A Secure and Reusable Artificial Intelligence Platform for Edge Computing in Beyond 5G Networks

D6.5 Final Dissemination, Impact Assessment and Exploitation Report

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D6.5 Final Dissemination, Impact Assessment and Exploitation Report	
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Glossary	
AI	Artificial Intelligence
BVLOS	Beyond Visual Line of Sight
CA	Consortium Agreement
DMP	Data Management Plan
ETSI	European Telecommunications Standards Institute
FG-AN	Focus Group on Autonomous Networks
FRMCS	ETSI Future Railway Mobile Communication Systems
GA	General Assembly
IA	Infrastructure Association
IBN	Intent-Based Networking
IETF	Internet Engineering Task Force
IPR	Intellectual Property Rights
IRTF	Internet Research Task Force
ITU-T	ITU Telecommunication Standardization Sector
KPI	Key Performance Indicator
LCM	Latent Class Model
nGRG	Next Generation Research Group
NM	Network Management
NMRG	Network Management Research Group
NWDAF	5G network data analytics function
SDA	Standards Developing Association
SDO	Standards Developing Organization
SNS	Smart Networks and Services
UC	Use-Case
WG	Working Group
WP	Work package

Executive Summary

This deliverable reports the activities in relation to WP6 tasks, which have been realized during the whole project life cycle. It follows the first and second deliverables: D6.3 presenting the activities of year 1 and D6.4 presenting the activities of year 2 of the AI@EDGE project. WP6 tasks have been continuous over the project lifetime and the activities have been monitored on a regular basis through a project Dissemination tracker to assess the impact and visibility of the project regarding different communities and the public.

After the document Introduction, Section 2 presents the activities of T6.1 for the dissemination and communication of the knowledge and results produced by the project. This has been a key enabler to promote the project realizations and create potential synergies and relations with various actors from academia or industries. Alongside with updating the online presence with news and update, a media pack containing a project leaflet, a roll-up banner, a project poster, and a project video has been prepared. Project partners also had the opportunity to participate in conferences and seminars to present the project results and to publish them in many scientific publications.

Section 3 is about standardization and reports the activity of T6.2. Although an initial plan has been setup already at the time of the proposal writing, it has been refined within the project life.

The activities carried out within T6.3 are reported in Section 4. These activities have been necessary to ensure interaction with other projects and WG from 5G Infrastructure Association (5G IA).

Then, it has been important to carefully manage IPR, to manage a proper exploitation and eventual commercialization of project results. This objective of T6.4 is presented within Section 5.

The last Section 0 reviews the feedback received from the partners based on a shared exploitation questionnaire that allowed to assess the potential exploitation of project results.

1. Introduction and highlights

The activities around dissemination and communication within T6.1 Dissemination and communication have been initiated in the early phases of project execution with the creation and maintenance of the plan for the dissemination and use of knowledge of the project. It has since continued with actions taken to ensure the project's visibility through online channels, such as a project website and social media outlets, as well as the outcomes of the project consortium's scientific publications and dissemination efforts in various organised and attended scientific events. Some highlights of the activities carried out are:

- The organisation of nr. 4 project workshops, 3 of which has been organised with the support of other projects: a) 1st Open Annual Workshop on Future ICT [2022], b) Joint INSPIRE-5G and AI@EDGE workshop "Platforms and Mathematical Optimization for Secure and Resilient Future Networks" [2022], c) Workshop at EUCNC 2023 "Exploring the Intersection of 6G and Artificial Intelligence: Unleashing the Potential of Next-Gen Technologies" [2023], d) AI4CI Workshop [2023].
- The organisation of 2 booths: at Mobile World Congress (MWC) 2023 and at IEEE ICC 2023, both organised with the H2020 DEAMON project.
- The organisation of nr. 3 online webinars to present some key parts of the project: a) Webinar on AutoML, b) Webinar on "Bringing the intelligence to the Edge" - AI@EDGE and DAIS Overall Architecture", and c) Webinar on "Closed Loop Automation" (see chapter 2.2 for more information).
- The publication of 40 scientific papers (see chapter 2.5 for more information).
- The presentation of the project in more than 55 events (see chapter 2.6 for more information).

AI@EDGE encompasses several research and industry fields, obviously AI, networking, edge computing but also those represented in use cases. As a result, the project may impact also on the standardization groups in these related areas. Because the project focus was on research, delivering new standards was not a primary goal but our main objective was to fuel discussions and orientations within these groups as well as testing the functionality and performance of the current standard implementations to have an impact in a long-term perspective. Hence, the main highlights in standardization are:

- An impact on the roadmap of IRTF NMRG regarding the integration of AI in NM endorsed by a dedicated document.
- Active participation to interoperability tests of 5G in the context of new railway and mission critical communication system.
- Active participation to the new ORAN nGRG that allows to disseminate research project results towards the ORAN alliance.

Regarding the project's contribution to 5G-PPP and with other projects, the main highlights to be presented are:

- The project has been active in the interactions with 5G-PPP/IA: in particular, AI@EDGE interacted with 5G-PPP and 5G-IA and with some of the working groups therein.

- The project has been active in the interactions with other projects, especially those belonging to the call ICT-52: very good relations has been established with the projects 5G-DAEMON, Hexa-X, and Hexa-X-II.

Regarding the management of the Intellectual Property Rights (IPR) and the management of exploitation activities, the main highlights have been:

- Definition of the final exploitation plan to be carried out after the project end.
- Definition of the IPR management and the partners' contributions regarding IPR-manageable assets, including a summary of the protection measures adopted.

1.1 Review recommendations

During the September 2022 review meeting, some recommendations have been made regarding dissemination and exploitation activities of the project. All the recommendations have been considered. In particular:

- The Consortium has improved the quality of scientific output and publications, with a collection of publications available during 2023 that have surpassed the expected KPI of >30, mostly available on Open access repositories.
- The project's website has been updated according to the recommendation with a new devoted section for uploading scientific publications and another one reporting on the project results.

2. Dissemination and Communication Activities

The development and upkeep of the plan for the distribution and use of project information marked the beginning of T6.1's dissemination and communication operations. Since then, efforts have been made to guarantee the project's visibility through the results of the scientific publications produced by the project consortium and the dissemination of information at numerous planned and attended scientific events, as well as through online platforms (website and social media accounts).

2.1 AI@EDGE dissemination strategy

The AI@EDGE dissemination strategy has been prepared within WP6 and has already been illustrated in D6.1. It has been kept regularly updated and managed. At the beginning of the project few activities were carried out because of the initial shortage of results and because of the insurgence of the Covid-19 epidemic. But starting from the second year of the project, with the possibility of having in-presence meetings and the initial project results, the activities increased, reaching a peak around fall 2023.

As it can be appreciated in the table below, all the initially defined KPIs for the AI@EDGE project have been reached.

Table 1 KPIs table

Key Performance Indicators for WP6	Project targets	Achieved
Number of events organized by AI@EDGE (webinars, workshops, etc.)	3	12
Number of press releases	3	6
Number of participants to webinars and workshops	300	807
Number of attendees in dissemination campaign, webinars, peer networking events	> 1.000	2235
Size of the community (incl. Twitter followers, mailing list subscribers, website visitors)	> 1.000	17251
Number of unique website visits	> 1.000	7457
Number of scientific/technical publications	> 30	40
Number of conference presentations	> 20	58
Number of newsletters	3	4
Number of views on YouTube	> 300	514

2.2 Events and webinars organised by AI@EDGE

During the project life cycle, many events have been organised by the project consortium. We provide here a list of these activities with a short overview.

1st Open Annual Workshop on Future ICT

When: 25 May 2022

Where: Venice, Italy

What about: A workshop organized by EIGHT BELLS focused on exploring the state of the art related to ICT, covering aspects such as 5G/6G, Cybersecurity, Quantum Computing, IoT and Cloud. A presentation on "Future ICT: a new approach from research to innovation" on the AI@EDGE project has been provided by Mr. Paolo Comi (ITL).

How many participants: around 40

ETSI MEC plenary #30

When: 14-17 June 2022

Where: Venice, Italy and online

What about: This meeting was organised by Athonet S.r.l. for the activities of the ETSI MEC standardisation group. In addition to the standardisation activities, Cristina Costa from FBK presented the AI@EDGE project.

How many participants: 49 attended

Joint INSPIRE-5G and AI@EDGE workshop – Platforms and Mathematical Optimization for Secure and Resilient Future Networks

When: 8-9 November 2022

Where: Paris, France

What about: The AI@EDGE project has organised a joint workshop entitled "Platforms and Mathematical Optimization for Secure and Resilient Future Networks" together with the INSPIRE-5Gplus project. The workshop has been co-organised with the INSPIRE-5G PLUS project and has seen the participation of 30+ people.

How many participants: 40

IEEE CLOUDNET 2022

Joint workshop INSPIRE-5G and AI@EDGE

8-9/11/2022, Paris (France)

08/11/2022

TIME	TOPIC	LEAD
8.30-9.15	Registration	
9.15-10.15	Opening Keynote: *Tackling "the identity problem"*	**Radia Perlman** ***Dell, USA***
10.15-11.00	*Coffee Break and networking*	
11.00-11.25	Presentation of INSPIRE-5G project	Jean-Philippe Wary, Orange
11.25-11.50	Presentation of IAI@EDGE project	Roberto Riggio, UNIVPM
11.50-12.15	Malware propagation in mobile device-to-device networks[i]	Benedikt Jahnel, WIAS-Berlin (webex)
12.15-14.00	*Lunch Break*	
14.00-15.00	Keynote: *Issues in Cloud Security*	**Charlie Kaufman** ***Dell, USA***
15.00-15.25	Dynamic counter-measures placements for network security: a hybrid AI/OR approach[ii]	Yann Dujardin, Orange
15.25-15.50	Quantum Technologies for securing communications at the edge[iii]	Paolo Comi, Italtel[1]
15.50-16.15	What are responsibility graphs and what can they teach us about responsibility repartition?	Gaber Chrystel, Orange
16.15-17.00	*Coffee Break and networking*	

