Call: H2020-ICT-2020-2

Project reference: 101015956

Project Name:

A flagship for B5G/6G vision and intelligent fabric of technology enablers connecting human, physical, and digital worlds

Hexa-X

Deliverable D8.3
Final dissemination and communication report

Date of delivery:	30/06/2023	Version:	1.0
Start date of project:	01/01/2021	Duration:	30 months

Document properties:

Document Number:	D8.3
Document Title:	Final dissemination and communication
Editor(s):	Mauro R. Boldi (TIM)
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Contractual Date of Delivery:	30/06/2023
Dissemination level:	PU[1]
Status:	Final
Version:	1.0
File Name:	Hexa-X D8.3

Revision History

Revision	Date	Issued by	Description
1.0	30.06.2023	Hexa-X WP8	Final version

Abstract

This document presents the activities on impact creation of the Hexa-X project during the full period of activity of the project. It provides the final assessment of the project progress towards the fulfilment of its objectives and especially Objective 5. The results are classified in three main groups, following the definition of the Hexa-X impact KPIs: (1) communication activities, which include the project website and social media; (2) dissemination activities, both industrial and scientific, which include, among others, scientific publications, or participation in events, and (3) and standardization/industry fora and intellectual property (the exploitation and business plans were first provided in D8.1 and updated in D8.4). The document provides summary statistics on the achievement rate for each of the identified categories, which in general confirms the good level of success of the impact creation activities.

[1] PU = Public

Keywords

Communication, Dissemination, Publications, Outreach, Standardization, Impact

Disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101015956.

Executive Summary

This document provides a summary of the dissemination and communication activities that have been carried out by Hexa-X partners during the project (note that the exploitation plans are provided in D8.1 [HEX21-81] and D8.4 [HEX23-84]).

The results are classified in three main groups, following the definition of the Hexa-X impact KPIs:

(1) communication activities, which include the project website and social media;

(2) dissemination activities, both industrial and scientific, which include, among others, scientific publications, and participation in events, and

(3) and standardization/industry fora and intellectual property.

Along with the report of the dissemination and communication activities performed, this document also includes an assessment of the impact achieved with respect to the dissemination KPIs. In general, this assessment is done using absolute figures, i.e., comparing the total number of publications achieved, press releases announced, etc., against the target ones.

Some key achievements of the project related to the work reported in this deliverable (see Section 1.1 for more details):

- the project has surpassed the target number of website visits, both absolute numbers and in terms of visits outside the consortium. The number of press releases has passed the target number of 10. Social media channels have been set up and have been regularly used. See Sections 2.2, 2.3, 2.4. For the case of YouTube, Hexa-X partners have generated 33 videos, which accumulate a total number of 9420 views as of late May 2023 (including videos of the demos for EuCNC 2023).
- The "Women in Hexa-X" initiative, launched in February 2021, has been expanded for the participations of the whole 5G PPP community in June 2021, and renamed as "Women in Telecommunications and Research (WiTaR)" in October 2021. For more details see Section 2.5.
- Demonstration activities, which were at zero in the first part of the project, have been significantly supported in the second period, reaching the expected number; 6 demonstrations have been shown in the dissemination events, and all together in the EuCNC 2023 exhibition booth in Göteborg in June 2023. Details in Section 3.3.
- Finally, the Hexa-X project has also produced several contributions to standardization bodies, driven some key activities within 5G PPP, generated intellectual property that has resulted in patents' applications triggered by different work packages. See Section 4.

To sum up, this document provides a detailed assessment on the dissemination and communication activities of the project, along with the comparison with the target KPIs. It serves to confirm the general good progress of the project activities.

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List of Acronyms and Abbreviations

3GPP	Third Generation Partnership Project
5G	Fifth Generation
5G PPP	5G infrastructure Public Private Partnership
6G	6th generation of mobile communications systems
ADC/DAC	Analog to Digital/Digital to Analog converter
AI/ML	Artificial Intelligence/Machine Learning
ATIS	Alliance for Telecommunications Industry Solutions
CCNC	Consumer Communications & Networking Conference
CNSM	Conference on Network and Service Management
ETSI	European Telecommunications Standards Institute
EuCNC	European Conference on Networks and Communications
EC	European Commission
FPGA	Field Programmable Gate Array
GSMA	GSM Association
H2020	Horizon 2020
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IPR	Intellectual Property Rights
ISG	Industry Standard Group (in ETSI)
ISWCS	International Symposium on Wireless Communications Systems
ITU	International Telecommmunication Union
IWPC	International Wireless Industry Consortium
KER	Key Exploitable Result
KPI	Key Performance Indicator
MANO	Management and orchestration
MEC	Multi-Access Edge Computing
MLOps	Machine Learning Operations
MWC	Mobile World Congress
NFV	Network Function Virtualization
NGMN	Next Generation Mobile Networks Alliance
nGRG	ORAN Next Generation Research Group
NR	New Radio (for 5G)
NTN	Non Terrestrial Networks

OFDM	Orthogonal Frequency Division Multiplexing
ONDM	Optical Network Design and Modelling (conference)
OSM	Open Source MANO (in ETSI)
PDL	Permissioned Distributed Ledger (in ETSI)
PIMRC	Personal, Indoor and Mobile Radio Communications
RAN	Radio Access Network
SDO	Standards Development Organisations
SDR	Software Defined Radio
SNS JU	Smart Networks and Services Joint Undertaking
TMF	Transformer-based Multiscale Fusion Network
UAV	Unmanned Aerial Vehicle
URLLC	Ultra Reliable Low Latency Communications
WiTaR	Women in Telecommunications and Research
WG	Working Group
WP	Work Package
WRC	World Radio Conference
WWRF	Wireless World Research Forum
XAI	eXplainable AI
ZSM	Zero-Touch network and Service Management

1 Introduction

This document reports the progress and activities of the Hexa-X project during the overall 30 months (January 2021-June 2023) extending the assessment made in the deliverable D8.2 [HEX21-82]. As already stated in D8.2, despite the effects of the global pandemic in the first 1,5 years of the project, communication and dissemination activities were carried out as planned, in several cases exceeding the expected number of contributions, and even at a higher speed during the second part of the project, which was less affected by the pandemic.

In fact, even though COVID-19 impacted several activities previously carried out in face-to-face (starting with the project meetings themselves, but also dissemination activities such as conference presentations, panels, workshops, etc.), the Hexa-X consortium managed to plan and invest the required efforts and resources to achieve remarkable communication and dissemination performance indicators. In the second part of the project, several opportunities to meet face-to-face have been exploited, allowing the project to significantly increase its impact footprint.

In a nutshell, communication, and dissemination activities were performed successfully in all the categories considered, including the following:

- Press releases.
- Event organizations.
- Appearances in news/media.
- Academic paper publications, both journals and conferences.
- Invited talks within various events.
- Standardization contributions.

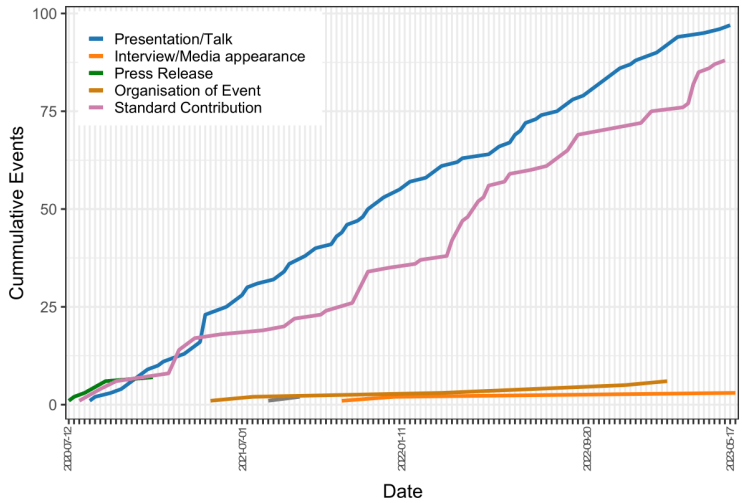


Figure 1. Cumulative events of Hexa-X.

As expected, and planned, the Impact activity has significantly grown in this second period also for the Demonstrations activities. The initial phase, also due to the pandemic crisis, recorded limited Impact on demonstrations, but it was nevertheless very useful to prepare these demonstrations so they could be ready to be presented in the events and conferences that took place during the second and final phase of the project. Demos from technical Work Packages have been shown in ICC 2023 in Rome in May 2023, and during the exhibition of the EuCNC/6G Summit in Göteborg in June 2023.

A general overview of the cumulative number of communication activities is provided in Figure 1, these being divided into several representative sub-categories. The figure serves to illustrate how the rate at which different categories grow varies, depending on the activity type: the presentations/talks recorded a steady rate throughout the whole project lifetime, similarly to standard contributions. Other categories

instead showed significant increases in specific situations, such as the press releases or interviews at the beginning of the project.

1.1 Objective of the deliverable

The objective of this deliverable is two-fold: first, to provide an overview of the dissemination and communication activities of Hexa-X project, and second, to present along with this overview an assessment of the impact achieved with respect to the dissemination KPIs. These dissemination and communication activities include published papers, events organized, presentation talks, social media impact, and so on.

This section gives an overview of the work in Hexa-X towards the objective of impact creation towards 6G.

1.1.1 Hexa-X outputs for impact creation towards 6G

To harmonize the Hexa-X view on 6G with the rest of the world:

Hexa-X has shared its vision, architecture and research results and topics in multiple key international conferences and events (a selection of the most important ones):

- EuCNC & 6G Summit, August 12th, 2021
- ICT-52 workshop Feb 2022 with presentations from Europe, Next G A, China, Japan and Korea as well as Abu Dhabi
- IEEE CCNC Workshop on 6G, Hexa-X Vision and approach overview was presented on January 11th, 2022, where Next GA was also represented.
- Presentation of Hexa-X to DoT India national 6G vision team, February 15th, 2022
- Invited speech and panel participation at EMPOWER panel, 2nd of March.
- EuCNC & 6G Summit, 2022.
- Joint panel with Next GA and Asia at IEEE VTC 2022, June 22nd.
- Invited presentation at Australian Beyond 5G Connectivity Summit, August 23rd, 2022
- Invited talk on Hexa-X at WWRF conference, November 7th, 2022.
- Joined panel at WWRF conference to represent Hexa-X, November 9th, 2022.
- Hexa-X presentation in a IETF 6G side meetings July 27th 2021 and July 27th 2022.
- Hexa-X presentation to ETSI MEC WG, 23rd of September 2021.
- Hexa-X ETSI Catalyst workshops on April 5th and September 1st 2022.
- Participated to an Industry Panel session on "AI-enabled Communication Networks", as part of IEEE ICC conference, on May 19th 2022.
- Participated to “Industry with jump in productivity?”, as part of Expert Roundtable eco Academy, on May 18th 2022.
- Moderator of an industry panel session on "Connecting Intelligence in 6G: learning to communicate & communicating to learn" at IEEE VTC2022-Spring on June 20th 2023.
- Participated to an Industry Panel session on "AI-enabled Communication Networks", as part of IEEE ICC 2022 conference (hybrid session) at IEEE ICC on May 19th 2022.
- Network-X workshop in Amsterdam, October 2022
- ICT-52 workshop Jan 2023 with presentations from Europe, Next G A, China, Japan and Korea
- EuCNC & 6G Summit, June 2023
- ICC 2023, June 2023, May 2023

To pave the way for B5G/6G systemisation and standardization, through industry consensus and interactions with the scientific community:

Hexa-X has been educating and preparing the networking ecosystem to the B5G/6G through participating to industrial and scientific exhibitions, events and business conferences where we have provided targeted presentations. We directly contribute to ITU-R, ETSI, IETF, O-RAN and 3GPP by

introducing Hexa-X use cases, concepts, and features. We arranged workshops with specific SDOs (ITU-T and ETSI), participated to the work of 6G-IA Pre-standardization WG.

Impact to critical foundational 6G documents and industrial white papers:

- ITU-R IMT Vision 2030 and beyond and its companion feasibility study on 100 GHz that are setting the direction to WRC-23 for 6G spectrum assignment considerations.
- GSMA and NGMN white papers on 6G.

Established direct liaisons with ITU-R, ITU-T and ETSI. Contributing to the establishment of ETSI THz ISG.

To identify the relevant gaps in the ongoing standardization activities and contribute to them:

For each the WPs of Hexa-X, we have identified a set of potential target fora with potential topics and the readiness of the topic and alignment with the roadmap of the target SDO. As Hexa-X is not a legal entity the contributions have been channelled through the partner organizations of the project, expect the cases where the project has established a direct liaison with a given SDO, i.e., ETSI, ITU-T, and 6G-IA.

On the architectural level we have identified the differences between Hexa-X architecture and the current 5G architecture, even though 5G advanced feature set is still evolving and details to be defined (e.g., Release 19 and Release 20 content is not yet decided by 3GPP and work on 6G topics has not even started). We expect the biggest gaps in the ongoing standardization in radio characteristics (RF, use of spectrum, use of AI/ML), separation of concerns and cloud native elasticity of network services, native use of AI/ML, support of function programmability, AI driven dynamic closed loop orchestration, merging of location and sensing and NTN integration.

ITU-R WP5D is preparing "IMT Vision 2030 and beyond" that is scheduled to be completed at the end of the first half 2023 simultaneously with a companion report on IMT feasibility above 100GHz. Hexa-X has been contributing to justify the need for 6G spectrum. Use case contributions were based on results of D1.1. and D1.2 and feasibility of above 100 GHz spectrum is based on D2.1. All contributions have been integrated to be a part of the corresponding ITU documents to be released in Q2 2023.

To foster the adoption of the Hexa-X solutions beyond the consortium participants ensuring an international footprint for the outcome of the project:

From the onset of the project, the consortium has been steadfast in its commitment to maximizing its international impact. Beyond the tangible outcomes discussed later, such as standardization efforts, scientific production, and workshop organization, the Hexa-X project has proactively implemented additional measures to gauge its influence. Through these comprehensive initiatives, Hexa-X solidifies its position as a catalyst for innovation and collaboration, leaving a lasting impression on the international stage.

Webpage. The total number of users that visited our website has been 53,717 (on May 22nd 2023, displayed in Figure 2), which exceeds the target number which were set to more than one thousand. Furthermore, it should be noted that roughly 42% of the visits from countries outside Europe, and therefore the consortium, which illustrates the great interest generated internationally by Hexa-X.

Zenodo: 110 accepted peer-reviewed scientific contributions, encompassing journal articles, conference papers, and book sections. Furthermore, Hexa-X utilizes the statistical data obtained from the Zenodo repository to assess its impact. These numbers reflect the widespread interest and engagement with Hexa-X's research, highlighting its significance within the scientific community. By utilizing the Zenodo repository, Hexa-X effectively disseminates its findings and maximizes its reach to researchers and readers alike.

