, Applications and Societal and Economic Needs. EMPOWER is already engaged with ATIS NGA noticeably on the technology roadmap.

The recommendations from EMPOWER to build future collaboration activities with USA are the following:

- It is recommended that the EU 6G-IA establishes a MoU with ATIS NGA, similar to the MoU established with ETSI, in order for both peer bodies EU 6G-IA and USA NGA to collaborate on the 6G roadmap priorities and areas of synergies bi-laterally and globally in international forums such as the ITU, NGMN and GSMA;

- It is recommended that the coordination of USA collaboration activities, jointly with the collaboration with other geographical areas, is handled in a separated CSA within the phase-2 of the SNS JU;

- EMPOWER recommends two kinds of R&I activities to be considered for further collaboration on the area of Advanced Wireless Platforms research. On the one hand, a R&I EU/USA collaboration project with twinned funding to liaise and further develop open advanced wireless platforms is recommended. This project's aim is to interlock the SNS Stream C platforms and their equivalent in the USA, including capacity budling and training. On the second hand, we recommend the development of a R&I project that will fund (cascade funding) experimental activities (using the Advance Wireless Platforms considered in the R&I project described above), research focused projects and mobility of European partners towards interworking with USA research ecosystem.

## 6.  Conclusion

This Whitepaper reports the different efforts and recommendations on how to foster the EU/USA collaboration on Advance Wireless Platforms in the nearly future. These recommendations have been discussed among different key representative players of US and EU represented in the EMPOWER Advisory Board. This document also provides the view of the EMPOWER project on how to sustain the collaboration efforts, mainly using the SLICES initiative as catalyst for the continuous discussion between both regions. A summary of the ongoing efforts on software mutualization and tools is also reported, indicating the current state of the different projects and joint initiatives undergone by EMPOWER partners. All of these activities have been broadly disseminated, in particular, through TheNetworkingChannel, of which we provide a short summary in this document.

Finally, a set of recommendations to the EC for the implementation of EU/US collaboration in the next phase of the SNS JU is provided, as conclusion and future path for the collaboration efforts on this critical research area.

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[1] Next G Alliance website, https://nextgalliance.org/