09/11/2022

TIME	TOPIC	LEAD
8.30-9.15	Registration	
9.15-10.15	Keynote: *Cloud deployments of 5G core networks: unleashing the power of private 5G*	**Nicola Di Pietro** ***Athonet, Italy***
10.15-10.45	*Coffee Break and networking*	
10.45-11-00	Scheduling algorithms in the service of routing computational processes in MEC servers[iv]	Stylianos Koumoutzelis, 8Bells research
11.00-11.25	ML-based applications at the edge of aeronautical networks[v]	Babak Mafakheri, SPI
11.25-11.50	End-to-end Security Problems in the Heterogeneous Multi-Party IoT-Cloud Infrastructure[vi]	Du Xiaojiang, Stevens Institute of Technology
11.50-12.15	AI@Edge Network Architecture and Automation of Future Telecom networks[vii]	Neiva Linder, EAB
12.15-14.00	*Lunch Break*	
14.00-15.00	Keynote: *Moving Target Defense (MTD) in Future Telco Networks: Design, Implementation and Challenges*[2]	**Dr G. Gur, University of Zurich**
15.00-15.30	Influence of transients on end-to-end network availability and resilience[viii]	Christian Tanguy, Orange
15.30-16.00	Formal Proof Metrics : the Developer's Guide to Formal[ix]	Gaber Chrystel, Orange (Webex)
16.00-16.15	Placement of Artificial Intelligence Functions for Anomaly Detection[x]	Yellas Nour El-houda, CNAM
16.15-17.00	*Coffee Break and networking*	

Figure 1 Joint workshop @ CLOUDNET 2022, participants (above) and agenda (below)

Mobile World Congress (MWC) 2023

When: 27 February- 2 March 2023

Where: Barcelona, Spain

What about: The main aim of this booth was to present the AI@EDGE project latest results with demos and to collect feedback from the industrial sector present at the event. It has also been the occasion to collect useful information on the latest trends on 5G and 6G. The booth has been co-hosted

with the 5G-PPP DAEMON project. Many visitors have joined the AI@EDGE team at the booth and asked information about the project results and what was being developed.

How many participants: at least 50 people has expressed interest in the project work.

Figure 2 Pictures from AI@EDGE booth in MWC 2023

IEEE ICC 2023 https://aiedge-inspire5g.roc.cnam.fr/

When: 28 May – 1 June 2023

Where: Rome, Italy

What about: Another booth has been arranged at the IEEE ICC 2023 in Rome, again co-hosted with the 5G-PPP DAEMON project. The focus of the conference was on "Sustainable Communications for Renaissance".

Within the AI@EDGE booth, information regarding project results, architecture and use-case videos showcasing the challenges in using the platform and future expectations have been presented.

How many participants: around 60

Figure 3 Images from the AI@EDGE Booth at the IEEE ICC 2023 conference

Smartbygd 2023 - Smart solutions for living and working in rural areas

When: 1-3 June 2023

Where: Lycksele, Sweden

What about: Smartbygd 2023 is the name of the series of rural events where material from research and innovation projects, national and international such as AI@EDGE and A5GARD, is presented to the general population. The purpose of the events was to disseminate project results, educate about the state-of-the-art and technological developments that are coming, and to create hope for the future. The main aim was to show that a bright future is possible with new technology and innovations, not least in the field of care, and illustrate the importance of preparedness for any crises that may arise. The Smartbygd event has gathered professionals, decision makers and the public to show what is happening in technology development for both the individual and society at large. The 2023 event took place in the municipality of Lycksele in the interior north of Sweden.

How many participants: around 400

Figure 4 AI@EDGE at Smartbygd 2023

EUCNC & 6G Summit 2023. Workshop "Exploring the Intersection of 6G and Artificial Intelligence: Unleashing the Potential of Next-Gen Technologies"

When: 6 June 2023

Where: Gothenburg, Sweden

What about: The main aim of the workshop has been to explore the intersection of artificial intelligence (AI) and 6G technology and the potential of AI and 6G to work together to create new business opportunities and support new application verticals. 6G is the next generation of mobile networks that promises to revolutionize the way we connect and interact with the world around us. With its high-speed, low-latency, and high-bandwidth capabilities, 6G has the potential to enable new and exciting use cases in a variety of industries, including transportation, healthcare, and manufacturing. AI, on the other hand, has the potential to drive innovation in a wide range of fields, including computer vision, natural language processing, and decision-making. The latest research and developments in these areas has been shown by all the projects involved, i.e., DAEMON, 5G-IANA, and HEXA-X, as well as the challenges and opportunities that lie ahead.

The workshop has been a great opportunity for researchers, engineers, and industry professionals to learn about the latest developments in AI and 6G and to network with other experts in the field. It has also provided a platform to share other research and ideas, and to explore potential collaborations.

How many participants: around 50

Figure 5 AI@EDGE's workshop at EUCNC 2023

Webinar "Introduction on #HPO and #AutoML"

When: 09 November 2023

Where: Online

What about: In recent years, Machine learning (ML) has achieved considerable successes, and an ever-growing number of disciplines rely on it. However, the unprecedented success of ML models comes at the cost of the complexity of choosing a suitable model. Moreover, a traditional ML experiment often extends to additional steps such as data preparation, cleaning, and setting hyper-parameters. In practice, researchers and data scientists rely on their experiences over similar problems to find the most promising pipeline. This manual approach is a tedious and error-prone task due to the enormous possibilities of experiment settings. AutoML (Automated Machine Learning) aims thus at addressing this limitation by automating the search process. This webinar will provide a thorough introduction to autoML's key fundamentals and discusses the problem of hyperparameter optimization, the simplest and most common problem that AutoML considers and describes the wide variety of different approaches that are applied.

How many participants: 14

Link: Available on YouTube at the following link.

Webinar "Bringing the intelligence to the Edge" - AI@EDGE and DAIS Overall Architecture

When: 29 November 2023

Where: Online

What about: In this webinar, AI@EDGE and DAIS projects have shared the results on their overall architecture and main components needed to bring the intelligence to the edge in B5G/6G networks. AI@EDGE project has presented the Network and Service Automation Platform (NSAP) and Connect-Compute Platform (CCP) with new modules/functions/services and interfaces for AI based Orchestration of AI Function (AIF), with dynamic AIFs placement on decentralized and distributed CCP. The key components, Multi-Tier Orchestrator (MTO) & Intelligent Orchestrator Component (IOC) exploiting data and AI/ML pipeline have been addressed together with further research area in this domain. The DAIS project has presented the approach and design of the software architecture and the enabling software components for the DAIS software platform. Additionally, they presented various challenges and design aspects related to enabling software components, coordination, and orchestration of distributed AI components, ensuring security and in the software environment and realization of a robust, flexible, and secure digital communications infrastructure, which are the key aspects of the DAIS Software platform. Lessons learned and challenges have also been discussed during an interesting panel just after presentations.

How many participants: 22

Link: Available on YouTube at the following link.

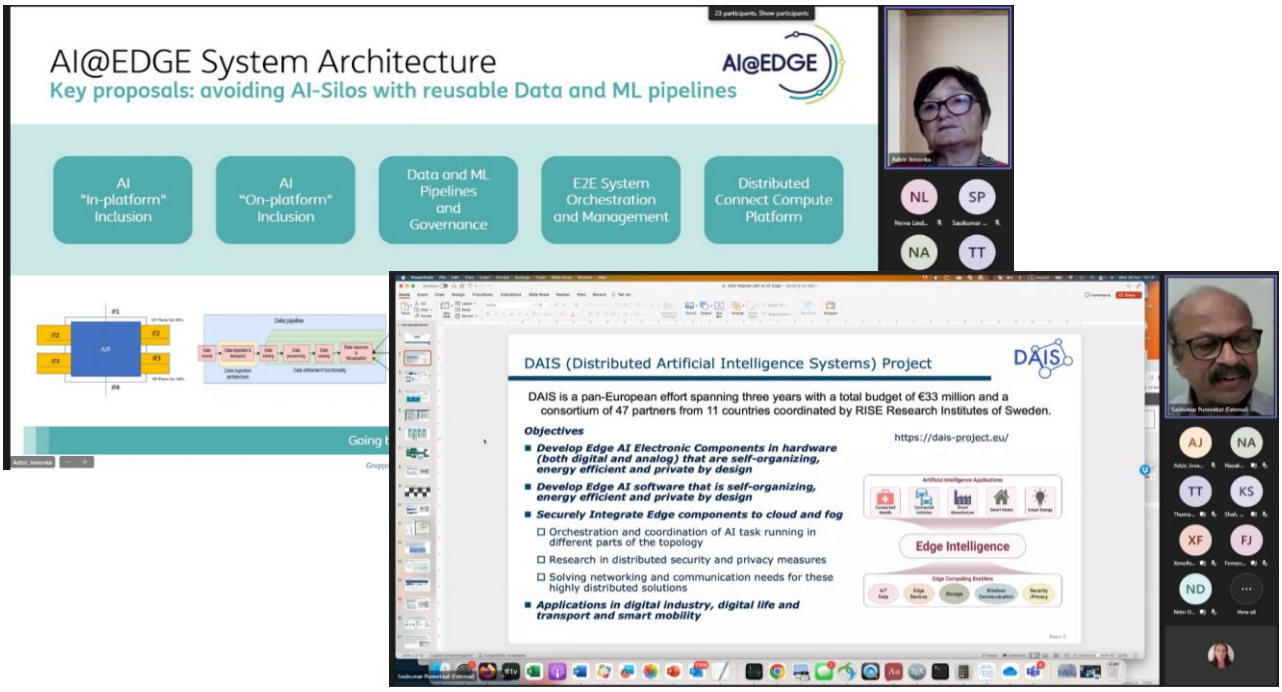


Figure 6 Webinar presentations on AI@EDGE architecture (by Jovanka Adzic TIM) and DAIS architecture (by Sasikumar Punnekkat)