Social channels: Hexa-X has utilized various social channels to distribute multiple presentations on YouTube. The dedicated Hexa-X YouTube channel has garnered 213 subscribers and accumulated an impressive 9.4K views. Similarly, Hexa-X maintains an active presence on Twitter, with a follower count of 513 and a substantial archive of 445 tweets. Additionally, Hexa-X has fostered a professional network and engagement through its LinkedIn group, which currently boasts 260 members. Through

these diverse social channels, Hexa-X effectively shares its insights, research, and updates with a wide audience, establishing connections and facilitating discussions within the scientific community.

To impact future European actions in the domain of Smart Network and Services:

This impact has been pursued since the start of the project. At the start, the actions were towards 5GPPP and related Working Groups, including Steering Board and Technical Board, now evolving towards the corresponding entities in 6GIA/SNS. As well as constantly monitoring and working with 5GPP/6GIA groups, Hexa-X has organised workshops with ICT-52 projects all the years. Documentation is available in the repositories and through the information exchange, e.g. via the emails.

To maximise the exploitation of Hexa-X results in the industrial, academic, and SMEs environments:

Initial exploitation plans provided during the proposal preparation phase by all partners have been updated during the first phase of the Hexa-X exploitation strategy and reported in D8.1 in October 2021. To foster collaboration, all exploitation activity by partners and within technical WPs centers around identified Key Exploitable Results (KERs). Respective actions in terms of organizational changes, marketing and communication activities, expected economic impacts and impacts on the ecosystem have been gathered via a structured questionnaire, with a second round of this activity conducted in late 2022. In this second round, expected Technology Readiness Levels (TRLs) for each KER and associated exploitable measures were detailed. Additionally, the Innovation Management Committee supported the ideation and exploitation process through Calls for Innovation and respective feedback to submitted innovations. Deliverable D8.1 contains the full description of the exploitation strategy, KERs, and individual exploitation and business sustainability plans. The final exploitation plan including detailed updates on the individual exploitable measures for each KER is to be published in D8.4, due at the end of the project

1.1.2 Hexa-X measurable results for impact creation towards 6G

Number of standardisation groups addressed, and contributions made:

See Section 4.1 for all the details on the groups and on the contributions made.

Public workshops (especially the series of “6G Summit”) organised by the consortium, resulting in 6G White Papers:

Over the course of its existence, Hexa-X has consistently strengthened its presence in various public workshops. One particularly notable event in which Hexa-X has actively participated is the "6G summit" series. Throughout the years, Hexa-X has showcased its expertise and research contributions in this esteemed summit by presenting a total of 9 high-quality papers. These papers reflect the depth and breadth of Hexa-X's advancements, contributing to the collective knowledge and development of 6G technologies. By actively engaging with the 6G summit series, Hexa-X demonstrates its commitment to staying at the forefront of cutting-edge research and fostering collaborations within the global 6G community. Most of these workshops have been organised in top and premium events, including EuCNC/6G Summit in 2022 in Grenoble and in 2023 in Göteborg.

Scientific publications (papers, journals, press releases):

The number of scientific publications, encompassing conference papers, journals, and others, has experienced significant improvement since its beginning. Following the initial investment of time during the project's early months to identify interesting research problems, and similar tasks, the advancement of scientific accomplishments has become increasingly significant. To date, Hexa-X has amassed a total of 110 approved scientific contributions, with a larger number of papers submitted. These contributions encompass journal articles, conference papers, and book sections. The rate of publications is anticipated to experience significant growth throughout the project's duration, exceeding the key performance indicator of surpassing 100 publications by a considerable margin. Furthermore, Hexa-X has also achieved a noteworthy milestone in terms of press releases, with over 15 releases already published.

Impact on ITU work on 6G requirements, and on roadmap for 6G standardisation in 3GPP:

Hexa-X has constantly followed the activities in ITU, also submitting contributions to drive the discussion. Anyway, the period in time of the project was mainly one of "pre-standardization" and the definition of the roadmap is still a matter to be defined in detail currently, despite it is commonly acknowledged that the future IMT2030 will be finalised by the end of the current decade only.

Impact future European actions in the domain of Smart Network and Services:

See the details in previous section on the achieved output and Section 3.4 in the following.

Success in the exploitation of the results by the participants of the project:

Based on the updated partner exploitation plans reported in D8.1, the final exploitation plan in D8.4 contains a detailed list of exploitation activities for each KER by all project partners, including an outlook on expected exploitation after the end of the project. Additional indicators for successful exploitation of the project results are the number of submitted IPR, scientific publications and organization of workshops and events with presentation of Hexa-X results (see later).

Number of patents issued by the participants of the project:

33 patents have been indicated by some partners during the project (see Section 4.3).

1.1.3 Hexa-X quantified results for impact creation towards 6G

More than (>100) standardisation contributions:

See Section 4.1, around 120 contributions recorded.

At least (>50) patents issued:

The number of patents declared officially by the partners is slightly below this threshold, around 33, but it is likely that some further patents are still in a phase when it is not possible to disclose details about them

(5) demos presented in A-series workshops and events, of which (3) organised by the consortium:

The consortium has reached 6 demos, all presented in EuCNC/6G Summit in June 2023, all internal to the consortium.

More than (>100) scientific publications:

To date, Hexa-X has achieved a remarkable milestone with 110 accepted scientific contributions, encompassing a wide range of formats such as journal articles, conference papers, and book sections. These publications hold tremendous significance, particularly within the context of advancing 6G research. They serve as a testament to Hexa-X's dedication to pushing the boundaries of knowledge and innovation in the field. As the project enters its final phase, the publication rate is projected to experience substantial growth, far surpassing the key performance indicator of surpassing 100 publications with a significant margin. This emphasis on scientific dissemination and sharing findings is crucial for the progress of 6G, fostering collaboration, inspiring further research, and propelling the collective understanding of next-generation communication technologies. By actively contributing to the body of scientific literature in 6G, Hexa-X plays a pivotal role in shaping the future of telecommunications and paving the way for transformative advancements in connectivity, networks, and applications.

More than (>10) press releases:

The press releases issued by Hexa-X partners (including Ericsson, Nokia, UC3M, B-COM, University of Oulu, and Chalmers, among others) hold immense significance in the realm of 6G, surpassing the milestone of 10. These renowned organizations understand the criticality of disseminating the activities and achievements across various web platforms. By strategically sharing their work through press releases, they effectively reach a diverse audience, including industry experts, researchers, policymakers, and the general public. The importance of press releases and web-based dissemination in

6G lies in their ability to amplify the impact of the research and development efforts undertaken by Hexa-X partners. By actively sharing their findings, breakthroughs, and innovations, these partners contribute to advancing the collective understanding of 6G technologies, shaping industry trends, and driving the adoption of future communication systems.

1.2 Structure of the deliverable

The deliverable is structured into four parts. In Section 2, the communication activities of Hexa-X including the communications activities to the general public. Here the overall achievements are presented, the web and social media impact, and a novel initiative on gender equality that started in Hexa-X but has grown to other projects. In Section 3, focus on the industrial and scientific dissemination. Overall achievements, online talks, scientific workshops, publications, and communication talks are presented. Finally, in Section 4 the standardization, industry fora and intellectual property achievements.

2 Communication activities

All partners have committed since the first day to promote the project to the general public through different kinds of activities. The Hexa-X project has carried out social media appearances, press releases, project communications, presentations, workshops, and so on. This strong initiative has resulted in the creation and use of social media networks like Twitter, LinkedIn, Youtube, and Instagram. The number of views and followers in these platforms have grown rapidly during this first year, reaching many users, and therefore increasing the awareness about the Hexa-X initiative and its developments.

In the following subsections, we report on all the activities that were categorized under the "communication to the general public" in the project plan.

2.1 Overall achievements

In this section, we report the Y1 achievements of the project related to communication activities with respect to the targets planned in the initial project plan. These are listed in Table 1.

Table 1: Communication achievements.

Type	Target by the end of the project	Achieved
Press releases	>10	15
Website visits/users	>1000, with >75% outside the consortium	172,552 views 53,717 users
Social media channels used	Twitter, LinkedIn, Instagram, Youtube	Yes

Regarding the press releases, the project has achieved reached and surpassed the target number of 10.

The number of website users exceeded the target of 1000 visits, with more than 75% of them originating from outside the consortium, already by the end of the first year of the project. As reported in Section 2.3, by the end of May 2023 the website had more than 53,700 users, the top country being the United States with over 6,100 users. The top five sources of traffic were directly (~22,300), via Google organic search (~20,800), via LinkedIn referrals (~1,300), ericsson.com referrals (~1,100), and Bing organic search (~1,000). This is detailed in Figure 5. The most viewed pages were the front page (> 47,900), Deliverables page (> 21,800), About (> 13,800), News archive (6,200), and the 2022 ICT-52 Workshop on 6G event page (> 5,400).

In addition to the website, the project utilized several social media platforms as planned. These social media sites help to further disseminate the project results, as some of the website statistics indicate, more on this in the Section 2.4.

2.2 Press releases

We list below in Table 2 the press releases published by Hexa-X partners, listed by publication date, partner involved, and link to the press release.

Table 2: Press releases

Date	Category	Partners involved	URL
1/28/2021	Press Release	Ericsson AB	https://www.ericsson.com/en/blog/2021/1/hexa-x-initiative-to-shape-6g

1/28/2021	Press Release	Nokia Solutions and Networks OY, Ericsson AB	Hexa-X – The joint European initiative to shape 6G - Hexa-X
3/2/2021	Press Release	Institute IMDEA Networks, Universidad Carlos III de Madrid	https://networks.imdea.org/5tonic-joins-hexa-x-project-to-set-the-path-for-the-next-generation-of-mobile-communication-networks-beyond-5g/
8/4/2021	Press Release	Universidad Carlos III de Madrid	https://www.uc3m.es/ss/Satellite/UC3MInstitucional/es/Detalle/Comunicacion_C/1371307779203/1371215537949/Arranca_el_proyecto_europeo_Hexa-X_para_el_desarrollo_de_la_tecnologia_6G
12/7/2020	Press Release	Nokia Solutions and Networks OY	https://www.nokia.com/about-us/news/releases/2020/12/07/nokia-to-lead-the-eus-6g-project-hexa-x/
1/26/2021	Press Release	B-COM	https://b-com.com/en/institute/bcom-galaxy/hexa-x
12/11/2020	Press Release	Chalmers Tekniska Högskola AB	https://www.chalmers.se/en/departments/e2/news/Pages/Designing-the-6G-networks-of-the-future.aspx
03/01/2021	Press Release	University of Oulu	https://hexa-x.eu/6g-vision/submission-of-first-hexa-x-deliverable/
03/02/2021	Press Release	University of Oulu	6G Flagship en Twitter: "European flagship project for #6G @Hexa_X_2020 has published its first deliverable just two months after the kick-off. The initial #vision including also @UniOulu @6Gflagship inputs is a must-read!" / Twitter
6/23/2021	Press Release	B-COM	https://www.eetimes.eu/ee-times-europe-magazine-june-2021/
7/15/2021	Press Release	Ericsson AB	https://www.ericsson.com/en/blog/2021/7/hexa-x-6g-technology-6g-use-cases
06/23/2021	Press Release	B-COM	EE Times Europe Magazine - June 2021 - EE Times Europe
03/06/2022	Press Release	Nokia Solutions and Networks OY	Suomi vahvasti mukana Euroopan 6G-taajuustyössä | Traficom
10/10/2020	Press Release	Sztaki	https://www.sztaki.hu/tudomany/hirek/6g-technologiat-kutatja-sztaki
6/5/2023	Press Release	Ericsson	https://www.ericsson.com/en/blog/2023/6/hexa-x-laying-the-foundation-for-6g

2.3 Project Website

The project website, reachable at https://hexa-x.eu/ has sustained a notable number of visits during the project. From January 1st, 2021, until May 22nd 2023, the total number of users that visited our web page has been 53,717. In Figure 2, the distribution of this number of users over time is depicted.

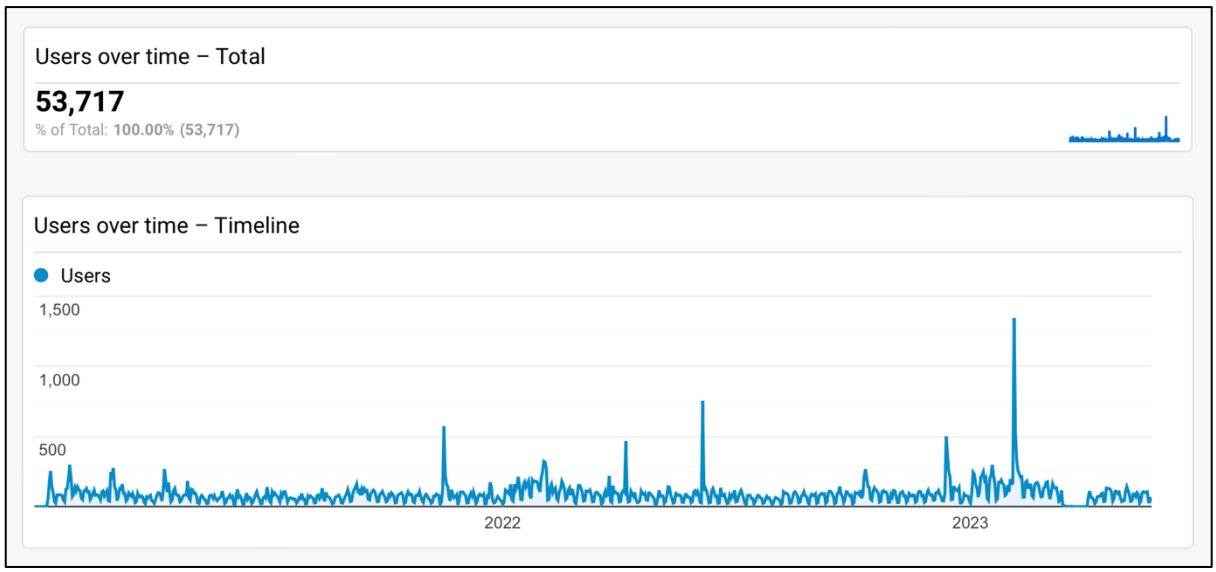


Figure 2. Number of website users over time.

The figure illustrates a typical daily pattern, with most of the visits happening during office hours on weekdays. The most notable spikes in traffic were mostly triggered by the events related to the Hexa-X project, either on the site itself (around the ICT Workshops) or on third-party platforms (such as around the first press releases on the launch of the Hexa-X-II). The highest peaks have been listed in a Table 3 below.

Table 3: Traffic peaks and anomalies on the Hexa-X website.

Date	Number of visitors	Assumed reason of activity
January 13 2021	254	Hexa-X website launch
January 28 2021	298	• News item published • Press releases
March 3 2021	276	• Deliverable published • News item published • Press release
April 12 2021	268	• EuCNC & 6G Summit 2021 proposal accepted
November 16 2021	573	• Internal reminder to follow our social channels • Partially unclear
February 2 2022	323	• Virtual ICT-52 Workshop on 6G 2022
April 7 2022	466	• Source: trafficland.xyz, most likely a bot
June 6 2022	755	• Source: shoptraffic.live, most likely a bot • Some traffic might be due to the EuCNC & 6G Summit

October 11 2022	266	• Hexa-X-II project announcement • News item published • Press releases
December 13 2022	501	• News item published
January 3 2023	244	• Registrations to ICT-52 Workshop on 6G 2023 • Hexa-X-II website and social media pages published
January 11 2023	248	• Registrations to ICT-52 Workshop on 6G 2023
January 18 2023	297	• ICT 52 Workshop on 6G 2023
Febryary 4 2023	1344	• ICT52 workshop • Some traffic might be due to the upcoming plenary meeting on February 7-9
March 14 – April 2 2023	16	• Technical issue, most visits were not recorded to the analytics

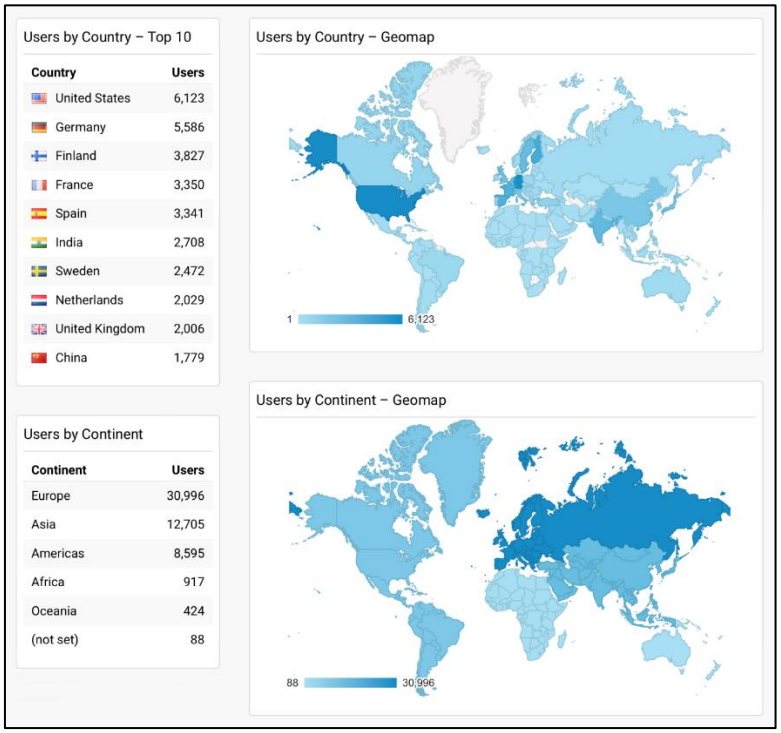
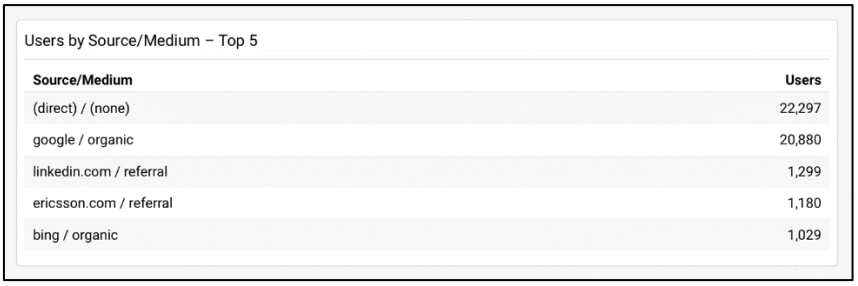


Figure 3. Website users by country and by continent.

The number of users by country and by continent is presented in Figure 3. Being a European initiative, most of the users come from Europe (~31,000). However, this also means, that roughly 42% of the users come from outside Europe, and therefore outside the consortium. Of course, we can't know exactly who the users are, and if they are somehow part of the consortium, but the top sources of traffic and the pages they view most indicate, that we have indeed achieved the set KPIs with flying colors.

Figure 4 indicates the source and medium of the traffic. Around 41,5% of the users access the site directly. Other main traffic sources are Organic search via Google and Bing, and referrals from social media such as LinkedIn, and third-party sources such as Consortium partners' websites.

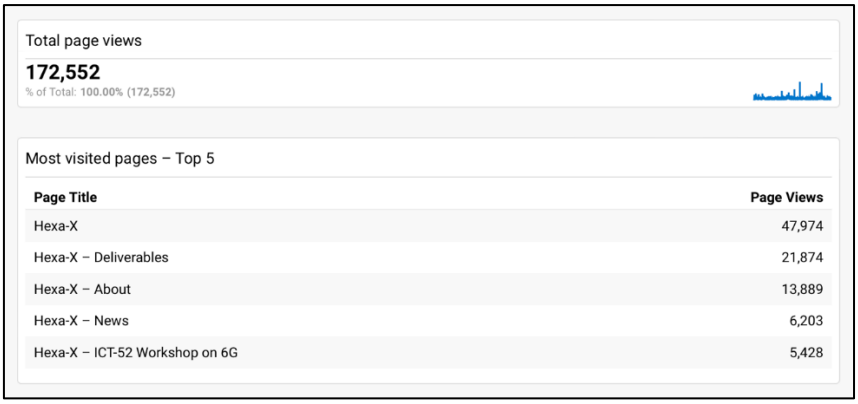


Users by Source/Medium – Top 5

Source/Medium	Users
(direct) / (none)	22,297
google / organic	20,880
linkedin.com / referral	1,299
ericsson.com / referral	1,180
bing / organic	1,029

Figure 4. Users by source and medium.

Figure 5 depicts the most visited pages. In total, the web page has accumulated 172,552 page views during the considered period (from January 1st, 2021, until May 22nd 2023). According to the statistics, about 28% of the visits are to the main page, 13% to the Deliverables page and 8% to the About page.



Total page views

172,552

% of Total: 100.00% (172,552)

Most visited pages – Top 5

Page Title	Page Views
Hexa-X	47,974
Hexa-X – Deliverables	21,874
Hexa-X – About	13,889
Hexa-X – News	6,203
Hexa-X – ICT-52 Workshop on 6G	5,428

Figure 5. Most visited website pages.

2.4 Social media and other sites (UC3M)

The project has set up and actively provided content to different social sites, namely:

- Twitter account: https://twitter.com/hexa_x_2020
- YouTube account: https://www.youtube.com/channel/UC_pKq13zKmepaEtl2Wv1dyg
- LinkedIn group: https://www.linkedin.com/groups/9019059/
- Instagram account: https://instagram.com/hexa_x_2020/

In the following, some additional details about the activity and statistics for each of these channels are presented.

2.4.1 Twitter

As of May 2023, the twitter account has 517 followers and follows 18 accounts. Figure 6 below depicts the number of tweet impressions.

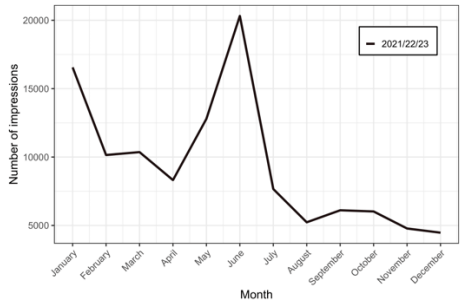


Figure 6. Tweet impressions by month.

2.4.2 YouTube

Project partners have invested a remarkable effort to disseminate the results through as many channels as possible. The YouTube channel exemplifies this. In addition to the online presentation of talks, partners have recorded their intervention for a later upload to the channel, in this way reaching a larger audience than by just the real-time streaming of the event. As of late May 2023, the YouTube account has 216 subscribers and accumulated 9646 views. Table 4: Hexa-X communication videos. presents uploaded videos during Y1 of the project.

Table 4: Hexa-X communication videos.

Date	Item	URL
8/6/2021	EuCNC Workshop	https://www.youtube.com/watch?v=2dkC3spqOqU&t=587s
8/6/2021	Hexa-X Use cases and key value indicators	https://www.youtube.com/watch?v=N_bUAGkzz-8
5/19/2021	Hexa-X overview panel	https://www.youtube.com/watch?v=js-v00y3jt4
16/6/2021	Hexa-X: Defining the Blueprint for 6G	https://www.youtube.com/watch?v=Xvc_w_VmlwA
14/5/2021	Hexa-X project overview	https://www.youtube.com/watch?v=d-_WERSmjPE
23/6/2021	Advances in network evolution and expansion	https://www.youtube.com/watch?v=-H2e-HeBHlU
8/6/2021	DEDICAT 6G	https://www.youtube.com/watch?v=829Tungv6-0
24/8/2021	Integrated communication, localization and sensing in 6G era.	https://www.youtube.com/watch?v=zGOGzbHz0SA
27/8/2021	AI Based Landscape Sensing	https://www.youtube.com/watch?v=XMrDfTemRUo&t=16s
1/7/2021	Hexa-X workshop on 6G vision	https://www.youtube.com/watch?v=v8RFpXIEfzs
11/06/2021	Connecting Intelligence and Smart Orchestration for B5G/6G Networks	https://www.youtube.com/watch?v=8Nbw99kOOX4
03/02/2022	ICT 52 Workshop on 6G - First day - Morning session	https://www.youtube.com/watch?v=GJYNqjlmVf8
03/02/2022	ICT 52 Workshop on 6G - First day - Afternoon session	https://www.youtube.com/watch?v=3cIuhx2VOTs
04/02/2022	ICT 52 Workshop on 6G - Second day - Morning session	https://www.youtube.com/watch?v=ozJPRVxCmYs
04/02/2022	ICT 52 Workshop on 6G - Second day - Afternoon session	https://www.youtube.com/watch?v=S00SDGmuHbc
2022	Hexa-X update overview (first released at EuCNC & 6G Summit 2022)	https://www.youtube.com/watch?v=_2fcE0RwTYs
2022	WiTaR video at EuCNC 2022	https://www.youtube.com/watch?v=o9SkIhs8iLY
10/06/2022	6G Radio Requirements to Support Integrated Communication, Localization, and Sensing - EuCNC 2022	https://www.youtube.com/watch?v=sAbK3_7PS2g
01/07/2022	Joint communication and sensing using the same HW waveforms based on 5G NR standard	https://www.youtube.com/watch?v=8uNwjm5FvL4

01/10/2022	Demo: FoReCo - Forecast-based Recovery mechanism for real-time Remote control of robot manipulators	https://www.youtube.com/watch?v=DwsewsDLQuA
15/02/2023	Workshop on 6G by Hexa-X and ICT-52 – Day 1, Session 1 (end)	https://www.youtube.com/watch?v=tnXTkimooHU
18/01/2023	Workshop on 6G by Hexa-X and ICT-52 – Day 1, Session 2	https://www.youtube.com/watch?v=epYgZd3ovQI
19/01/2023	Workshop on 6G by Hexa-X and ICT-52 – Day 2, Session 1	https://www.youtube.com/watch?v=UzCe2F3KXYk
19/01/2023	Workshop on 6G by Hexa-X and ICT-52 – Day 2, Session 2	https://www.youtube.com/watch?v=U5DQ8mg5GWk
05/06/2023	Hexa-X Demo 5 - Scenario 1- "Continuum orchestration of AI/ML driven traffic lights control service"	https://www.youtube.com/watch?v=daOKXkUAF60
05/06/2023	Hexa-X Demo 5 - Scenario 3 - "Reactive security for the edge"	https://www.youtube.com/watch?v=4iVdBF_G5E0
05/06/2023	Hexa-X Demo 5 - Scenario 4 - "MLOps techniques to deploy AI/ML service orchestration"	https://www.youtube.com/watch?v=wzw7MhiiOPI
05/06/2023	Hexa-X Demo 2 - "Fed-XAI"	https://www.youtube.com/watch?v=azuTyB-LdmQ
05/06/2023	Hexa-X Demo 3 - "FLEX-TOP"	https://www.youtube.com/watch?v=UUWbOEsYmvs
05/06/2023	Hexa-X Demo 4 - "ROBO-HUSIIC"	https://www.youtube.com/watch?v=fLgkcUI_FsE
05/06/2023	Hexa-X Demo 5 - Scenario 2 - "Prediction-based URLLC service orchestration and optimization"	https://www.youtube.com/watch?v=Icq7-m8Yf5A
05/06/2023	Hexa-X Demo 1- "Joint Communication and Sensing"	https://www.youtube.com/watch?v=OMqRZjrZJyI
05/06/2023	Hexa-X Demo 1- "Analogue Multicarrier Over 140 GHz channel"	https://www.youtube.com/watch?v=1X3SMWCtlxc

Figure 7. Number of unique YouTube videos. below depicts the number of unique viewers since the beginning of the project.

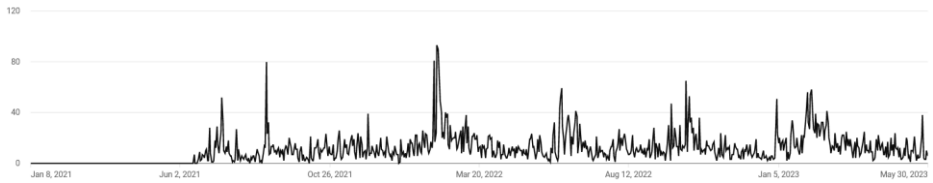


Figure 7. Number of unique YouTube videos.

2.4.3 LinkedIn

The total number of members of the LinkedIn group as of May 2023 is 261. According to the "Group Analytics" recently provided by Linkedin, it had 146 active members during the last year.

2.4.4 Instagram

The Instagram account was set up. In contrast to the other social media sites and groups, the activity of this account is relatively smaller, since the service aims to provide a photo and video sharing service,

with an increasing emphasis on short videos and real-time content. The total number of followers of Instagram as of May 2023 is 56 with a total number of 20 posts and 55 likes.

2.5 Women in Telecommunications and Research (WiTaR)

The women in telecommunications and research is the outcome of Hexa-X initiative "Women in Hexa-X" which was established in February 2021 and then was expanded for the participation of the whole 5G PPP community in June 2021. To reflect the wide participation, the initiative was renamed "Women in Telecommunications and Research (WiTaR)" in October 2021, with its webpage available at https://hexa-x.eu/witar/. This initiative aims at stepping into closing gender gaps and increasing women's participation in as many social fields as possible in the 6G R&I community. The road to close gender equality is still a very long one evidence that the participation of women in Hexa-X is only 20%.

The initiative is open to all and gender neutral. The WiTaR mission statement is many folds:

- Promote equality, diversity and is gender balanced approach in 6G R&I community and working environment;
- Empower women and promote the visibility of women and women leadership in European 6G R&I community;
- Establish a global network from industry, universities, and schools to provide personal support to women in 6G R&I community;
- Promote and encourage to take gender perspective into account in the 6G design;
- Promote and encourage more women joining into technical and engineering studies and actively participate in European 6G R&I community.

The WiTaR community gathers every month to discuss the current issues as well as exchange ideas and work together toward unified goals. The group is also active on social media, in particular, LinkedIn[2] to supply a comprehensive database on specialized women in the field as well as provide recommendations for the open positions in various conferences, TPC members, etc.

WiTaR with the help of its partners and members be able to organize annual workshops in European Conference on Networks and Communications (EUCNC) for two consequence years 2022 and 2023. These workshops aim as spreading the word on the efforts toward gender equality as well as open the door for more interested parties to join.