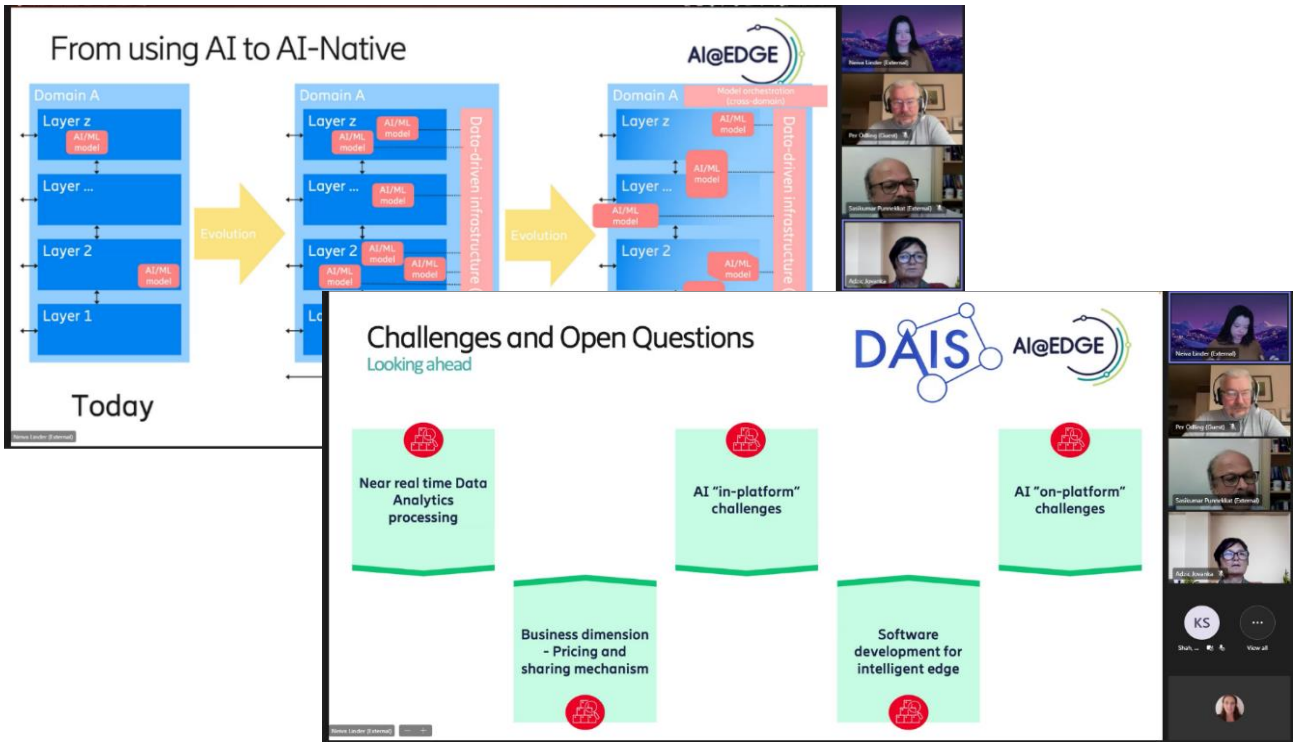


Figure 7 Panel session

Panel session within the AI4CI Workshop

When: 5 December 2023, 2-4:30 pm

Where: Paris, France

What about: AI@EDGE has organised and will participate in a panel in the afternoon of the 5th of December at 2 pm to discuss advanced research activities and learn which skills the industry needs.

How many participants: 30 in presence and 14 online

Figure 8 AI@EDGE presented at the AI4CI workshop

Webinar on Closed Loop Automation for Networked Systems

When: 11 December 2023

Where: In presence Paris, France and online

What about: In this webinar, we have presented a closed-loop automation system making use of AI to automatically mitigate anomalous states of the connect-compute software infrastructure. We have also described different functional blocks of the algorithmic framework, and particularly the anomaly detection module using federated learning, the AI function scheduling to meeting detection performance targets while mitigating AIF stragglers, the data-pipeline system design to ensure high accuracy, real-time data preprocessing and arrival, and a reinforcement learning framework to automatically find reconfiguration intents. The webinar has ended with a preliminary demonstration of key system blocks and a highlight further research in this area.

How many participants: 17 in presence and 11 online.

Link: Available on YouTube at the following link.

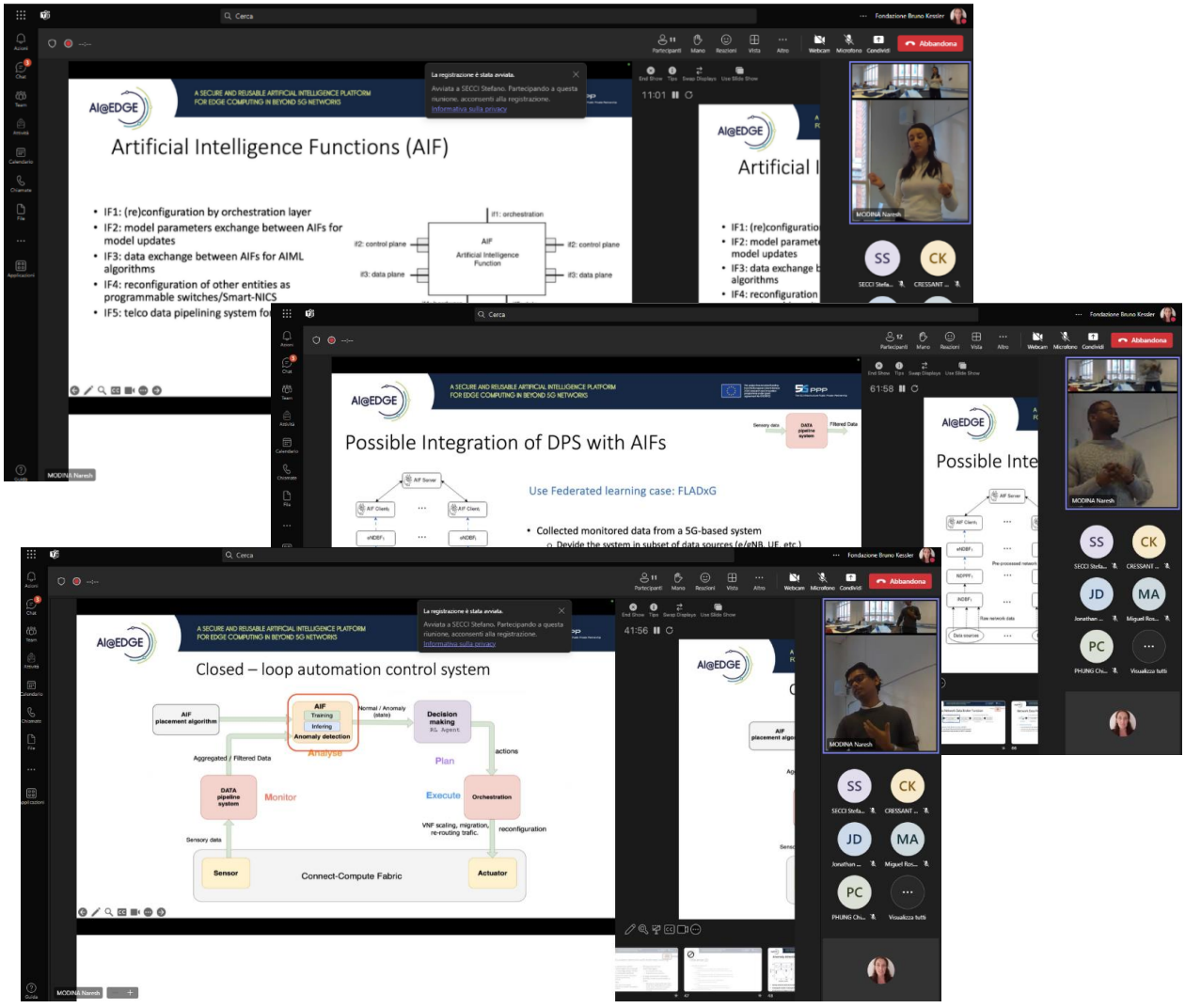


Figure 9 AI@EDGE presentations at the 3rd webinar

Final AI@EDGE workshop

When: 13 December 2023

Where: In presence Wessling, Munich, Germany, and online

What about: Within this workshop, the importance of the AI@EDGE platform for all use cases, with a focus in the of UC4, has been discussed. The event started with an overview of Safran Passenger Innovations' activities and business by Leonardo Goratti (SPI) and followed by an introduction to the AI@EDGE project by Irene Facchin PMP (FBK). Subsequently, there were three presentations focusing on UC2 (Daniel Reti), UC3 (Miguel Rosa Serván), and UC4 (Babak Mafakheri), presenting their respective results. In the afternoon session, the core partners of UC4 provided insights into their technologies and their integration within the UC4 testbed, through presentations from Javier Palomares Torrecilla (i2CAT), Justin Tallon (SRS), Nicola di Pietro (HPE), and Phung Chi-Dung (CNAM). The day concluded with a tour of the Safran Passenger Innovations R&T lab, where visitors had the opportunity to explore the final setup of the AI@EDGE UC4 and assess the performance of its various components.

How many participants: 11 in presence (of which 3 external visitors) and 11 online.