The group also run three successful campaigns "International Women in engineering day" and "International Women's day" Figure 8, 9 and 10

[2] https://www.linkedin.com/groups/12586184/

Figure 8. WiTaR campaign demonstrating how 6G can help toward shaping the world

Figure 9. WiTaR campaign for Internation women's day 2022

Figure 10. WiTaR campaign for International women's day 2023, embracing the equity

3 Industrial and scientific dissemination

This section reports the status on industrial and scientific dissemination. This dissemination corresponds to activities such as participation in industrial and scientific exhibitions, events, small-scale demonstrators, industrial and scientific workshops organized by Hexa-X, 5GPPP activities, etc.

Table 5 provides a summary of the target KPIs and the achievement reached. Hexa-X members have been very active across the different categories, impacting the various fora considered.

Table 5: Industrial and scientific dissemination achievements.

Type	Target by the end of the project	Achieved
Participation in industrial and scientific exhibitions and events; business conferences	MWC, IWPC, NGMN, EuCNC, IEEE Future Networks	13
Number of small-scale demonstrators	At least 5 (at the end of the project)	6
Organisation and attendance of Hexa-X industrial and scientific workshops	Three A series (beginning, middle, and end of the project) of workshops, each with 100+ attendees, creating the “6G Workshops” series	10
5G PPP activities	Contribution to “Steering Board (SB), Technology Board (TB)”, pre-standardization, trials, architecture, vision, spectrum, SW networks, Vision and societal challenges, and SME WGs	Participation in several WGs, participation in the SB and TB, lead of a white paper on 6G vision.
Smart Networks and Services Programme	Active contributions to the SN&S activities within Horizon Europe framework	SNS initiative approved in November 2021
Number of publications	>100	110

It is worth to recognize the notable progress made by the number of publications the Hexa-X consortium, achieving the ambitious goal of > 100 publications. The publication count is expected to keep on increasing after the finalization of the project, since there are multiple ongoing submissions that have not been accepted. Overall, the substantial quantitative impact of Hexa-X's scientific endeavours confirms its success in advancing 6G research and becoming a driving force in the field.

3.1 Participation in industrial and scientific exhibitions and events; business conferences

Here we summarize the participation in industrial and scientific exhibitions and events. Note that here we only consider those cases when the involvement is relatively low and does not require taking assuming a leading role. Note that in addition to these there are 125 communication activities listed in section 3.6 – many of those are also presentations at major events including conferences. The following Table 6 presents a summary of the events.

Table 6: Participation in industrial and scientific exhibitions and events, and business conferences. Note also the numerous conference presentations mentioned in section 3.6.

Date	Venue	Description
10/06/2021		Swedish 6G workshop - 6G for society https://www.chalmers.se/en/conference/swedish-6G-workshop/Pages/default.aspx
01/11/2022	IEEE CCNC 2022	1ST INTERNATIONAL WORKSHOP ON 6G: VISIONS, USE CASES AND TECHNOLOGIES 1st International Workshop on 6G: Visions, Use Cases and Technologies (6G'22) | IEEE Consumer Communications & Networking Conference - 2022 IEEE CCNC (ieee-ccnc.org)
09/12/2022	PIMRC2022	CLEEN2022 workshop https://pimrc2022.ieee-pimrc.org/
06/06/2023	EuCNC 2023	Synergies between communication, localization, and sensing towards 6G
06/06/2023	EuCNC 2023	Aligning European NTN Convergence and Integration
06/06/2023	EuCNC 2023	Measuring societal value impact in 6G with KVIs
07/06/2023	EuCNC 2023	Dependable wireless communication systems and deterministic 6G communication
07/06/2023	EuCNC 2023	Magnus Frodigh: "6G – Connecting a cyber-physical world"
08/06/2023	EuCNC 2023	6G Architecture – European View
08/06/2023	EuCNC 2023	The path to 6G standardization
08/06/2023	EuCNC 2023	Peter Vetter: "6G getting into next gear"
09/06/2023	EuCNC 2023	Research Challenges and Opportunities in 6G

3.2 Organisation and attendance of Hexa-X industrial and scientific workshops

The industrial and scientific workshops of Hexa-X are presented in Table 7, which account for a total number of seven. They include the "6G Summit" series as well as other topics addressed in the project, such as artificial intelligence or localization.

Table 7: Hexa-X workshops

Date	Venue	Description
9/13/2021	IEEE PIMRC	1st Workshop on Integrated Communication, Localization and Sensing in 6G Era https://pimrc2021.ieee-pimrc.org/integrated-communication-localization-and-sensing-in-6g-era/
9/13/2021	IEEE PIMRC	1st Workshop on Dependable Connectivity in 6G https://pimrc2021.ieee-pimrc.org/workshop-on-dependable-connectivity-in-6g/
6/8/2021	EuCNC & 6G Summit	Hexa-X - The European 6G Initiative

		https://www.eucnc.eu/programme/workshops/workshop-5/
6/28/2021	ONDM2021	Hexa-X workshop on 6G vision https://ondm2021.chalmers.se/hexa-x-workshop-on-6g-vision/
02/03/2022	Virtual event	ICT-52 workshop on 6G ICT-52 Workshop on 6G 2022 - Hexa-X
7/6/2022	EuCNC & 6G Summit	6G workshop series https://hexa-x.eu/eucnc-6g-summit-2022-the-6g-workshop-series-by-hexa-x/
10/18/2022	Network-X	The 6G workshop series by Hexa-X Network X | The 2022 Agenda (networkxevent.com)
01/18/2023	Virtual event	Workshop on 6G by Hexa-X and ICT-52 ICT 52 Workshop on 6G 2023 - Hexa-X
6/6/2023	EuCNC & 6G Summit	6G workshop series https://www.eucnc.eu/programme/workshops/workshop-3/
6/6/2023	EuCNC & 6G Summit	WiTaR: Women in telecommunication and Research

Regarding the audiences of the workshops, sometimes it was difficult to accurately estimate it given the conditions caused by COVID19. Still, according to Hexa-X participants the number of people online were estimated as:

- IEEE PIMRC: approx. between 50-100 people for each workshop.
- EuCNC & 6G: approx. between 50-100 people/workshop.
- ONDM: approx. between 20-50 people.

3.3 Demonstrations activities

Demonstrations activities have been carried out in the second phase of the project, after working on their preparations in the first months.

In particular, demos have been shown at the ICC 2023 in Rome in May 2023 and at the EuCNC in Goteborg in June 2023.

Regarding ICC 2023 Wings and Nokia have shown the Flexible Topology demo, also presented later on during the EuCNC/6G Summit 2023.

Regarding EuCNC/6G Summit 2023, at the Hexa-X exhibition booth, visitors witnessed six demos showcasing various aspects of the 6G technology. The booth has been the best one in the overall exhibition at the EuCNC/6G Summit 2023, according to the results of the vote performed during the event. The demos have been:

- Joint communication and sensing by Qamcom
- Collaborative robots in industrial contexts by WINGS and Nokia
- Data-driven device-edge-cloud continuum management by Atos, Nextworks, University of Pisa, University Carlos III de Madrid, University of Murcia, BCOM
- 6G waveforms in action by TU-Dresden and University of Oulu
- Federated explainable AI by University of Pisa, Intel, TIM
- Flexible topology by WINGS

During the event, the first three demos have been shown with live presence, while the latter three have been recorded and shown in specific videos, due to lack of space. These videos are all available on the Youtube channel of the project as well.

Some details on the demos and the related exhibition events are reported in the following.

3.3.1 Joint communication and sensing

Demo description: The demo shows that hardware initially designed for communications (60GHz), can readily be used to perform radar-like sensing. Since the demo is based on real RF and digital hardware, all commonly seen hardware impairments are present. The setup uses completely independent transmit and receive analog hardware with analog beamsteering. The waveform used for communication and sensing is based on 5G-NR.

Main message: Sensing (in the sense of radar) and communication historically use very similar hardware. We demonstrate that sensing and communication can be performed using the same hardware as well as the same waveforms.

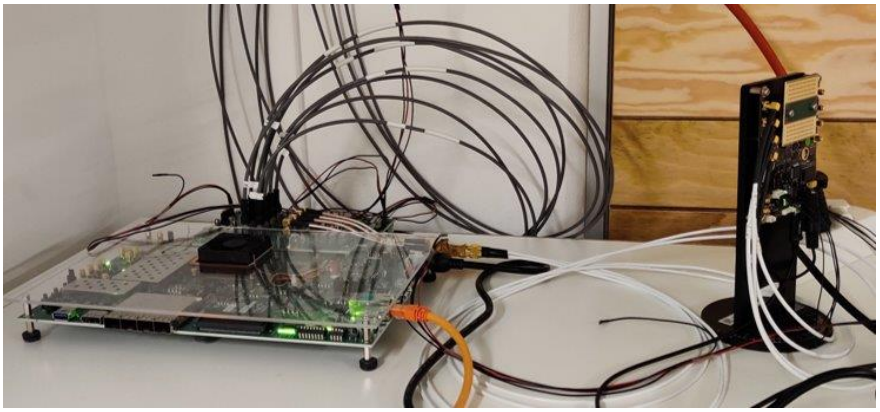


Figure 11. Joint communication and sensing demo

3.3.2 Collaborative robots in industrial contexts

Demo description: this demo aims to demonstrate the "fabric" for the future 6G system that connects the human, physical, and digital worlds. It involves virtual reality, autonomous cobots, which allow for human involvement in industrial tasks with digital twins via VR technology with immersive realistic 3D graphics. Specifically, the demo includes AI-enabled algorithms, mobile robots, wireless connectivity, extreme edge-enabled cloud infrastructure system to enable remote and real-time control, monitoring as a service, diagnostics, digitalization, and automation in industrial environments. The ultimate goal is to connect the Human, Physical and Digital worlds through cloud-native resource provisioning from the cloud to the extreme edge and specifically over autonomous robots, with the human in the loop for interactions, repairs, or even manual teleoperation. The architecture supports orchestration procedures for automatic and even predictive (re-)deployments, as well as real-time Monitoring (MaaS) and analysis of the system, network, and robot metrics. The developed Digital Twin application allows for remote monitoring and control of industrial systems, robots, and their parts with real-time video streaming and VR glasses for interaction and adjustments.

Main message: this demo cloud-native resource provisioning system employs intelligent orchestration, management, monitoring, and diagnostics to seamlessly connect the Human, Physical, and Digital worlds, as part of the 6G continuum. With Digital Twin application, cobots, networks and applications can be remotely monitored, supervised, or even manually controlled, using VR goggles or user-friendly and intuitive app. AI/ML algorithms optimize networks and applications/services placement, reconfiguration, and predictive orchestration at the extreme-edge. At exhibitions, audience could experience the future of robotics and automation first-hand, by interacting and controlling robots with ease.

Figure 12. Collaborative robots in industrial contexts demo.

3.3.3 Data-driven device-edge-cloud continuum management

Demo description: this demo targets the demonstration of the data-driven device-edge-cloud continuum management concept, focusing on a simulated road-traffic urban environment on which services are deployed through the device-edge-cloud continuum, extending the M&O scope beyond the edge. The demo relies not only on simulations, but also on practical hardware-based implementations of certain extreme-edge resources by means of small-scale computing devices, to simulate the traffic lights and their associated controllers in that urban environment.

Main message: the demo focuses on using data-driven and AI/ML techniques in different scenarios, covering aspects such as the deployment of an AI/ML-driven network service to provide a smart control of the traffic lights in the urban environment, application of proactive scaling polices for a URLLC service based on the predicted road traffic conditions, security aspects applied to this context, and the application of MLOps techniques to deploy AI/ML services.

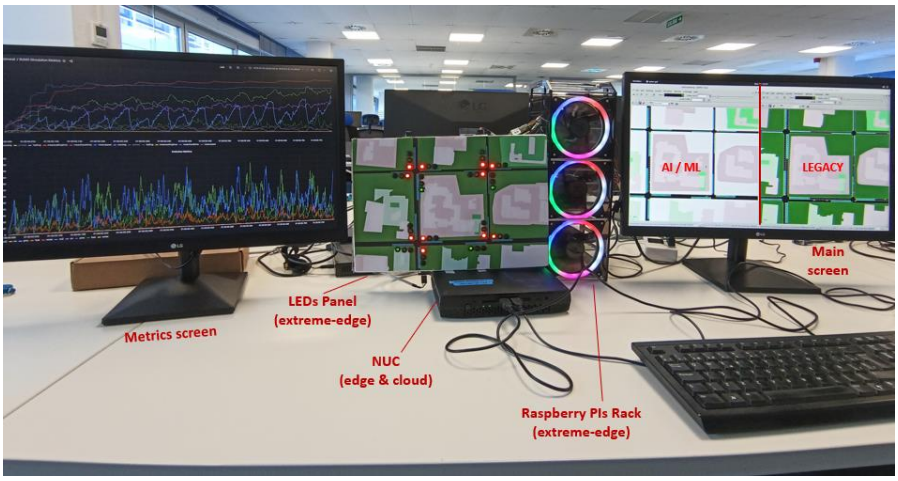


Figure 13. Data-driven device-edge-cloud continuum management demo – Scenario 1.

3.3.4 6G waveforms in action

Demo description: the sub-THz frequency band (100 – 300 GHz) offers ultra-wide bandwidth, which is crucial for ultra-high data rate transmission. However, generating ultra-wideband waveforms, such as OFDM and its variant, with a single transceiver chain is challenging because of the need of high speed and high-resolution DAC/ADC. Alternatively, channelization can be employed, where the large bandwidth is split into multiple narrower-band channels, each using a dedicated IF transceiver chain for

each channel (carrier). In this demo, we illustrate the concept of channelization, denoted as analogue multicarrier waveform, and conduct real-time transmission over 140 GHz link. The IF transceivers (0-6 GHz) are implemented using SDR platforms, while frequency extenders are used in the conversion to 140 GHz. A real-time flexible digital baseband transceiver is implemented on FPGA for waveform generation and receiver detection. Video broadcasting is used as an example for data transmission, with several showcases' demonstration highlighting the feasibility of communication at sub-THz at different ranges. The impact of blockage and penetration through different materials is also examined. In addition, we demonstrate various waveforms and illustrate the transceiver flexibility by controlling the sub-channels (carrier and bandwidth) and adjusting waveform parameters.

Main message: the demo illustrates the feasibility of sub-THz communication and presents an implementation architecture for 6G ultra-wideband that allows relaxing the baseband hardware requirements of the transmitter and receiver, such as ADC speed. This architecture also provides a high degree of flexibility in spectrum management and enable implementation of wideband across non-contiguous band.

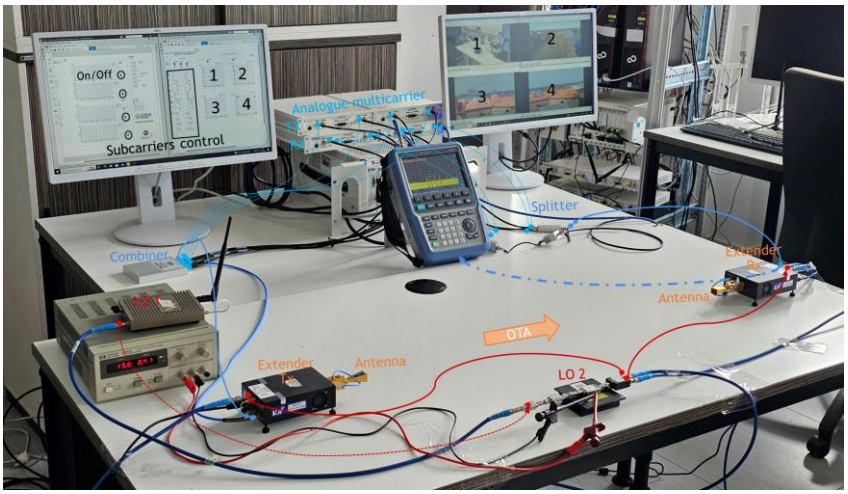


Figure 14. 6G waveforms in action demo.

3.3.5 Federated explainable AI

Demo description: the demo resembles a tele-operated driving use case, where the high quality of the video streaming sent by a car to a remote driver is key to the correct operation of the service. The implemented testbed shows the real-time forecasts of future QoE of a video stream sent through an emulated mobile network. The testbed is realized using four devices connected via Ethernet cables, and is meant to work as follows: a video is streamed from a laptop (host A) to a tablet (host B), via a PC running the emulated network (host C). The tablet plays out the received video, whose quality depends on the radio conditions encountered by the video stream while traversing the emulated network. During the streaming, QoS metrics are collected in real time from the emulated network and sent to a fourth PC (host D) that predicts the future QoS of the video stream. This is accomplished by using an XAI model, pre-trained according to the Federated Learning approach. The results of the inference are shown in real time on a screen through a graphical dashboard. The audience can see the predicted QoE in the dashboard and, in parallel, the corresponding quality of the video on the tablet. For example, when the dashboard predicts a poor QoE, the video on the tablet freezes or shows impairments after a few seconds. The dashboard also shows which performance indicators caused the QoE degradation. This may be useful for end users or network operators to learn root causes for the degradation and take the relevant countermeasures.

Main message: In-network AI enhances the services offered to both end users and network operators, for instance predicting the QoS experienced by users. By exploiting Federated Learning of eXplainable AI (FED-XAI) models, users and/or network operators can learn the motivations that produced the predictions in order to take the appropriate actions in advance. This is accomplished without sharing private user data, hence favouring the transition towards a trustworthy and transparent mobile network.

Figure 15. Federated explainable AI demo.

3.3.6 Flexible topology

Demo description: 6G will focus on improved communication between humans and machines, seamless integration of various network types, and the deployment of new communication interfaces in the new so-called network of networks. Devices will evolve to include smart wearables, integrated headsets, and implants, leading to the potential end of traditional smartphones. Modularization, open interfaces, and software-defined networking will enable customizable, adaptable, and interoperable network solutions. Integration of AI and ML will enhance network performance, optimize operations, and ensure more efficient resource management. UEs will connect to multiple access points simultaneously, providing improved connectivity and reduced handover latency. NPNs will allow for customized, end-to-end service management and mobility for devices without dual SIM connectivity. FLEX-TOP demo is a key enabler for integrating these aspects, providing a versatile and dynamic network infrastructure that can adapt to various requirements and scenarios.

Main message: Evaluating the feasibility of using specialized UAVs for wildfire monitoring in remote rural areas. A novel approach to address connectivity and computing requirements. Firefighters equipped with sensors (thermal/hyperspectral cameras, temperature sensors, etc.). Assess the feasibility and effectiveness of using specialized UAVs vs. pre-deployed static infrastructure for streaming multimedia footage. Balancing infrastructure costs, energy consumption, trustworthiness, and sustainability.

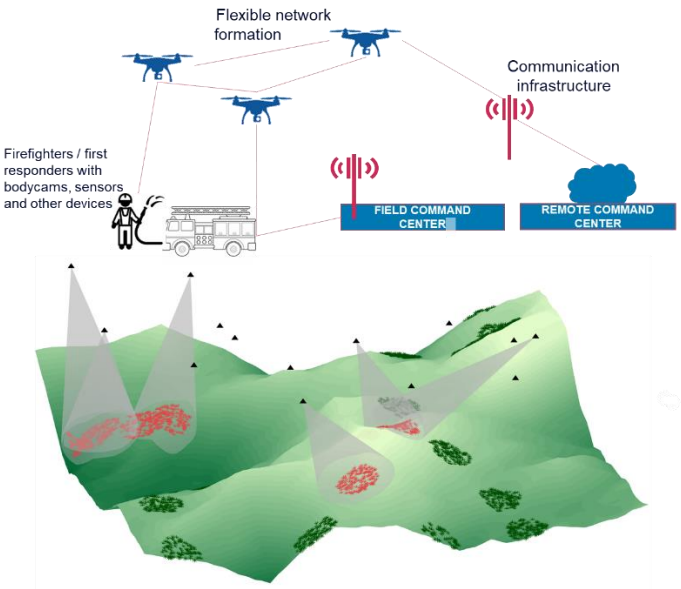


Figure 16. Flexible topology demo.

3.4 5GPPP and Smart Networks and Services Joint Undertaking

As we stated already in previous deliverable, the Council of the European Union approved the creation of the European Smart Networks and Services Joint Undertaking (SNS JU) in November 2021. Members from the Hexa-X consortium have contributed towards the success of this initiative, with the project Hexa-X representing a foundational cornerstone for the creation and implementation of the JU itself.

Meanwhile, the JU has progressed its starting activities, giving itself the name of "6GSNS" and launching the first projects in its framework in January 2023. Among these projects, also a new flagship, called "Hexa-X-II" has started, with a much larger consortium than Hexa-X, but referring to Hexa-X as a fundamental project as an input. Indeed, Hexa-X-II will likely bring to a synthesis many of the activities and achievements of its predecessor, in the next few years, paving the way to the European view on 6G.

Within 6GSNS many of the Working Groups previously hosted by 5GPPP/5GIA have been brought forward. Among these, Hexa-X has ensured its support and cooperation to many. Not mentioning Steering and Technical Board, where the Project Coordinator and the Technical Manager have continuously ensured their contribution, some Working Groups must be mentioned, being those where Hexa-X has been more active.

In particular, the "Pre-Standardization" Working Group has been constantly monitored by Hexa-X, with an active participation of the T8.2 leader. WG Vision has also seen frequently contributions from Hexa-X, especially in the phase of settlement of the future trends towards 6G implementation.

Mention apart is for the Working Group "Architecture", where Hexa-X has strongly influenced the activities in the latest two and a half years. In 2022 Hexa-X has actively contributed to the preparation and publication of the White Paper on the 6G Architecture, which has been the most important and impactful activity of that group, with several contributions from WP1, WP2 and WP5 mainly. In 2023, the WG Architecture has taken the lead to issue a new book on 6G "trends" with nowpublishers.com, book that has been made public in June 2023 during the EuCNC&6G Summit event in Göteborg. The book includes prefaces from the European Commission and the 6GSNS, as well as a specific chapter on the foreseen roadmap towards 6G in Europe and worldwide.

Finally, as mentioned above, the project also presented the "Women in Hexa-X/6G Initiative" to the Steering Board, which was eventually rebranded and extended to the whole 6GSNS association.

3.5 Scientific Publications

The numbers of scientific publications (conference papers, journals, etc.) has started growing since the beginning. After the initial time invested during the first months of the project, to perform the initial gap analyses, identify the research problems, etc., the growth of scientific achievements is gaining importance. Up to the date, Hexa-X has 110 accepted scientific contributions (the number of submitted papers is obviously larger), including journal articles, conference papers, and book sections. This publication rate is expected to grow significantly surpassing the KPI of having > 100 publications with a large margin.

Figure 17 depicts the research activities of Hexa-X project. As can be observed, conference papers are majority, followed by journal articles,book sections and posters. In Table 8, the aforementioned activities are detailed with the corresponding title and publisher.

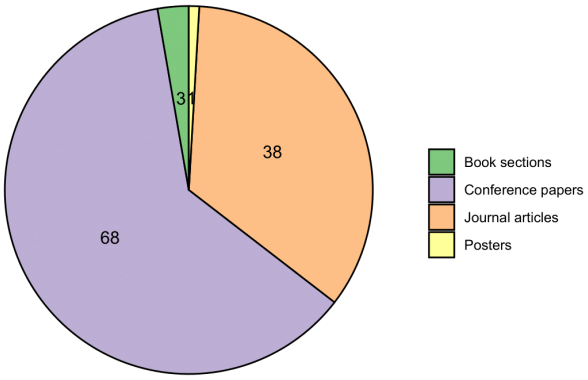


Figure 17. Research activities by type of Hexa-X.

Table 8: Scientific publications.

Type	Title	Publication/Conference
Journal	Federated Learning at the Network Edge: When Not All Nodes are Created Equal,	IEEE Communication Magazine
Journal	6G networks: Beyond Shannon towards semantic and goal-oriented communications	Elsevier Computer Networks
Journal	Why Do We Need 6G?	ITU Journal on Future and Evolving Technologies: 2 (6).
Journal	Scalable Real-time Emulation of 5G Networks with Simu5G	IEEE Access
Journal	Discontinuous Computation Offloading for Energy-Efficient Mobile Edge Computing	IEEE Transactions on Green Communications and Networking.
Journal	6G Vision, Value, Use Cases and Technologies From European 6G Flagship Project Hexa-X	IEEE Access
Journal	How many beams does sub-THz channel support?	IEEE Antennas and Wireless Propagation Letters
Conference	Hexa-X The European 6G flagship project	EuCNC 2021

Conference	Predictive Network Management and Orchestration Towards 6G	EuCNC 2021
Conference	Study of Reflection-Loss-Based Material Identification from Common Building Surfaces	EuCNC 2021
Conference	Blind Neural Belief Propagation Decoder for Linear Block Codes	EuCNC 2021
Conference	Above-100 GHz Wave Propagation Studies in the European Project Hexa-X for 6G Channel Modelling	2021 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit)
Conference	Measured Blockage Effect of a Finger and Similar Small Objects at 300 GHz	2021 15th European Conference on Antennas and Propagation (EuCAP), 22-26 March 2021
Conference	XAI Models for Quality of Experience Prediction in Wireless Networks	2021 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), Luxembourg, Luxembourg, 11-14 July 2021
Conference	Hexa-X: Trustworthy Networking Beyond 5G	EuCNC 2021
Conference	Nuberu: Reliable RAN Virtualization in Shared Platforms	ACM MobiCom 2021: The 27th Annual International Conference On Mobile Computing And Networking (ACM MobiCom 2021),
Conference	Uncertainty of Millimeter-Wave Channel Sounder due to Integration of Frequency Converters	International Symposium on Wireless Communication Systems 2021 (ISWCS 2021)
Conference	AI Based Landscape Sensing Using Radio Signals	2021 IEEE 32nd Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC)
Conference	6G Architectural Trends and Enablers	5GWF 2021
Conference	Resilience Analysis of Distributed Wireless Spiking Neural Networks	IEEE Wireless Communications and Networking Conference (WCNC)
Book section	Wireless Edge Machine Learning in 5G/6G Networks	MACHINE LEARNING AND 5G/6G NETWORKS: INTERPLAY AND SYNERGIES
Conference	Privacy Preserving Federated RSRP Estimation for Future Mobile Networks	IEEE GLOBECOM
Conference	Interference-aware Distributed Precoding in Coherent Large-scale Distributed MIMO	IEEE GLOBECOM

Conference	Predictive network management and orchestration towards 6G	EuCNC
Journal	Analysis of scaling policies for NFV providing 5G/6G reliability levels with fallible servers	IEEE Transactions on Network and Service Management
Conference	Deep learning for location based beamforming with NLOS channels	arXiv
Conference	Waveform Comparison under Hardware Limitations for 6G Sub-THz Communications	CCNC
Conference	Dynamic Ensemble Inference at the Edge	IEEE GLOBECOM
Conference	Learning Semantics: An Opportunity for Effective 6G Communications	CCNC
Conference	Integration of Communication and Sensing in 6G: a Joint Industrial and Academic Perspective	PIMRC
Journal	Limited Feedforward Waveform Design for OFDM Dual-Functional Radar-Communications	IEEE TRANSACTIONS ON SIGNAL PROCESSING
Journal	MIMO-OFDM Joint Radar-Communications: Is ICI Friend or Foe?	IEEE JOURNAL OF SELECTED TOPICS IN SIGNAL PROCESSING
Conference	Radar Sensing with OTFS: Embracing ISI and ICI to Surpass the Ambiguity Barrier	ICC Workshops
Conference	Towards Power Efficient 6G Sub-THz Transmission	EuCNC
Conference	A Federated Fuzzy c-means Clustering Algorithm	CEUR Workshop
Journal	On Topology Optimization and Routing in Integrated Access and Backhaul Networks: A Genetic Algorithm-based Approach	OJ-COMS
Conference	Uncertainty of Millimeter-Wave Channel Sounder due to Integration of Frequency Converters	ISWCS
Journal	Millimeter-wave Mobile Sensing and Environment Mapping: Models, Algorithms and Validation	IEEE Transactions on Vehicular Technology
Conference	Energy-Efficient Classification at the Wireless Edge with Reliability Guarantees	ICC Workshops
Conference	Indoor Material Transmission Measurements between 2 GHz	EuCAP

	and 170 GHz for 6G Wireless Communication Systems	
Conference	Effective Goal-oriented 6G Communications: the Energy-aware Edge Inferencing Case	EuCNC
Conference	Energy-Efficient Dynamic Edge Computing with Electromagnetic Field Exposure Constraints	EuCNC
Conference	Deep Learning for Wireless Dynamics	ICC Workshops
Conference	Leveraging triplet loss and nonlinear dimensionality reduction for on-the-fly channel charting	SPAWC
Conference	Multi-Sensory HMI for Human-Centric Industrial Digital Twins: A 6G Vision of Future Industry	IEEE SMS
Conference	Setting 6G Architecture in Motion - the Hexa-X Approach	EuCNC
Journal	Lyapunov-based Optimization of Edge Resources for Energy-Efficient Adaptive Federated Learning	IEEE Transactions on Green Communications and Networking
Conference	Probabilistic 5G Indoor Positioning Proof of Concept with Outlier Rejection	EuCNC
Conference	Pervasive Artificial Intelligence in Next Generation Wireless: The Hexa-X Project Perspective	AI6G
Conference	Towards Trustworthy AI for QoE prediction in B5G/6G Networks	AI6G
Conference	Hoeffding Regression Trees for Forecasting Quality of Experience in B5G/6G Networks	OLUD
Poster	Demo: FoReCo - a forecast-based recovery mechanism for real-time remote control of robotic manipulators	SIGCOMM
Journal	Design and Validation of an Open Source Cloud Native Mobile Network	IEEE Communications Magazine
Conference	MCRB-based Performance Analysis of 6G Localization under Hardware Impairments	ICC Workshops
Conference	6G Radio Requirements to Support Integrated Communication, Localization, and Sensing	EuCNC