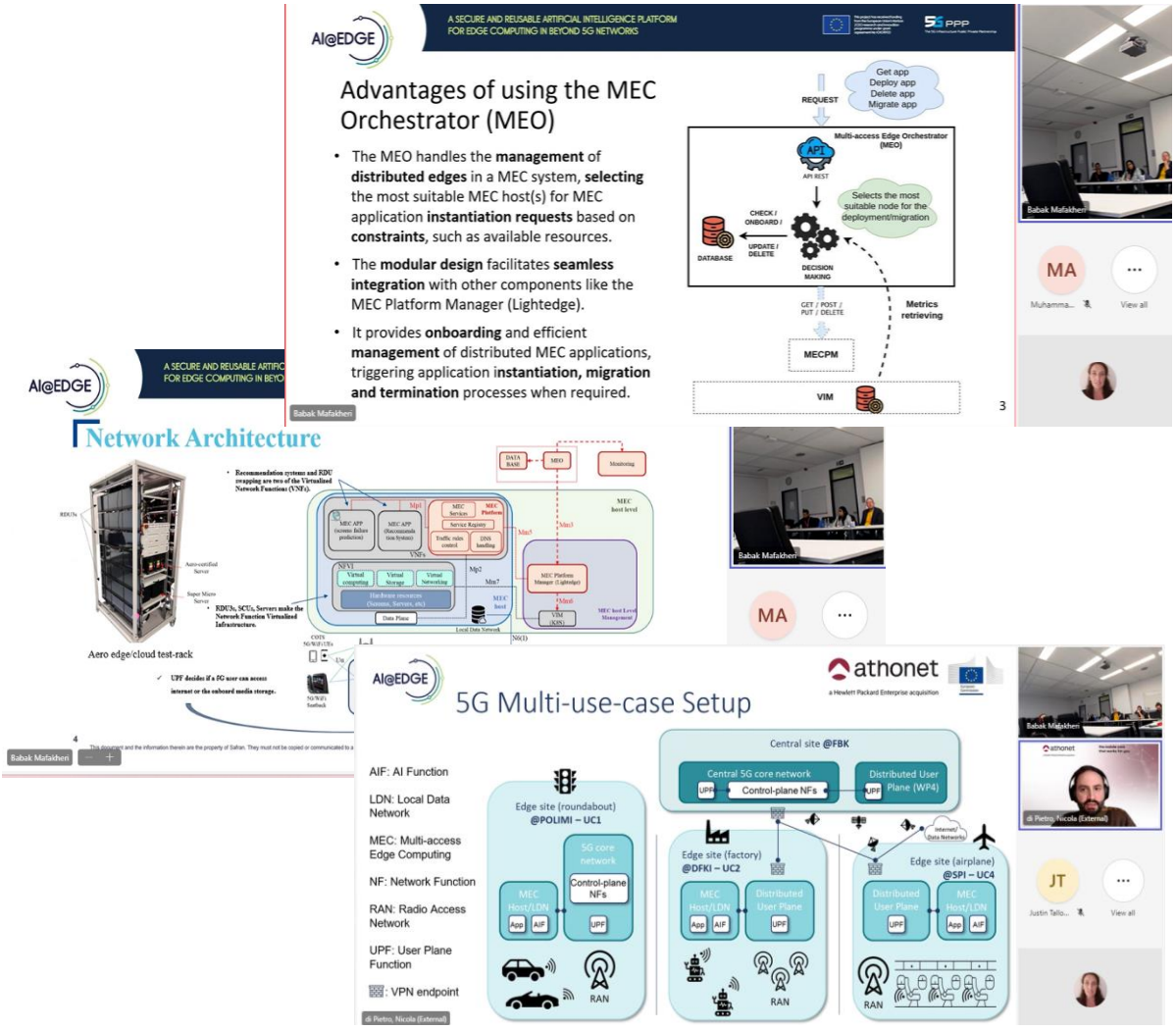


Figure 10 AI@EDGE Final workshop

2.3 AI@EDGE online presence

The AI@EDGE website has been the main showcase of the project to the broadest audience and external institutions. The website has been the prime public dissemination tool, making available the content derived from the development activities and providing access to other informative material such as project technical reports, posters, and presentations. The website has been kept up to date with the latest project achievements and dissemination activities. A section called "Publications" reporting the project deliverables marked as Public and other interesting scientific publications has been published. An additional page showcasing the project Results has been also recently added.

The website statistics as of December 22, 2023, shows 17.251 users, with 7.457 unique website visits.

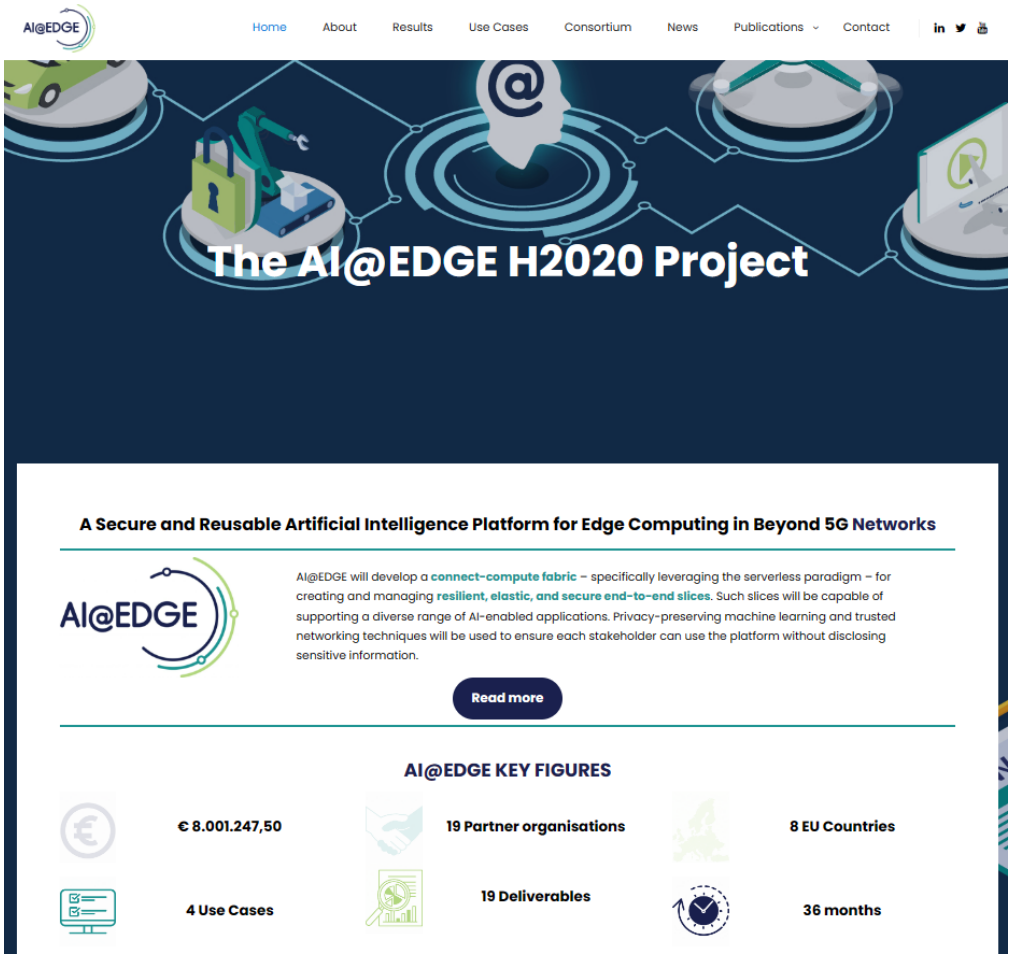


Figure 11 AI@EDGE website main page

2.3.1 LinkedIn

The project's LinkedIn page has reached 204 followers as of December 22, 2023.

Figure 12 AI@EDGE account on LinkedIn

2.3.2 *Twitter*

The project's Twitter account, available at https://twitter.com/AIatEdgeH2020, has posted 93 tweets and has 213 followers as of December 22, 2023.

Figure 13 AI@EDGE account on Twitter

2.4 Opportunity-based dissemination

Opportunity-based dissemination takes place through partners' and other websites, as well as partners' and other newsletters, news press, publications, press releases, etc. The full list is available in Annex 3.

2.5 Scientific publications

The full list of the scientific publications of the AI@EDGE project are provided herewith.

OPEN ACCESS

1. **AI@EDGE: A Secure and Reusable Artificial Intelligence Platform for Edge Computing** https://aiedge-inspire5g.roc.cnam.fr/

   Authors: Riggio R., Coronado E., Linder N., Jovanka A., Mastinu G., Goratti L., Rosa M., Dieter Schotten H., Pistore M.

   Venue: 2021 EuCNC & 6G Summit - 6GV

2. **FaaS and Curious: Performance implications of serverless functions on edge computing platforms** https://aiedge-inspire5g.roc.cnam.fr/

   Authors: Tzenetopoulos A., Apostolakis E., Tzomaka A., Papakostopoulos C., Stavrakakis K., Katsaragakis M., Oroutzoglou I., Masouros D., Xydis S., Soudris D.

   Venue: International Supercomputing Conference - High Performance (ISC) 2021, Workshop VHPC'21

3. **Towards sharing one FPGA SoC for both low-level PHY and high-level AI/ML computing at the edge** https://aiedge-inspire5g.roc.cnam.fr/

   Authors: Stratakos I., Papatheofanous E.A., Danopoulos D., Lentaris G., Reisis D., Soudris D.

   Venue: Int'l Mediterranean Conf. on Communications and Networking (meditcom 2021), Workshop 1 on Acceleration for Edge Computing

4. **Delay-Sensitive Wireless Content Delivery: An Interpretable Artificial Intelligence Approach**

   Authors: Coronado E., Gómez B., Villalón J., Garrido A., Siddiqui S., Riggio R.

   Venue: 1st International Workshop on Network Programmability (NetP 2021) co-located with CNSM 2021

5. **An AI-empowered framework for cross-layer softwarized infrastructure state assessment**

   Authors: Diamanti A., Sanchez Vilchez J., Secci S.

   Venue: IEEE Transactions on Network and Service Management

6. **Robust Access Point Clustering in Edge Computing Resource Optimization**

   Authors: Elhouda Yellas N., Boumerdassi S., Maaz B., Ceselli A., Secci S.

   Venue: IEEE Transactions on Network and Service Management

7. **A Lightweight Southbound Interface for Standalone P4-NetFPGA SmartNICs**

   Authors: Patetta M., Taktak S., Secci S.

   Venue: 6GNET 2022 conference

8. **An Open Dataset for Beyond-5G Data-driven Network Automation Experiments**

   Authors: Phung C., Elhouda Yellas N., Bin Ruba S., Secci S.

   Venue: 6GNET 2022 conference

9. **Anomaly Detection for 5G Softwarized Infrastructures with Federated Learning**

   Authors: Elhouda Yellas N., Bin Ruba S., Secci S.

   Venue: 6GNET 2022 conference

10. **LSTM acceleration with FPGA and GPU devices for edge computing applications in B5G MEC**

    Authors: Danopoulos D., Stamoulias I., Lentaris G., Masouros D., Kanaropoulos I., Kakolyris A.K., Soudris D.

    Venue: SAMOS 2022

11. **Sequence Clock: A Dynamic Resource Orchestrator for Serverless Architectures**

    Authors: Fakinos I., Tzenetopoulos A., Masouros D., Xydis S., Soudris D.

    Venue: IEEE CLOUD 2022

12. **Zero Touch Management: A Survey of Network Automation Solutions for 5G and 6G Networks**

    Authors: Coronado E., Behravesh R., Subramanya T., Fernández-Ferńandez A., Siddiqui S., Costa-Pérez X., Riggio R.

    Venue: IEEE Communications Surveys and Tutorials

13. **Function Placement and Acceleration for In-Network Federated Learning Services**

    Authors: El-houda Yellas N., Addis B., Riggio R., Secci S.