Journal	High-Rate Uninterrupted Internet of Vehicle Communications in Highways: Dynamic Blockage Avoidance and CSIT Acquisition	IEEE Communications Magazine
Journal	A Tutorial on Terahertz-Band Localization for 6G Communication Systems	IEEE Communications Surveys & Tutorials
Journal	FoReCo: a forecast-based recovery mechanism for real-time remote control of robotic manipulators	IEEE Transactions on Network and Service Management
Journal	Ambient Backscatter Communications in Mobile Networks: Crowd-Detectable Zero-Energy-Devices	IEEE Journal of Radio Frequency Identification
Journal	Survey on Fully Homomorphic Encryption, Theory, and Applications	Proceedings of the IEEE
Conference	Simulating the radar cross section of a bare tree: From Megahertz to Terahertz	EuCAP
Journal	DeepTx: Deep Learning Beamforming with Channel Prediction	IEEE Transactions on Wireless Communications
Journal	Digital twin- and extended reality-based telepresence for collaborative robot programming in the 6G perspective	Digital Communications and Networks
Journal	A New Agent-Based Intelligent Network Architecture	IEEE Communications Standards Magazine.
Journal	Empowering 6G Communication Systems With Digital Twin Technology: A Comprehensive Survey	IEEE Access
Conference	Modeling the System-Level Reliability towards a Convergence of Communication, Computing and Control	ISRERM
Conference	Enabling Network and Service Programmability in 6G Mobile Communication Systems	FNWF
Book section	Impact of AI and Digital Twins on IIoT	Intelligent Edge-Embedded Technologies for Digitising Industry
Book section	Lesson Learnt and Future of AI Applied to Manufacturing	Intelligent Edge-Embedded Technologies for Digitising Industry
Conference	Layer-1 Mobility in Distributed MIMO with Non-Coherent Joint Transmission	IEEE VTC

Journal	A Survey and Guideline on Privacy Enhancing Technologies for Collaborative Machine Learning	IEEE Access
Journal	Neural Belief Propagation Auto-Encoder for Linear Block Code Design	IEEE Transactions on Communication
Conference	Ambient Backscatter Communications in Mobile Networks: Crowd-Detectable Zero-Energy-Devices	RFID-TA
Conference	Ambient backscatter communications using LTE cell specific reference signals	RFID-TA
Conference	AI-driven Orchestration for 6G Networking: the Hexa-X vision	IEEE GLOBECOM
Journal	Traffic Prediction and Fast Uplink for Hidden Markov IoT Models	IEEE Internet of Things Journal
Conference	A Learning-Based Trajectory Planning of Multiple UAVs for AoI Minimization in IoT Networks	EuCNC
Conference	A Security-Friendly Privacy Solution for Federated Learning	CEUR-WS
Conference	Using network simulators as digital twins of 5G/B5G mobile networks	WoWMoM
Conference	Fed-XAI: Federated Learning of Explainable Artificial Intelligence Models	AIxIA
Conference	An Approach to Federated Learning of Explainable Fuzzy Regression Models	FUZZ-IEEE
Conference	Increasing Accuracy and Explainability in Fuzzy Regression Trees: An Experimental Analysis	FUZZ-IEEE
Journal	Positioning and Sensing in 6G: Gaps, Challenges, and Opportunities	IEEE Vehicular Technology Magazine
Conference	Joint RIS Calibration and Multi-User Positioning	IEEE VTC
Conference	Doppler-Enabled Single-Antenna Localization and Mapping Without Synchronization	IEEE GLOBECOM
Conference	Localization Coverage Analysis of THz Communication Systems with a 3D Array	IEEE GLOBECOM
Conference	Channel Model Mismatch Analysis for XL-MIMO	GLOBECOM

	Systems from a Localization Perspective	
Journal	Out-of-Band Information Aided mmWave/THz Beam Search: A Spatial Channel Similarity Perspective	IEEE Communications Magazine
Journal	Exploiting Simu5G for generating datasets for training and testing AI models for 5G/6G network applications	SoftwareX
Journal	Cutting-Edge Assets for Trust in 5G and Beyond: Requirements, State of the Art, Trends, and Challenges	ACM Computer Surveys
Conference	Double-directional multipath data at 140 GHz derived from measurement-based ray-launcher	IEEE VTC
Conference	Energy-efficient cooperative inference via adaptive deep neural network splitting at the edge	IEEE ICC
Journal	On the Feasibility of Out-of-Band Spatial Channel Information for Millimeter-Wave Beam Search	IEEE Transactions on Antennas and Propagation
Conference	Mobile RF Scenario Design for Massive-Scale Wireless Channel Emulators	EuCNC
Conference	Channel charting based beamforming	Conference on Signals, Systems, and Computers
Journal	Monostatic Sensing With OFDM Under Phase Noise: From Mitigation to Exploitation	IEEE Transactions on Signal Processing
Conference	ESPRIT-Oriented Precoder Design for mmWave Channel Estimation	ICC
Journal	Spatial Signal Design for Positioning via End-to-End Learning	IEEE Wireless Communications Letters
Conference	The Architectural Design of Service Management and Orchestration in 6G Communication Systems	INFOCOM 2023
Journal	Mapping the VNFs and VLs of a RAN Slice Onto Intelligent PoPs in Beyond 5G Mobile Networks	IEEE Open Journal of the Communications Society
Conference	Enabling Application Relocation in ETSI MEC: A Container-Migration Approach	CLEEN 2022
Conference	Pathways towards Network-as-a-Service: the CAMARA project	SIGCOMM 2022

Conference	Trustworthy AI for Next Generation Networks: the Fed-XAI innovative paradigm from the Hexa-X EU Flagship Project	Ital-IA 2023
Conference	An Application for Federated Learning of XAI Models in Edge Computing Environments	FuzzIEEE
Conference	Federated TSK Models for Predicting Quality of Experience in B5G/6G Networks	FuzzIEEE
Journal	Rapid prototyping and performance evaluation of ETSI MEC-based applications	Simulation Modelling Practice and Theory
Journal	Performance-Aware Orchestration of P4-based Heterogeneous Cloud Environments	IEEE Transactions on Network and Service Management
Journal	Innovation Management in 6G research: the case of Hexa-X project	IEEE Communications Magazine
Journal	Towards an Open, Intelligent, and End-to-End Architectural Framework for Network Slicing in 6G Communication Systems	IEEE Open Journal of the Communications Society
Journal	The Hexa-X project vision on Artificial Intelligence and Machine Learning-driven Communication and Computation co-design for 6G	IEEE Access

Given that Hexa-X is using the Zenodo platform developed by the OpenAIRE project ([Zenodo]) to keep track of the scientific papers, it is possible to obtain certain statistics about them. As of May 2023, the community has 110 records, with a total impact of 8282 views and 5944 downloads, as illustrated in Figure 18..

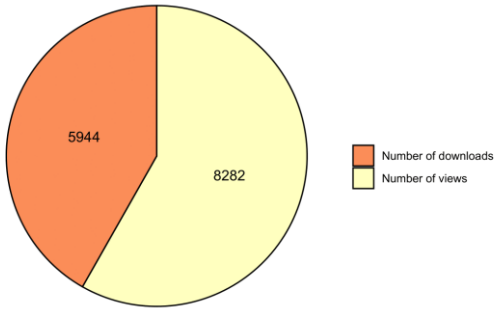


Figure 18. Hexa-X Zenodo statistics.

3.6 Communication, Talks and Other Actions

The Hexa-X project has made extra efforts to carry out talks and other communication activities (apart from scientific peer reviewed talks, or participation in industrial conferences). Because of the COVID19

situation at the beginning of the project, they were initially conducted via online events. Figure 19Figure 19 depicts the communication statistics for these types of activities, which are listed in Table 9.

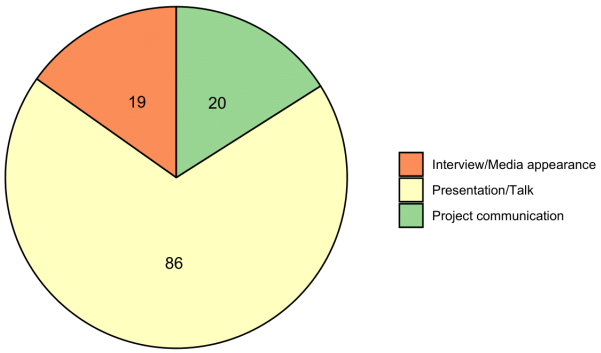


Figure 19. Communication statistics.

Table 9. Communication activities of Hexa-X

Date	Category	Partners involved	URL
3/19/2021	Interview/Media appearance	Nokia Bell Labs	https://www.fiercewireless.com/tech/6g-doesn-t-mean-ditching-5g-but-evolving-to-next-g
1/25/2021	Interview/Media appearance	University of Pisa	https://www.primaonline.it/2020/12/18/317707/universita-di-pisa-al-lavoro-sul-6g-la-prossima-generazione-di-rete-mobile-che-usera-lintelligenza-artificiale/
1/25/2021	Interview/Media appearance	University of Pisa	https://www.greenreport.it/news/scienze-e-ricerca/altro-che-5g-luniversita-di-pisa-prepara-il-6g/
1/25/2021	Interview/Media appearance	University of Pisa	https://www.key4biz.it/il-1-gennaio-2021-partira-il-nuovo-progetto-europeo-sul-6g/335949/
1/25/2021	Interview/Media appearance	University of Pisa	https://www.9colonne.it/289405/tecnologia-l-universit%C3%83%C2%A0-di-pisa-prepara-il-6g-2#.X-L0hulKiu4
1/25/2021	Interview/Media appearance	University of Pisa	https://www.villaggiotecnologico.it/luniversita-di-pisa-prepara-la-prossima-generazione-di-rete-mobile-che-usera-lintelligenza-artificiale/
1/25/2021	Interview/Media appearance	University of Pisa	https://www.iltempo.it/adnkronos/2020/12/18/news/tlc-unipi-prepara-il-6g-la-prossima-generazione-di-

			rete-mobile-che-usera-l-intelligenza-artificiale-25589617/
1/25/2021	Interview/Media appearance	University of Pisa	https://www.corr.it/news/adnkronos/25589615/tlc-unipi-prepara-il-6g-la-prossima-generazione-di-rete-mobile-che-usera-l-intelligenza-artificiale.amp
1/25/2021	Interview/Media appearance	University of Pisa	https://www.dropbox.com/s/55q6p15ffg0qi3g/20210125547516315.pdf?dl=0
06/23/2021	Interview/Media appearance	B-COM	https://www.eetimes.eu/ee-times-europe-magazine-june-2021/
4/27/2021	Interview/Media appearance	Universidad Carlos III de Madrid	https://play.cadenaser.com/audio/ser_madrid_hoyporhoymadrid_20210427_122003_140000/
9/11/2021	Interview/Media appearance	Universidad Carlos III de Madrid	https://www.rtve.es/play/videos/zoom-net/robots-2-0-proyecto-hexa-galaxy-z-flip3proyecto-hexagalaxy-z-flip3/6090713/
01/25/2022	Interview/Media appearance	Universidad Carlos III de Madrid	Hexa-X: el proyecto europeo de 6G permitirá construir un gemelo virtual del mundo real | 5G: el futuro es ahora | Tecnología | EL PAÍS (elpais.com)
12/15/2021	Interview/Media appearance	Wings ICT Solutions PC	Interview on HEXA-S and Machine Learning with SIGNAL Magazine, SIGNAL MAGAZINE
01/14/2022	Interview/Media appearance	Nokia Solutions and Networks OY	https://www.rcrwireless.com/20220114/5g/5g-advance-act-stepping-stone-future-6g-networks-nokia
09/13/2022	Interview/Media appearance	Atos Spain SA	AI MANO (HEXA-X) and ATOS at the EC's Innovation Radar platform (Internal to the whole Atos group)
07/01/2022	Interview/Media appearance	Atos Spain SA	Participation of Atos Research and Innovation in EuCNC22, highlighting our role in Hexa-X project (Internal to the company)
01/10/2023	Interview/Media appearance	Nokia Solutions and Networks OY	ETSI_Enjoy_MAG_2023_N01_January
06/14/2023	Interview/Media appearance	Nokia Solutions and Networks OY	https://www.tivi.fi/uutiset/tv/9bfbaf90-5add-4ea5-8a98-5bd31aaeee36

01/08/2021	Project communication	B-COM	https://www.linkedin.com/posts/irt-b-com_wireless-networks-activity-6742031548054302720-lVIe
1/27/2021	Project communication	Nokia Solutions and Networks OY, 2. Ericsson AB, 23. University of Oulu	https://hexa-x.eu/research/hexa-x-the-joint-european-initiative-to-shape-6g/
2/10/2021	Project communication	Nokia Solutions and Networks OY, 2. Ericsson AB, 23. University of Oulu	https://www.linkedin.com/feed/update/urn:li:activity:6765180465541341184
1/27/2021	Project communication	Nokia Solutions and Networks OY, 2. Ericsson AB, 23. University of Oulu	https://www.linkedin.com/feed/update/urn:li:activity:6760185895795662848
1/27/2021	Project communication	Nokia Solutions and Networks OY, 2. Ericsson AB, 23. University of Oulu	https://www.linkedin.com/posts/university-of-oulu_hexa-x-the-joint-european-initiative-to-activity-6760186007204761602-vnkC
4/19/2021	Project communication	University of Oulu	https://hexa-x.eu/6g/strong-participation-of-hexa-x-at-the-eucnc-6g-summit/
5/3/2021	Project communication	University of Oulu	https://hexa-x.eu/6g-vision/d1-2-expanded-6g-vision-use-cases-and-societal-values-including-aspects-of-sustainability-security-and-spectrum/
5/18/2021	Project communication	University of Oulu	https://hexa-x.eu/dissemination/simu5g-the-first-real-time-open-source-5g-simulator-will-support-federated-xai-within-hexa-x-project/
6/8/2021	Project communication	University of Oulu	https://hexa-x.eu/6g/european-vision-on-6g-revealed/
6/22/2021	Project communication	Chalmers Tekniska Högskola AB, 23. University of Oulu	https://hexa-x.eu/networks/6g-and-optical-networks/
6/23/2021	Project communication	University of Oulu	https://hexa-x.eu/6g/women-in-hexa-x-eu-flagship-project-leads-the-way-to-gender-equality-and-diversity-in-6g-research-innovation/
7/1/2021	Project communication	University of Oulu	https://hexa-x.eu/6g/first-technical-deliverables-from-hexa-x-published/