    Venue: IFIP CNSM 2022

14. **Beyond 5G/6G KPIs and Target Values. A white paper from the Test, Measurement and KPIs Validation Working Group**

    Authors: Nielsen L., Gavras A., Dieudonne M., Mesogiti I., Roosipuu P., Houatra D., Kosmatos E.

    Publisher: 5G-PPP White report

15. **5G PPP Architecture Working Group - View on 5G Architecture, Version 4.0**

    Authors: Gavras A., Bulakci Ö., Gramaglia M., Iordache M., Ghoraishi M., Garcia A., Cogalan T., Gutiérrez J., Tzanakaki A., Warren D., Li X., Landi G., Mangues J., Tsagkaris K., Frascolla V., Lee H.

    Publisher: 5G PPP Architecture Working Group - View on 5G Architecture, Version 4.0.

16. **DQN-based Intelligent Application Placement with Delay-Priority in Multi MEC Systems**

    Authors: Sebastian Camargo J., Coronado E., Torres-Perez C., Palomares J., Shuaib Siddiqui M.

    Venue: EuCNC & 6G Summit 2023 (EUCNC 2023)

17. **SUMO Roundabout Simulation with Human in the Loop**

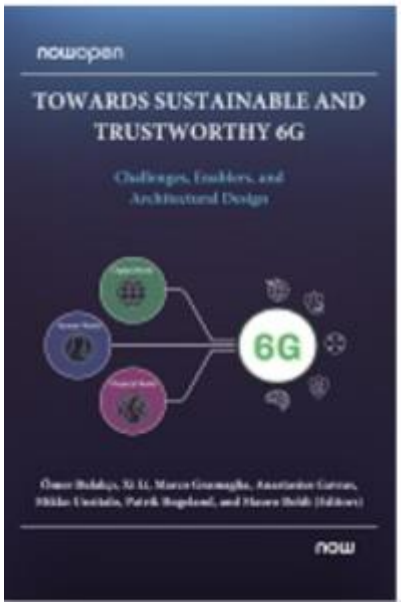
    Authors: Previati G., Mastinu G.

Venue: SUMO User Conference 2023

18. **TOWARDS SUSTAINABLE AND TRUSTWORTHY 6G Challenges, Enablers, and Architectural Design**

    Authors: Bulakçı Ö., Li X., Gramaglia M., Gavras A., Uusitalo M., Rugeland P., Boldi M.

    Publisher: Boston-Delft: now publishers



19. **Beyond 5G/6G KPI Measurements Whitepaper**

    Authors: Dieudonne M., Wang H., Mesogiti I., Kosmatos E.

    Publisher: Zenodo

20. **Design and Evaluation of a K8s-based System for Distributed Open-Source Cellular Networks**

    Authors: Palomares J., Coronado E., Rincon R., Shuaib Siddiqui M.

    Venue: International Wireless Communications & Mobile Computing Conference (IWCMC 2023)

21. **A memory footprint optimization framework for Python applications targeting edge devices**

    Authors: Katsaragakis M., Papadopoulos L., Konijnenburg M., Catthoor M., Soudris D.

    Publisher: Journal of Systems Architecture

22. **Deep Reinforcement Learning for QoS-aware scheduling under resource heterogeneity Optimizing serverless video analytics**

    Authors: Giagkos D., Tzenetopoulos A., Masouros D., Soudris D., Xydis S.

    Venue: 2023 IEEE 16th International Conference on Cloud Computing (CLOUD)

23. **Evaluating Versal ACAP and conventional FPGA platforms for AI inference**

    Authors: Leftheriotis A., Tzomaka A., Danopoulos D., Lentaris G., Theodoridis G., Soudris D.

    Venue: 2023 12th International Conference on Modern Circuits and Systems Technologies (MOCAST 2023)

24. **Quantitative and Qualitative Evaluation of Reinforcement Learning Policies for Autonomous Vehicles**

    Authors: Ferrarotti L., Luca M., Santin G., Previati G., Mastinu G., Campi E., Uccello L., Albanese A., Zalaya P., Roccasalva A., Lepri B.

25. **Cooperative, connected, and automated vehicles into a roundabout**https://aiedge-inspire5g.roc.cnam.fr/

    Authors: Mastinu G., Previati G., Campi E.

    Venue: Fisita World Conference

26. **Roundabout Traffic: Simulation With Automated Vehicles, Ai, 5g, Edge Computing and Human in the Loop**

    Authors: Mastinu G., Previati G., Campi E., Gobbi M., Uccello L., Varela Daniel A., Albanese A., Roccasalva A., Santin G., Luca M., Lepri B., di Pietro N.

    Venue: International Design Engineering Technical Conferences and Computers and Information in Engineering Conference IDETC/CIE 2023

27. **Traffic simulation with human in the loop: roundabout scenario in a driving simulator**

    Authors: Mastinu G., Previati G., Campi E., Gobbi M.

    Venue: DSC 2023

28. **Roundabouts: Traffic simulations of connected and automated vehicles - A state of the art**

    Authors: Campi E., Mastinu G., Previati G., Studer L., Uccello L.

    Publisher: IEEE TRANSACTIONS ON INTELLIGENT TRANSPORT SYSTEMS

29. **Edge Intelligence in 5G and Beyond Aeronautical Network with LEO Satellite Backhaul**

    Authors: Mafakheri B., Yan C., Narayanaswamy K., Trang I., Betz T., Pientka K., Goratti L.

    Venue: 2023 EuCNC & 6G Summit (EUCNC)

30. **Auto-tuning of Hyper-parameters for Detecting Network Intrusions via Meta-learning**

    Authors: Anser O., François J., Chrisment I.

    Venue: NOMS 2023 - IEEE/IFIP Network Operations and Management Symposium (NOMS) - AnNet workshop

31. **DQN-based intelligent controller for multiple edge domains**

    Authors: Llorens-Carrodeguas A., Cervelló-Pastor C., Valera F.

    Publisher: Journal of Network and Computer Applications, vol. 218, pp. 1-14, Sep. 2023.

32. **An intelligent scheduling for 5G user plane function placement and chaining reconfiguration**

    Authors: Leyva-Pupo I., Cervelló-Pastor C.

    Publisher: Computer Networks, vol. 237, pp. 1-15, Sep. 2023.

33. **DeepGANTT: A Scalable Deep Learning Scheduler for Backscatter Networks**

    Authors: Perez-Ramirez D.F., Pérez-Penichet C., Tsiftes N., Voigt T., Kostić D., Boman M.

    Venue: Proceedings of the 22nd International Conference on Information Processing in Sensor Networks (IPSN '23).

IEEE EXPLORE

34. **Roadrunner: O-RAN-based Cell Selection in Beyond 5G Networks**

Authors: Coronado E., Siddiqui S., Riggio R.

Venue: NOMS 2022-2022 IEEE/IFIP Network Operations and Management Symposium

35. **Machine Learning at the Mobile Edge: The Case of Dynamic Adaptive Streaming Over HTTP (DASH)**

    Authors: Behravesh R., Rao A., Perez-Ramirez D.F., Harutyunyan D., Riggio R., Boman M.

36. **Compression of Signal Activation from Split Deep Neural Network**

    Authors: Brito F., Silva L., Ramalho L., Lins S., Linder N., Klautau A.

    Venue: 2022 LATINCOM

37. **Service Management in Dynamic Edge Environments**https://aiedge-inspire5g.roc.cnam.fr/

    Authors: Torres-Pérez C., Coronado E., Cervelló-Pastor C., Shuaib Siddiqui M.

    Venue: IEEE/IFIP Networking, accepted but pending publication

38. **Distributed Learning for Application Placement at the Edge Minimizing Active Nodes**

    Authors: Torres-Pérez C., Coronado E., Cervelló-Pastor C., Camargo J., Shuaib Siddiqui M.

    Venue: 2023 2nd International Conference on 6G Networking (6GNet)

39. **A network architecture for scalable end-to-end management of reusable AI-based applications**

    Authors: Brito F., Castaneda Cisneros J., Linder N., Riggio R., Coronado E., Palomares J., Adzic J., Renart J., Lindgren A., Rosa M., Odling P.

    Venue: 2023 14th International Conference on Network of the Future (NoF)

40. **Enabling Intelligence Inclusiveness in Edge to Cloud Continuum: Challenges and Opportunities**

    Authors: Palomares J., Coronado E., Cervello-Pastor C., Siddiqui S.

    Venue: 2023 IEEE 9th International Conference on Network Softwarization (NetSoft)

POSTERS

1. **Auto-configuration des systèmes de détection d'intrusions grâce aux expériences passées** https://aiedge-inspire5g.roc.cnam.fr/

   Authors: Anser O., Francois J., Chrisment I.

   Venue: RESSI (Rendez-Vous de la Recherche et de l'Enseignement de la Sécurité des Systèmes d'Information)

2. **A Secure and Reusable Artificial Intelligence Platform for Edge Computing in Beyond 5G Networks**

   Authors: presented by Soudris D., general intro of AI@EDGE and then focus on acceleration cluster

   Venue: HIPEAC 2023 (WRC workshop)

3. **Service Management in Dynamic Edge Environments**

   Authors: Torres-Pérez C., Coronado E., Cervelló-Pastor C., Shuaib Siddiqui M.

   Venue: PhD Symposium on Next-Generation Networks (IFIP Networking 2023)

2.6 Conference presentations

The full list of the AI@EDGE project presentations is provided in Annex 2. Herewith we provide some highlights.

@5GPPP webinar Europe accelerates towards #6G

When: 16 March 2021

Where: Online

Description: The webinar gave the floor to the 9 new 5G-PPP Smart Connectivity beyond 5G projects, selected for funding under the H2020-ICT-52-2020: 5G-PPP Smart Connectivity beyond 5G Call, which started in January 2021 and at the time were already developing exciting advances beyond 5G towards 6G. The webinar was held in two parts, where all projects presented their vision of 6G in the first part as the motivation for their projects and the technical challenges they are addressing to move towards 6G in the second part.

Participants: 310

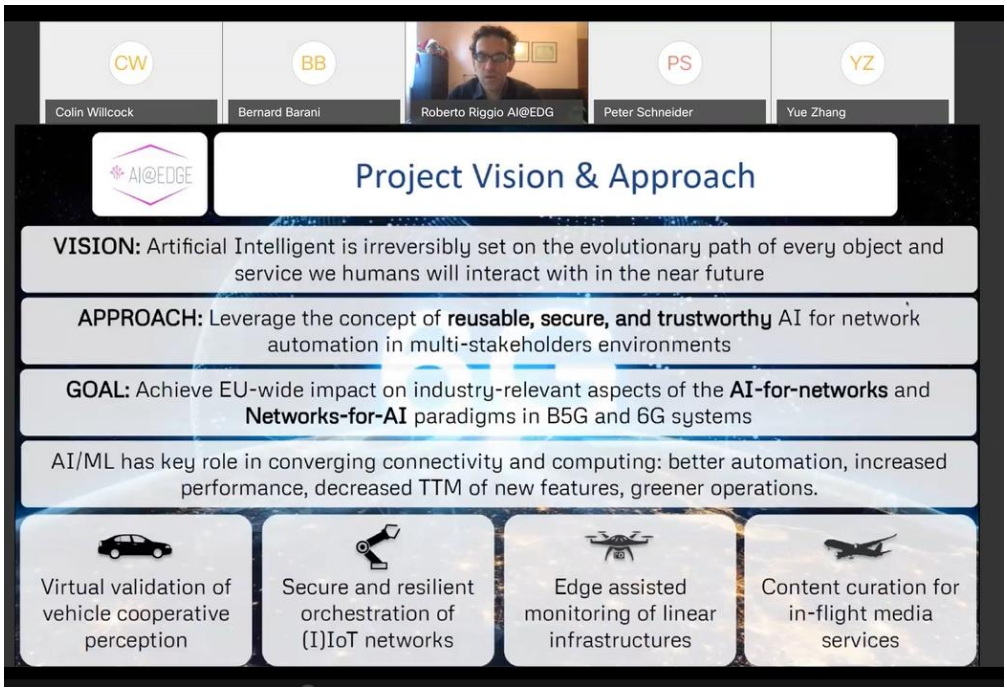


Figure 14 Roberto Riggio, TM, presenting AI@EDGE

IEEE International Mediterranean Conference on Communications and Networking

When: 7-10 September 2021

Where: Athens, Greece, and virtual.

Description: Visionaries from academia, research facilities, and business worldwide came together at IEEE MeditCom, which featured programming aimed at resolving many of the unresolved issues in networking and communications. Research papers on a wide range of research topics, including theoretical and systems research as well as vertical technologies, have been invited for the conference. AI@EDGE participated to the "Workshop 1 on Intelligent operations, security, and acceleration for edge computing" presenting the paper entitled "Towards sharing one FPGA SoC for both low-level PHY and high-level AI/ML computing at the edge".

IEEE/IFIP Network Operations and Management Symposium

When: 25-29 April 2022

Where: Budapest, Hungary

And

When: 8-12 May 2023

Where: Miami, FL, USA

Description: The NOMS conference offered a plethora of opportunities for learning, sharing, and exchanging ideas through keynote addresses, panels, technical sessions, demo sessions, dissertation sessions, mini-conference sessions, poster sessions, tutorials, and workshop. "Network and Service Management in the Era of Cloudification, Softwarization and Artificial Intelligence" was the primary theme for 2022, highlighting the pressing need for cloudification, digitalization, softwarization, and AI-driven management of the ever-more complex network and service environments. One paper from AI@EDGE has been accepted and published: "Roadrunner: O-RAN-based Cell Selection in Beyond 5G Networks", Coronado E., Siddiqui S., Riggio R.

6GNET 2022 conference

When: 06-08 July 2022

Where: Paris, France

Description: The program of the first edition explored and assessed the progress of various aspects of 6G networking research in the company of internationally-renown experts. AI@EDGE participated to "Session#6: AI native 6G" with a presentation on "Distributed Learning for Application Placement at the Edge Minimizing Active Nodes", as well as with 3 accepted papers:

- "A Lightweight Southbound Interface for Standalone P4-NetFPGA SmartNICs", Patetta M., Taktak S., Secci S.
- "An Open Dataset for Beyond-5G Data-driven Network Automation Experiments", Phung C., Elhouda Yellas N., Bin Ruba S., Secci S.
- "Anomaly Detection for 5G Softwarized Infrastructures with Federated Learning", Elhouda Yellas N., Bin Ruba S., Secci S.

IEEE INTERNATIONAL CONFERENCE ON CLOUD COMPUTING 2022

When: 11-15 July 2022

Where: Barcelona, Spain

Description: The IEEE International Conference on Cloud Computing (CLOUD) is a premier global platform for exchanging the most recent and significant developments in the field' state of the art and application, identifying hot areas for future research, and defining cloud computing's future. Every topic pertaining to cloud computing fits under the CLOUD theme.

18th International Conference on Network and Service Management

When: 31 October - 04 November 2022

Where: Thessaloniki, Greece

Description: CNSM 2022 has focused on the theme "Intelligent Management of Disruptive Network Technologies and Services". The core track has been accompanied by a series of workshop and poster sessions. One paper from AI@EDGE has been presented: "Function Placement and Acceleration for In-Network Federated Learning Services".

IEEE Cloudnet 2022

When: 07-10 November 2022

Where: Paris, France

Description: When it comes to delivering dependable, affordable services and data across data centre fabrics and wide-area backbones, cloud networking has shown great promise. Virtualization technologies have become widely adopted in computer and communication infrastructure, sparking ongoing innovation in the form of new software platforms, network protocols, and orchestration techniques based on artificial intelligence. The world's most eminent researchers and business leaders in this sector convened at CloudNet 2022, offering participants a fantastic chance to present their work and engage in intellectual conversation. AI@EDGE has contributed to the conference with a keynote by Nicola di Pietro (ex ATHONET) on "Cloud deployments of 5G core networks: unleashing the power of private 5G" and the Joint H2020 AI@EDGE and INSPIRE-5G project workshop

Participants: 60 in the conference, and 40 in the workshop

2022 Latincom

When: 30 November – 2 December 2022

Where: Rio de Janeiro, Brazil

Description: Every year, the most significant communications conference in Latin America takes place, drawing submissions and attendees from throughout the world. This three-day conference is

renowned for bringing together academic and industry audiences to discuss the most recent advancements in networking and communications technology, exchange ideas and best practices, and work together on upcoming projects. AI@EDGE presented a paper entitled "Compression of Signal Activation from Split Deep Neural Network".

Participants: 50

VIRTUAL ICT-52 Workshop on 6G 2023

When: 19 January 2023

Where: Virtual

Description: AI@EDGE has made a presentation on AI@EDGE Network Architecture and Automation of Future Telecom networks at the "VIRTUAL ICT-52 Workshop on 6G 2023". The presentation by Neiva Linder (Ericsson) on behalf of AI@EDGE took place on the 19th of January in the afternoon.

Participants: 86

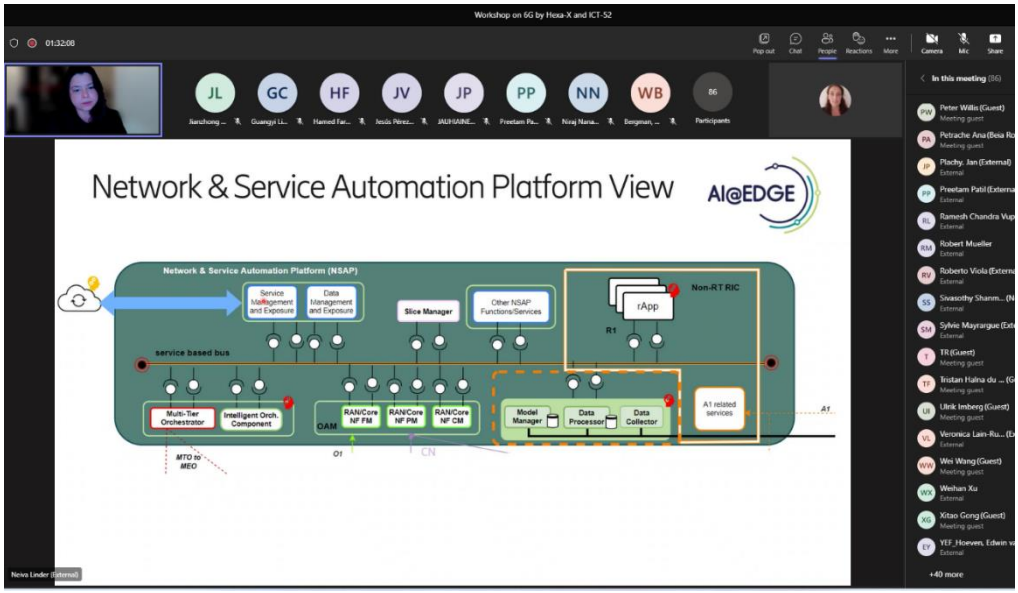


Figure 15 AI@EDGE presented at VIRTUAL ICT-52 Workshop on 6G 2023

16th HiPEAC Workshop on Reconfigurable Computing (WRC'2022)

When: 20 June 2023

Where: Budapest, Hungary

Description: The major goal of this conference was to give researchers working in areas related to reconfigurable computing a place to talk about the most recent advancements. Its primary focus was on reconfigurable platforms and the tools, algorithms, and reconfigurable architectures that enable reconfigurable systems and applications. The following subjects have been the focus of the WRC'22 forum: Coarse-Grained Reconfigurable Arrays (CGRAs)

and their recent research; Open-source initiatives of High-Level Synthesis (HLS) for FPGAs; Graph-Algorithm acceleration using FPGAs; and the role of FPGAs in Artificial Intelligence (AI).