9/9/2021	Project communication	University of Oulu	https://hexa-x.eu/research/call-for-papers-to-the-1st-international-workshop-on-6g-vision-use-cases-and-technologies-at-the-ieee-ccnc22-conference-in-las-vegas-usa-8-11-jan-2022/
6/4/2021	Project communication	Atos Spain SA	https://booklet.atosresearch.eu/units/smart-networks-services
12/16/2021	Project communication	Atos Spain SA	News about Hexa-X and Atos role, ARI internal newsletter, internal to the company
05/11/2022	Project communication	B-COM	EuCNC 2022: 5G and AR in the spotlight | b-com
05/11/2022	Project communication	B-COM	EuCNC 2022 : la 5G et la RA à l'honneur | b-com
06/08/2022	Project communication	B-COM	https://twitter.com/IRT_BCom/status/1534561296850509825
05/04/2023	Project communication	Orange	European project Hexa-X-II leads the way towards a sustainable 6G - Hello Future Orange
05/04/2023	Project communication	Orange	Eric Hardouin en LinkedIn: At Orange, we think 6G has to be designed to bring value to society, which…
1/28/2021	Presentation/Talk	Nokia Solutions and Networks OY	http://w-i-c.org/MWM2021/MWM2021_invitation.pdf
1/27/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://www.kauppalehti.fi/uutiset/nokia-vetoinen-jattiprojekti-piirtaa-6g-verkkojen-suuntaviivoja-tama-on-ainoa-6g-lippulaivahanke-joka-on-eu-tasolla-kaynnissa/a0ef43fa-da21-4617-bc07-302b789f0c0b
3/16/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://5g-ppp.eu/event/5g-ppp-webinar-europe-accelerates-towards-6g/
12/7/2021	Presentation/Talk	Siemens Aktiengesellschaft	https://globecom2020.ieee-globecom.org/workshop/ws-02-future-wireless-access-industrial-iot-futureiiot-enabling-industry-40-revolution-2
4/12/2020	Presentation/Talk	Chalmers Tekniska Högskola AB	https://student.portal.chalmers.se/en/chalmersstudies/courseinformation/Pages/Se

			archCourse.aspx?course_id=30246&parsergrp=3
4/27/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://events.vtsociety.org/vtc2021-spring/conference-sessions/keynote-panels/
6/8/2021	Presentation/Talk	Nokia Solutions and Networks OY, 2. Ericsson AB	https://www.eucnc.eu/workshops/workshop-5/
6/24/2021	Presentation/Talk	Telecom Italia S.p.A.	https://tmt.knect365.com/6g-digital-symposium/agenda/2
6/28/2021	Presentation/Talk	Ericsson AB	https://ondm2021.chalmers.se/hexa-x-workshop-on-6g-vision/
5/27/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://asut.ch/asut/de/page/index.xhtml
6/7/2021	Presentation/Talk	Nokia Solutions and Networks OY, 2. Ericsson AB, 4. Atos Spain SA, 6. Chalmers Tekniska Högskola AB, 11. Intel Deutschland GmbH, 13. Nokia Solutions and Networks GmbH & Co. KG, 14. Orange, 18. Technische Universität Dresden, 20. Telecom Italia S.p.A., 21. Telefónica Investigación y Desarrollo S.A.U., 22. Universidad Carlos III de Madrid, 23. University of Oulu, 25. Wings ICT Solutions PC	https://5g-ia.eu/single_post/?slug=the-5g-infrastructure-association-5g-ia-publishes-the-white-paper-european-vision-for-the-6g-network-ecosystem
6/11/2021	Presentation/Talk	Nokia Solutions and Networks OY, 11. Intel Deutschland GmbH	https://www.telecomtv.com/content/intel-network-and-edge/
6/22/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://tmt.knect365.com/5gworldevent/6g-digital-symposium-2021/
7/7/2021	Presentation/Talk	University of Pisa	https://www.dii.unipi.it/5g-enabling-technologies-opportunities-and-research-challenges-ahead
7/1/2021	Presentation/Talk	Orange	https://www.6gwff.org/
5/31/2021	Presentation/Talk	Commissariat à l'énergie atomique et aux énergies alternatives	https://digicosme.cnrs.fr/event/digicosme-webinar-of-the-wg-future-access-networks/
5/31/2021	Presentation/Talk	Commissariat à l'énergie atomique et aux énergies alternatives	https://www.6gworld.com/spring-2021-6g-symposium-agenda/
9/15/2021	Presentation/Talk	1. Nokia Solutions and Networks OY, 2. Ericsson AB	https://pimrc2021.ieee-pimrc.org/global-view-on-6g/
9/24/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://tmt.knect365.com/5g-world-series/

10/13/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://5g-ppp.eu/5g-ppp-workshop-5g-world-forum-call-for-papers/
10/19/2021	Presentation/Talk	Siemens Aktiengesellschaft	https://5g-ppp.eu/5g-ppp-work-groups/
10/28/2021	Presentation/Talk	Siemens Aktiengesellschaft	https://www.bayern-innovativ.de/veranstaltung/summit-event-thinknet-6g
6/1/2021	Presentation/Talk	Telefónica Investigación y Desarrollo S.A.U.	https://www.gsma.com/newsroom/wp-content/uploads//NG.127-v1.0-2.pdf
10/28/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://www.bdva.eu/
11/9/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://www.businessfinland.fi/suomalaisille-asiakkaille/palvelut/ohjelmat/sustainable-manufacturing-finland-ohjelma
11/10/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://www.omc.co.jp/beyond5G/en
11/10/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://forum-americas.org/toronto/home/
11/30/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://www.aalto.fi/fi/tapahtumat/internet-forum-avoimet-verkkoluennot-5g-what-do-we-all-have-to-know
12/1/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://www.wwrf.ch/wwrf46.html
12/1/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://www.psc-europe.eu/news-events/events/psce-conference-in-brussels-nov21.html
9/16/2021	Presentation/Talk	Ericsson AB	https://www.netsys2021.org/program/#zdn02
12/6/2021	Presentation/Talk	Ericsson AB, 6. Chalmers Tekniska Högskola AB	https://www.wwrf.ch/wwrf46.html
13/10/2021	Presentation/Talk	Ericsson AB	https://ieee-wf-5g.org/path-to-6g/
06/08/2021	Presentation/Talk	ATOS, INT	https://www.eucnc.eu/2021/www.eucnc.eu/index.html
01/11/2022	Presentation/Talk	Ericsson AB	https://ccnc2022.ieee-ccnc.org/workshop/6g22/program
01/11/2022	Presentation/Talk	Telecom Italia S.p.A.	https://ccnc2022.ieee-ccnc.org/workshop/6g22
01/19/2022	Presentation/Talk	Ericsson AB	

02/01/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://www.corenect.eu/
12/29/2021	Presentation/Talk	Nokia Solutions and Networks OY	https://www.fiercewireless.com/tech/5g-voice-evolving-6g-nokia-shoots-moon-top-10-stories-fiercewireless-tech-2021
02/10/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://eco6g.com/
02/16/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://5g-acia.org/
03/02/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://cordis.europa.eu/project/id/824994
04/05/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://portal.etsi.org/tb.aspx?tbid=283&SubTB=283,777,558,605#/
05/17/2022	Presentation/Talk	Nokia Solutions and Networks OY	
06/01/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://mp.weixin.qq.com/s/6a62yVKsODZp9wyaBU1e_g
06/07/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://www.eucnc.eu/programme/workshops/workshop-2/
06/14/2022	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/Pages/wsp-imt-vision-2030-and-beyond.aspx
06/20/2022	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB, Technische Universität Dresden	https://events.vtsociety.org/vtc2022-spring/conference-sessions/keynote-speakers-and-panels/
06/20/2022	Presentation/Talk	Intel Deutschland GmbH	https://events.vtsociety.org/vtc2022-spring/conference-sessions/industry-tracks/
05/19/2022	Presentation/Talk	Intel Deutschland GmbH	https://icc2022.ieee-icc.org/program/industry-panels#IP-7
06/07/2022	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB, Atos Spain SA, B-COM, Commissariat à l'énergie atomique et aux énergies alternatives, Ericsson Araştırma, Geliştirme ve Bilişim Hizmetleri A.Ş., Ericsson Magyarország Kommunikációs Rendszerek Kft, Institute for Computer Science and Control (SZTAKI), Intel Deutschland GmbH, Nextworks S.R.L., Nokia Solutions and Networks GmbH & Co. KG,	https://www.eucnc.eu/programme/workshops/workshop-2/

		Orange, University of Oulu, University of Pisa, Wings ICT Solutions PC	
07/25/2022	Presentation/Talk	Ericsson AB	https://www.optica.org/en-us/events/congress/advanced_photonics_congress/
08/29/2022	Presentation/Talk	Commissariat à l'énergie atomique et aux énergies alternatives	https://2022.eusipco.org/?page_id=2263
09/28/2022	Presentation/Talk	Ericsson AB	https://5g-ppp.eu/event/workshop-on-6g-kpis-and-how-to-measure-them/
07/07/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://6g-conference.dnac.org/
07/08/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://6g-conference.dnac.org/
08/23/2022	Presentation/Talk	Nokia Solutions and Networks OY	
08/24/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://www.optica.org/en-us/careers/professional_development/webinar_series/
09/20/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://rspg-spectrum.eu/2022/09/
09/21/2022	Presentation/Talk	Nokia Solutions and Networks OY	
09/30/2022	Presentation/Talk	Nokia Solutions and Networks OY	
04/04/2022	Presentation/Talk	Siemens Aktiengesellschaft	https://hexa-x.eu/ict-52-workshop-on-6g/
05/18/2022	Presentation/Talk	Siemens Aktiengesellschaft	https://www.medienakademie-koeln.de/event/6g-2022/
09/22/2022	Presentation/Talk	Siemens Aktiengesellschaft	
11/15/2022	Presentation/Talk	Siemens Aktiengesellschaft	
10/13/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://fnwf2023.ieee.org/
10/18/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://networkxevent.com/agenda/
10/19/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://networkxevent.com/agenda/
11/07/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://wwrf.tii.ae/
11/09/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://wwrf.tii.ae/
11/29/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://www.5gtechritory.com/
11/30/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://www.5gtechritory.com/
12/09/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://sites.google.com/view/emergingwireless/keynote-speakers?authuser=0

12/12/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://www.analysysmason.com/events-and-webinars/events/6g-evolution-summit/
12/13/2022	Presentation/Talk	Nokia Solutions and Networks OY	https://www.networldeurope.eu/
07/03/2023	Presentation/Talk	Universidad Carlos III de Madrid	https://www.etsi.org/events/2154-evolving-nfv-towards-the-next-decade
02/06/2023	Presentation/Talk	Nokia Solutions and Networks OY	https://www.businessfinland.fi/en/for-finnish-customers/services/programs/6g-bridge
03/15/2023	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	https://networkingchannel.eu/networking-events/
04/20/2023	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	European 6G Flagships Hexa-X and Hexa-X-II High level TTC meeting between Europe and USA
05/04/2023	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	https://global6gsummit.com/
05/24/2023	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	6G panel https://www.critical-communications-world.com/
05/24/2023	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	What to expect from 6G? https://www.critical-communications-world.com/
05/25/2023	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	Global Vision on 6G from the European Level Flagships, Hexa-X and Hexa-X-II Venue: Explore 6G
05/30/2023	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	https://www.comsoc.org/conferences-events/ieee-international-conference-communications-2023#:~:text=IEEE%20ICC%202023%3A%20IEEE%20International%20Conference%20on%20Communications,latest%20developments%20in%20telecommunications%20from%20a%20technical%20perspective.
06/13/2023	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	https://coe.northeastern.edu/Groups/wowmom2023/index.html
06/21/2023	Presentation/Talk	Nokia Solutions and Networks OY, Ericsson AB	https://www.sigmobile.org/mobisys/2023/

4 Standardization, Industry fora, and Intellectual Property

This section is based on Hexa-X driven the standardization activities of the Hexa-X project. The original the objectives of Hexa-X for standardization, industry fora and intellectual property are as follows: (i) standards and industry groups (e.g., 3GPP, ETSI MEC, IETF and IEEE); (ii) more than 100 standards contributions by participants based on work in Hexa-X; (iii) at least 50 patent applications.

4.1 Overall achievements

The overall achievements of Hexa-X in standardization, industry impact and patents are listed in Table .

Table 10: Standardization, Industrial impact, and IP achievements.

Type	Original target	Achieved
Standards and industry groups impacted	3GPP RAN, 3GPP SA, ETSI ENI, ETSI ZSM, ETSI PDL, ETSI OSM. ETSI NFV, ETSI MEC, NGMN, GSMA ITU, IETF, IEEE, TMF	3GPP RAN, 3GPP SA, ETSI ZSM, ETSI MEC, ETSI THz, O-RAN nGRG, IETF, ITU-R, ITU-T, GSMA, NGMN
Total number of standards contributions by participants based on work in Hexa-X	More than 100	120
Number of patent applications	At least 50	33

6G is still in its early stage and only few Standards Development Organisations (SDOs) have 6G related agenda points. ITU-R has worked on IMT-2030 Vision and Beyond including feasibility studies and use cases and ITU-T is working sustainability. 3GPP has not yet started nor agreed on timetable for 6G study items, however topics related to applying AI/ML and energy efficiency have been addressed by Hexa-X contributions paving the way for the subsequent studies and work items anticipated by the Hexa-X project for 6G era. O-RAN set up 2022 a research group, nGRG, to study the impact of 6G to the O-RAN architecture and ETSI has set up an ISG for terahertz communication.

4.2 Standards and industry groups

Our first targeted SDO for impact was ITU-R WP5D and its preparations for “Future technology trends of terrestrial International Mobile Telecommunications systems towards 2030 and beyond”, released November 2022 [IMT-22], to be followed by “ITU-R IMT Vision of IMT towards 2030 and beyond” that will be released later in 2023 [IMT-23]. Our contributions covered use cases, technology trends to be considered, and justifications for new spectrum for 6G.

Sustainability topic area was an active topic for dissemination for the project as is under active considerations in multiple SDOs including ITU-T SG5, 3GPP SA2, ETSI and ATIS. The project has contributed to 3GPP SA2 and RAN as well as ITU-T through multiple individual and co-signed contributions on sustainability and energy efficiency matters.

Towards ETSI and ETSI RISE [ETR21] community we have had multiple presentations and organized specific meetings and workshops to identify topics that would have most common interest within the ETSI community. Channel modelling and the related measurements from WP2 was found to be the

most attractive area for a deep dive and to create motivation for other 6G topics. The project provided key inputs to set up ETSI THz ISG to which many project partners are participating. The project participants continue to contribute to the ETSI THz. We have contributed to ETSI ZSM about resource locality and scarcity on closed loop automation.

Even though 3GPP has not yet started 6G studies, the project has been actively contributing to the key topical areas that will create the solid starting point for subsequent 6G work in the forthcoming releases 3GPP releases. We have contributed to energy efficiency studies of 3GPP SA2 (e.g., TR 37.817) and SA5 (TR 28.915), AI/ML studies in RAN1, analytics framework in SA2, security in SA3, slicing and energy efficiency in SA5.

We have also contributed to NGMN and GSMA white papers investigating 6G use cases and initial requirements.

O-RAN established a study group for next generation networks (nGRG) that is chartered to consolidate relevant 6G research results for the later needs of 6G work. The project has been attending to O-RAN nGRG workshops providing project presentations, and technical talks as well as input to the ongoing research reports.

A summary of the standardization contributions is provided in the Table 11 below.

Table 11 Submissions to standardization and industry groups

Standard Contributions: title	**Date**	**SDO**	**ID**	**Hexa-X partners involved**
Proposal for the working document towards DRAFT NEW Report on "future technology trends"	21/06/2021	ITU-R WP5D	5D/540-E	Nokia, Ericsson, Intel
PROPOSAL FOR THE DEVELOPMENT OF THE VISION OF IMT-2030 AND BEYOND	31/05/2021	ITU-R WP5D	5D/653-E	Nokia, Ericsson, Intel
Proposals for WORKING DOCUMENT TOWARDS PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M.[IMT.VISION 2030 AND BEYOND]	31/05/2021	ITU-R WP5D	5D/675-E	Ericsson
UPDATE PROPOSAL FOR THE DEVELOPMENT OF THE VISION OF IMT FOR 2030 AND BEYOND	27/09/2021	ITU-R WP5D	5D/843-E	Ericsson, Intel, Nokia
PROPOSALS AND UPDATES FOR DRAFT WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS OF TERRESTRIAL IMT SYSTEMS TOWARDS 2030 AND BEYOND]	27/09/2021	ITU-R WP5D	5D/856-E	Ericsson
INPUT ON USAGE SCENARIOS FOR WORKING DOCUMENT TOWARDS PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M.[IMT.VISION 2030 AND BEYOND]	31/01/2021	ITU-R WP5D	5D/1035-E	Ericsson
PROPOSAL FOR RADIOWAVE PROPAGATION TEXT FOR THE	31/01/2021	ITU-R WP5D	5D/1053-E	Nokia, Ericsson, Intel

DRAFT NEW REPORT ITU R M.[IMT.ABOVE 100 GHZ]				
Proposal to section 2.4 of Working document towards preliminary draft new RECOMMENDATION ITU-R M.[IMT.VISION 2030 and Beyond]	31/01/2021	ITU-R WP5D	5D/1037-E	Ericsson, Nokia
Proposal for radio-wave propagation text for the draft new Report ITU-R M.[IMT.ABOVE 100 GHZ]	03/10/2022	ITU-R WP5D	5D/1493	Nokia
INPUT ON USAGE SCENARIOS AND CAPABILITIES FOR WORKING DOCUMENT TOWARDS PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M.[IMT.VISION 2030 AND BEYOND]	06/06/2022	ITU-R WP5D	5D/1296-E	Ericsson
New SID on the security aspects of Artificial Intelligence (AI)/Machine Learning (ML) for the NR Air Interface and NG-RAN	16/05/2022	3GPP TSG-SA3	S3-221062-r1	Ericsson, Nokia
Study on Zero Trust Security	14/06/2022	3GPP TSG-SA3		Nokia, Telefonica, Ericsson, Intel
PROPOSAL FOR UPDATE TO A WORKING DOCUMENT TOWARDS PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M. [IMT.VISION 2030 AND BEYOND]	2022-09	ITU-R WP5D		Ericsson, Intel, Nokia
Solution proposal: KI#1 How to improve correctness of NWDAF analytics	2022-04	3GPP SA2	S2-2203360	Nokia
Solution proposal: KI#4: Data Collection and Storage Enhancements	2022-04	3GPP SA2	S2-2203364	Nokia
KI #7 & #3, New Solution: Federated learning analytics as assistance to AI/ML application server	2022-04	3GPP SA2	S2-2203558	Nokia
KI #7 & #3, New Solution: Federated Learning Server assisting on federated learning members selection	2022-04	3GPP SA2	S2-2203576	Nokia
New SID: Study on Passive IoT	06/06/2022	3GPP TSG RAN	RP-221706	Orange
New SID: Study on x-IoT	12/09/2022	3GPP TSG RAN	RP-222453	Orange
Moderator's summary for discussion [94e-02-R18-MIMO] MIMO Evolution for Downlink and Uplink	06/12/2021	3GPP TSG RAN	RP-213539	Orange
New SI: Study on network energy savings for NR	06/12/2021	3GPP TSG RAN	RP-213554	Orange, TIM, Nokia, Ericsson

New SI: Study on evolution of NR duplex operation	06/12/2021	3GPP TSG RAN	RP-213591	Orange
New WID: MIMO Evolution for Downlink and Uplink	06/12/2021	3GPP TSG RAN	RP-213598	Orange, TIM, Nokia, Ericsson
New WI: Artificial Intelligence (AI)/Machine Learning (ML) for NG-RAN	06/12/2021	3GPP TSG RAN	RP-213602	Orange, Nokia, Ericsson, Intel
Rel-17 CR 28.541 network slice subnet provider capability IOC	17/05/2022	3GPP SA5	S5-223622	Telefónica
Rel-17 CR 28.531 Network slice subnet capabilities	17/05/2022	3GPP SA5	S5-223743	Telefónica
Rel-17 CR 28.541 Update Figure L.2.1 and accompanying paragraph	17/05/2023	3GPP SA5	S5-223562	Telefónica
pCR TR 28.809 Business use case - DSO provides an Incident Report	24/08/2022	3GPP SA5	S5-225867	Telefónica
pCR TR 28.829 Business use case - DSO Provides Performance Reporting indicating Problems	24/08/2022	3GPP SA5	S5-225866	Telefónica
pCR 28.908 Addressing wording issues	18/11/2022	3GPP SA5	S5-226916	Telefónica, ATOS
pCR 28.908 Clarifying simultaneous and separate execution of training and inference phases	18/11/2022	3GPP SA5	S5-226917	Telefónica, ATOS
pR 28.836 Solution for intent-driven management to deliver a network slice	18/11/2022	3GPP SA5	S5-226956	Telefónica, Netxworks, ATOS
Discussion on the structuring Rel-18 work in SA5	15/11/2021	3GPP SA5	S5-216551	Orange, Telefónica
Enhance 5G Core managed NF Profile NRM fragment (stage 2)	15/11/2021	3GPP SA5	S5-216364	Nokia, Nextworks Telefónica
New SID on intent-driven management of network slicing	26/01/2022	3GPP SA5	S5-221512	Ericsson and Telefónica
Rel-17 CR 28.541 Update RANSliceSubnetProfile	28/01/2022	3GPP SA5	S5-221035	Telefónica
DP on the relationship of CAMARA and SA work on capability exposure	12/04/2022	3GPP SA5	S5-222574	Telefónica, Ericsson, Intel, Orange,
Discussion paper on 5G exposure	14/04/2022	3GPP SA5	S5-222723	Ericsson, Intel, Orange, Telefónica
pCR 28.824 Describe possible solution for EGMF	14/04/2022	3GPP SA5	S5-222756	Ericsson, Orange, Telefónica
Rel-17 CR 28.541 network slice subnet provider capablity IOC	17/05/2022	3GPP SA5	S5-223213	Telefónica
IETF Network Slice Use Cases and Attributes for Northbound Interface of IETF Network Slice Controllers	24/07/2022	IETF TEAS	draft	Telefónica
pCR TR 28.813 Potential solution for KI #5 (5GC NF Energy Consumption)	09/03/2021	3GPP SA5	S5-212408	Nokia, Intel, Orange, Telefónica
Rel-17 CR TS 28.310 Add use case and requirements for switching off edge UPFs	09/03/2021	3GPP SA5	S5-212398	Orange, Telefónica

Rel-17 CR TS 28.554 Add Energy Consumption KPI for 5G NF and 5G CN	19/05/2021	3GPP SA5	S5-213534	Orange, Telefónica
Rel-16 CR 28.531 clarify misleading information in network slicing use cases	19/05/2021	3GPP SA5	S5-213462	Orange, Telefónica
Rel-17 CR TS 28.554 Add Energy Consumption KPI for 5G NF and 5G CN	19/05/2021	3GPP SA5	S5-213534	Orange, AT&T, DTAG, Telefónica
Rel-17 CR TS 28.554 Add EE KPI for eMBB Network Slice based on RAN measurements	19/05/2021	3GPP SA5	S5-213535	Orange, Telefónica
pCR TR 28.813 Conclusion of Key Issue No.1	19/05/2021	3GPP SA5	S5-213554	Orange, Telefónica
pCR TR 28.813 Conclusion to DV based EE KPI for 5GC Key Issue	19/05/2021	3GPP SA5	S5-213555	Orange, Telefónica
Rel-17 CR 28.541 Update relationship between GST and Network Slice NRM fragment	22/10/2021	3GPP SA5	S5-215649	Telefónica
Key issues relative to network slice management capabilities exposure	20/10/2021	3GPP SA5	S5-215526	Orange, Telefónica
ZSM009-3 Section 5 Resource locality and scarcity on closed loop automation	14/11/2022	ETSI ZSM	ZSM(22)000392r2	Telefonica, BCO
ZSM009-3 Section 6 Add potential solution for handling resource locality and resource scarcity in closed loop automation	14/11/2022	ETSI ZSM	ZSM(22)000393r2	Telefonica, BCO
ZSM014 Annex A Securing a closed loop via another closed loop	14/11/2022	ETSI ZSM	ZSM(22)000394r1	Telefonica, BCO
CAMARA Initiative - The Telco Global API Alliance	11/05/2022	ETSI ZSM	ZSM(22)000208	Telefonica
Hexa-X presentation and requirement to IMT 2030	14/07/2022	ITU-R WP5D		Nokia
Hexa-X presentation to ETSI MEC	23/09/2021	ETSI MEC		Nokia
Hexa-X presentation to IETF 6G side meeting	09/03/2022	IETF 6G side meeting		Nokia
Hexa-X presentation to IETF 6G side meeting	25/07/2022	IETF 6G side meeting		Nokia
ETSI Catalyst WS #1 Management and Orchestration	05/04/2022	ETSI CATALYST		ATOS
ETSI Catalyst WS #1 Radio aspects RF	05/04/2022	ETSI CATALYST		Oulu uni
ETSI Catalyst WS #1 Radio aspects Channel modeling	05/04/2022	ETSI CATALYST		Aalto uni
ETSI Catalyst WS #1 AI/ML for radio	05/04/2022	ETSI CATALYST		Ericsson

ETSI Catalyst WS #2: RF modeling	01/09/2022	ETSI CATALYST		Oulu uni
ETSI Catalyst WS #2 Channel modeling and measurements	01/09/2022	ETSI CATALYST		Aalto Uni
O-RAN nGRG Research Stream 02 Hexa-X network architecture (WP5) presentation 11 Jan 2023	11/01/2023	O-RAN nGRG		Ericsson, Nokia
O-RAN nGRG Research Stream 02 Hexa-X network architecture D8.3 presentation 17 May 2023	17/05/2023	O-RAN nGRG		Ericsson
New WID on intent-driven management	09/01/2023	3GPP SA5	S5-231016	Ericsson, Telefonica
NaaS ecosystem and 3GPP SA5 work on capability exposure	27/01/2023	3GPP SA5	S5-232537	Telefonica
SA5 way forward on capability exposure topic	27/01/2023	3GPP SA5	S5-232893	Telefonica
DP on relationship between NEST, URSP and ServiceProfile	27/01/2023	3GPP SA5	S5-233092	Telefonica
MTLF-based ML Model Accuracy Monitoring	16/01/2023	3GPP SA2	S2-2301986	Nokia, Ericsson
Key Issue #3: Data and analytics exchange in roaming case	16/01/2023	3GPP SA2	S2-2301990	Nokia
Roaming architecture for data or analytics exchange	16/01/2023	3GPP SA2	S2-2301991	Nokia
Data Storage Management	16/01/2023	3GPP SA2	S2-2301996	Nokia
Key Issue #9: Analytic ID that supports location accuracy estimate	16/01/2023	3GPP SA2	S2-2302005	Nokia
Hexa-X presentation in O-RAN nGRG workshop, https://www.o-ran.org/blog/2nd-o-ran-next-generation-research-group-ngrg-workshop-in-prague-february-2023	16/02/2023	O-RAN nGRG		Nokia
Hexa-X standardization presentation, https://www.etsi.org/newsroom/news/2189-etsi-research-conference-research-and-standards-on-a-successful-journey	10/02/2023	ETSI		Nokia
Key Issue #9: Analytic ID that supports location accuracy estimate	16/01/2023	3GPP SA2	S2-2302005	Nokia
Data Storage Management	16/01/2023	3GPP SA2	S2-2301996	Nokia
Roaming architecture for data or analytics exchange	16/01/2023	3GPP SA2	S2-2301991	Nokia
Key Issue #3: Data and analytics exchange in roaming case	16/01/2023	3GPP SA2	S2-2301990	Nokia
MTLF-based ML Model Accuracy Monitoring	16/01/2023	3GPP SA2	S2-2301986	Nokia
Cloud friendly RAN architecture principles	24/05/2023	O-RAN nGRG		Nokia

Add use case and requirements for switching off UPFs deployed at the edge of the network during off-peak hours to achieve energy savings.	10/03/2023	3GPP SA5	S5-212398	Orange, Telefonica
Potential solution for KI#5 (5GC NF Energy Consumption)	01/03/2023	3GPP SA5	S5-212408	Orange, Telefonica, Nokia, Intel
Enhance 5G Core managed NF Profile NRM fragment (Stage 2)	15/11/2021	3GPP SA5	S5-216364	Nokia, Orange, Telefonica
Outdoor and indoor MIMO channel data at 140 GHz	09/05/2023	ETSI THZ ISG	THz(23)000082	University of Oulu
Use cases and representative use cases for Ambient IoT	12/12/2022	3GPP TSG RAN	RP-223397	Orange
Ambient IoT deployment scenarios and their characteristics	12/12/2022	3GPP TSG RAN	RP-223398	Orange
Connectivity topologies for Ambient IoT	12/12/2022	3GPP TSG RAN	RP-223399	Orange
RAN design targets for Ambient IoT	12/12/2022	3GPP TSG RAN	RP-223400	Orange
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4.3 Patents

The Hexa-X project brings several opportunities for patent creation (IPR). The IPR creation is generally a difficult process to be tracked properly, considering:

- The time needed from the initial idea and the actual filing of a patent.
- The preliminary stage of the activities towards 6G related to the actual period of time of Hexa-X. Patents are often being developed in the different companies, but they can't yet be fully disclosed

The actual impact of the project is then verified through many other indicators than the number of patents, which is for sure under-estimated in this phase. Having said that, anyway, some partners have declared to have some patents filing in the period of Hexa-X, with an embargo end-date in the next few years.

In particular, Nokia has at least 11 patents filed and related to Hexa-X, ranging from non-linear power amplifiers to deep neural networks, to digital twin, among others. Ericsson has made known that they have at least 15 patents, covering multiple technical areas, such as methods for communication systems towards 6G, channel estimation, federated learning, hardware impairment compensation, physical layer security, sensing. Siemens has also reported IPR items (at least 6) on sustainability, satellite-based services, network adaptation, intelligent surfaces, among others. TIM has also at least one patent application on topics related to Hexa-X activities.

5 Summary

This document provides a detailed report on the dissemination and communication activities of the Hexa-X project. It provides an accurate description of the various achievements of the project, structured in different categories, along with an estimation of the extent to which the communication KPIs are achieved. The collected statistics serve as a milestone to confirm the good overall success of the impact creation activities in general, and to identify how the communication objectives have been achieved during the whole period of work of Hexa-X project.

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