AI@EDGE participated with an invited talk "AI at the extreme edge: the role of FPGAs for enabling onboard AI in space missions" (George Lentaris): *The success of AI/ML in terrestrial applications and the commercialization of space are now paving the way for the advent of AI/ML also in Low Earth Orbit satellites. The two most important hurdles in this direction are the reliability of AI algorithms and the processing power of classical space processors. To overcome the latter, the community considers extending the use of FPGA in space, either with space-grade or Commercial-Off-The-Shelf devices. The FPGA capabilities can be complemented with VPU or TPU co-processors to further enhance high-level AI development and in-flight reconfiguration in space. Thus, selecting the most suitable FPGA devices and designing the most efficient avionics architecture becomes critical for the success of novel AI space missions. The current work presents industrial trends and future ideas, as well as in-house benchmarking and architectural designs utilizing FPGAs to enable AI in space applications.*

UPTIME 2023

When: 8-9 June 2023

Where: Bologna, Italy, and online

Description: Organized and hosted by Athonet, UPTIME is the global event that every year brings together Private 5G and LTE professionals in the evocative setting of Villa Griffone, home of Guglielmo Marconi and the cradle of wireless communications. Connected Workers and Connected Assets - Why Mobile Private Networks are a "must-have" asset in a period of economic uncertainty. Event dedicated to the private 5G world community. A dedicated presentation focused on 5G-PPP projects, including AI@EDGE.

Participants: 500

IEEE INTERNATIONAL CONFERENCE ON CLOUD COMPUTING 2023

When: 02-08 July 2023

Where: Chicago, USA

Description: The IEEE International Conference on Cloud Computing (CLOUD) has established itself as a premier global platform for exchanging the developments in the field's state of the art and application, identifying hot areas for future research, and defining cloud computing's future. Every topic pertaining to cloud computing fits under the CLOUD theme. AI@EDGE participated with an accepted paper entitled "Sequence Clock: A Dynamic Resource Orchestrator for Serverless Architectures" (Fakinos I., Tzenetopoulos A., Masouros D., Xydis S., Soudris D.)

IEEE 14th International Conference on Network of the Future

When: 04-06 October 2023

Where: Izmir. Turkey

Description: Every year, NoF is a top conference covering developments in the field of Future Internet design, with a focus on services, architectures, and enabling technologies. As evidenced by the early rollout of 5G networks and services today, networks have undergone a tremendous transformation in recent years that is leading to new approaches to the deployment of applications and services in a digital society. The evolution of the telecom and ICT industries is being shaped by key trends like softwarization, which is facilitated by Software-Defined Networking (SDN), Network Function Virtualization (NFV), Cloud and Edge Computing, as well as the introduction of new radio techniques.

International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (IDETC-CIE 2023)

When: 20-23 August 2023

Where: Boston Park Plaza, Boston MA

Description: August 2024 is the date of the ASME 2024 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference. The IDETC/CIE 2024 event this year has focused on emerging technologies that affect the important engineering problems of manufacturing, information system management and integration, and product design and development. These are important international gatherings for manufacturing and design engineers from academia, government, and business. AI@EDGE participated with the paper "Roundabout Traffic: Simulation with Automated Vehicles, AI, 5g, Edge Computing and Human in the Loop" (Mastinu G., Previati G., Campi E., Gobbi M., Uccello L., Varela Daniel A., Albanese A., Roccasalva A., Santin G., Luca M., Lepri B., di Pietro N.).

AIRSPACE INTEGRATION WEEK MADRID & EXPODRONICA AIR SHOW 2023

When: 27-28 September 2023

Where: Madrid, Spain

Description: AERO exhibited with a booth dedicated to AI@EDGE and other R&D projects.

Presentation of AI@EDGE project and its contribution to the newly introduced U-SPACE and UAM concepts for drones' operation.

2.7 Newsletters

One electronics newsletter in which to present the project main achievements and training activities is expected to be released each year, but the consortium agreed to produce more newsletters if needed to provide updates on the project outcomes.

The **1st newsletter** has been published on the 28th of June 2021 and is available on the project website at the following link.

The **2nd newsletter** has been published on May 9th, 2022, and presents an overview of the project first year of activities. The newsletter can be read herewith.

The **3rd newsletter** has been published on July 31st, 2023, and presents an overview of the project second year of activities. The newsletter can be read herewith.

The final and 4th newsletter presents the project results. This final newsletter has been published on December 21st, 2023 and is available herewith.

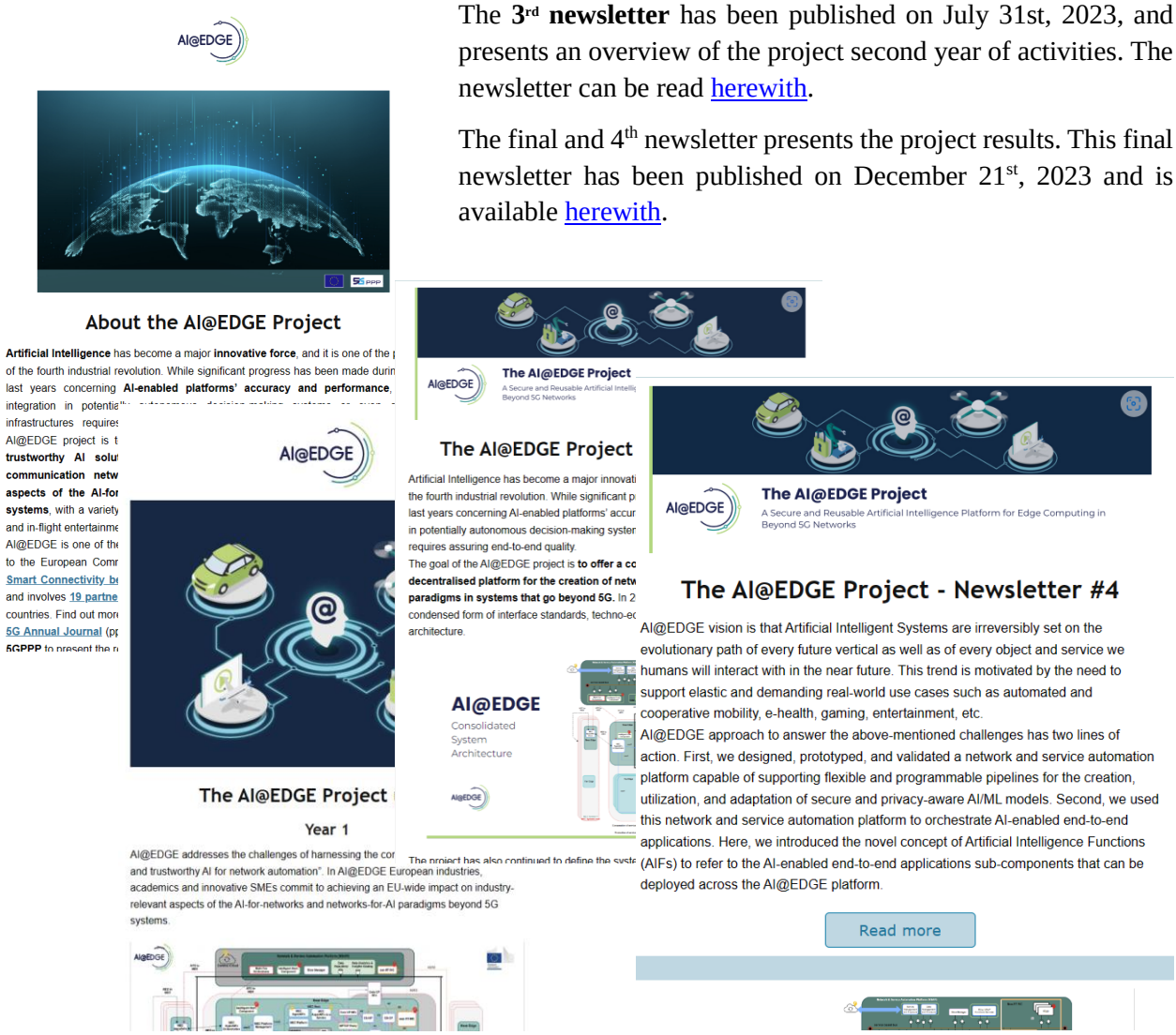


Figure 16 AI@EDGE Newsletters

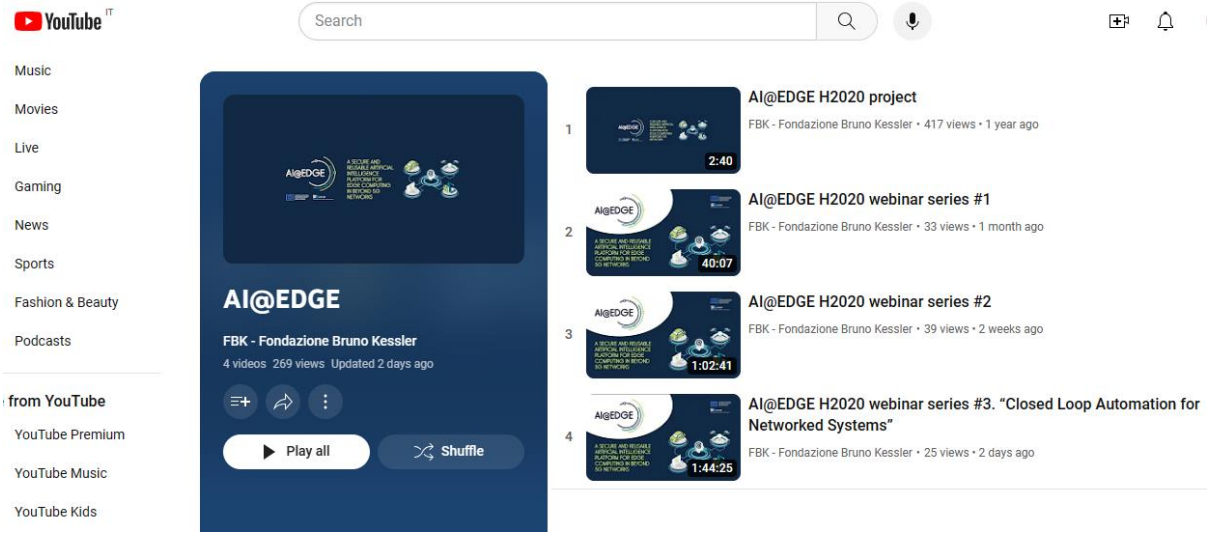
2.8 YouTube views

A YouTube playlist is available for the project within the official YouTube channel of FBK, the AI@EDGE project coordinator. It has been decided best to have a playlist instead than a dedicated

channel. As also reported within D6.1 "Project website, dissemination channels and social media communications", the decision has been taken to capitalise on the subscribers of followers already available in the FBK channel, thus maximising the outreach potential of AI@EDGE videos.

Additionally, 3 more videos have been added: they are related to the 3 AI@EDGE project webinars.

As of December 22, 2023, the total views have been 514.



2.9 Other activities

Project media pack

As it has already been presented within D6.3, a project media pack has been prepared to offer a common visual identity. This media pack contains:

- A **project leaflet** providing general information on the project and its expected outcomes and impacts, as well as an overview of the project 4 use cases. The project leaflet has been distributed at the project booths (Mobile World Congress 2023 and ICC IEEE 2023).
- A **roll-up banner** in 85 x 210 cm format.
- A **project poster.**
- A **video** of the project available in YouTube, as well as the videos from the 3 project webinars.

3. Contribution to Standards

In T6.2, the AI@EDGE project aimed to monitor and contribute to relevant standardization organizations. This was an important task to ensure the potential integration and interoperability of solutions developed by AI@EDGE with other solutions and projects. To maximise the impact of AI@EDGE regarding standardisation, a three-step strategy has been established from the beginning of the project:

1. Identification of relevant standards AI@EDGE can rely on.
2. Identification of gaps. The project will analyse relevant standards and identify gaps in current state of standards development to fulfil the project objectives and so refine technical and scientific contributions.
3. Contributions to standards. These contributions have been provided in different forms. Indeed, not all the project's developments necessarily have to be included into standard documents. However, it is also important to disseminate the project's activities towards the different organizations and groups, that will increase the awareness of the whole community. Therefore, attending to standardization-related meetings, participating in discussions, presenting the project outcomes are also relevant contributions in addition to writing standards whose adoption is also a long-term process and can span over the project duration.

Steps 1 and 2 are done along works performed in technical WPs 2 to 5, while step 3 analysed within T6.3 and documented there. As standardization activities are a constant work, we decided to adopt an incremental structure in this document by identifying for each standardization activities the work done in each year. So, year 1 and year 2 correspond to D6.3 and D6.4 respectively, but this structure helps to understand how the activities has evolved.

The Figure below highlights the project' strategy to provide valuable contributions to standards. As highlighted, many groups have been pre-identified at the project kick-off phase based on common objectives and pre-existing associations of partners within standardization organisations. The process illustrates two steps of refinement. First, based on results achieved alongside the project execution, the groups targeted have been refined and we have engaged in discussions with those groups. Most of the time, this leads to discussions and/or project presentations. These interactions were fruitful for the project to get feedback and directions on how to contribute to standards or to increase awareness about the project in the different SDOs and SDAs.

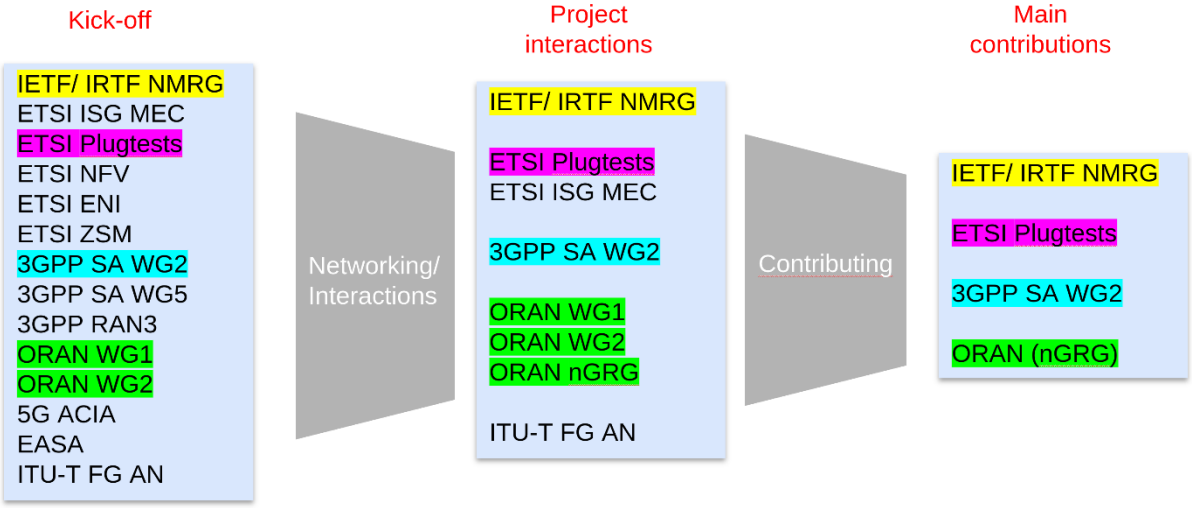


Figure 17 Standardisation strategy of AI@EDGE

Obviously, some of these interactions led to more sustainable exchanges and implication of AI@EDGE partners with the aim to either provide inputs to the standardization groups or better be acquainted with recent advances the project can benefit from. Again, as a research project, publishing new standards is a complex task as AI@EDGE research does not align well with the standardization requirements in terms of industry maturity and timeframes due to generally long standardization processes. However, there is a clear interest by SDOs and SDAs to maintain the connection with research. Therefore, researchers can be implied into more research-oriented pre-standardization inputs by providing guidance or analysis of research results and outcomes. Such types of contribution are entitled differently, for example study item in 3GPP or informational RFC in IETF. We therefore mix the different types of contributions and finally have 4 contributions as highlighted in the last step of the figure above, knowing that our target was 3:

- **IETF/IRTF NMRG (Network Management Research Group):** a new core topic of NMRG is AI and in the context of AI@EDGE most specifically the use of AI to support network management tasks. INRIA, also acting as co-chaired of NMRG, were constantly fuelling discussions around this topic to prepare a refined research agenda for the group to address relevant challenges. As such, INRIA is the main editor of a document dedicated to AI challenges in network management that covers problems investigated in AI@EDGE (like resource allocation or configuration of AI-based functions, embedded AI in hardware components) but also beyond (explainability, AI algorithm-problem mapping, etc). After being an individual draft, the document has been adopted a group document and is now quite stable. With several rounds of refinements, modifications have been done with no more comments recently. We expect this document to go for a "last call" in Q1 2024 to enter the RFC publication

process. Additionally, INRIA co-organized 6 NMRG meetings where AI applied to network management was part of the agenda.

- **ETSI plugtest**: ATH continuously participate in ETSI plugtests events to perform interoperability of its 5G network solution. This counts for 6 events either dedicated to Future Rail Mobile Communication System (FRMCS) or Mission-Critical (MCX) use cases. There were relevant unique opportunities to test and validate in standard-compliant environments The same platform was brought to AI@EDGE's use cases and benefits directly from experience learned during their preparation and execution.
- **ORAN**: TIM and EAB were active partners in ORAN WG1 and WG2. Thanks to the project results or experience learned during its execution, they fuelled the discussions to these groups accordingly (but not limited to the scope of the project), mainly related to functionalities in non-RT RIC framework and the Decoupled SMO Architecture. It is worth mentioning that this activity counts for 3 F2F meetings and regular weekly online meetings. Although AI@EDGE research appears in too-early stage regarding ORAN WG1/WG2 objectives, there was a clear interest and AI@EDGE was invited to join the meetings of a new research-oriented group created in June 2022, nGRG (next Generation Research Group). Questions addressed by the projects as well as use case presentation were warmly welcomed and could create a higher impact in a close future in nGRG, which the main aim is also to ensure the transfer of potential research result to standards.
- **3GPP SA2**: TIM is involved in the edition of two technical reports related to 3GPP Release 18: study of Enablers for Network Automation for 5G System (5GS), study on 5G System Support for AI/ML-based Services that are in-line with the work performed in AI@EDGE. From these reports, the normative work in 2023 has been derived. Study together with normative phase for Release 18 has been completed in 2023 (TS 23.501 v18.3.0, TS 23.502 v18.3.0, TS 23.088 v18.3.0). In the final part of 2023 TIM has participated in the discussion about new SID on "Core Network Enhanced Support for AI/ML" for Release 19. This study item builds on Release 18 work to support enhancements to 5GC intelligence, alignment, and convergence between SA2 and RAN WG for UE data collection framework, and ML model sharing. This may include 5GC NF operations (i.e. policy control and QoS) assisted by NWDAF, and support for AI/ML for air interface.

3.1 IRTF network management research group

Jérôme François (INRIA) is co-chairing NMRG from IRTF, a parallel organization of IETF. Like other research groups of IRTF, the group of NMRG is to foster collaborations between researchers and engineers. Indeed, through the proximity with IETF, application of research proposals to practical problems can be discussed in-depth and, sometimes, when research is mature enough (with prototype and good validation), transfer to a standardization working group can occur. In a nutshell, the NMRG facilitates cooperation between academia and industry interested in network management. The current research agenda of the group has been defined around three themes. The first one is overarching as it continues the effort of the group towards more automation in the network (autonomous network, self-driving networks…). Two themes have been then derived: Intent-Based Networking (IBN) to ensure the interface between a self-driving network and the humans managing the network and the coupling between AI and network management, a critical component to support automated decisions in an

autonomous network. Therefore, automation and AI for managing networks are topics fully aligned with AI@EDGE objectives and expected contributions.

In addition to co-chairing the group, INRIA is particularly leading the activities about the AI topic by organizing technical presentations and leading an effort to write a joint document on challenges of AI and network management. This document partially covers topics related to the application of AI for network management like resource allocation and network security including intrusion detection or collaborative security. All these topics are linked to the work done in the project and is based on the partner expertise.

3.1.1 Year 1

In March 2021, NMRG organized a session at IETF 110. We invited two presenters for technical talk on AI: Stefan Schneider (Self-Driving Network and Service Coordination Using Deep Reinforcement Learning) and Matthews Jose (Problems and Strategies implementing in-network AI).

In May 2021, NMRG organized an interim meeting virtually co-located with the IFIP/IEEE IM 2021. INRIA presented the activities of the group and invite newcomers to the group to contribute to the different topics. For instance, we introduce the research challenge on AI document under progress. In addition, MonB5G H2020 project was presented. It is about automating the creation of network slices and started one year before AI@EDGE. There are some similarities between the two projects and so this NMRG meeting allowed identifying this project for potential future synergies.

In June 2021, INRIA organized an interim NMRG meeting to resume the activity about the documentation of AI challenges in Network Management (NM). The goal was to free the main challenges and to define a common template to reach the same level of details for all challenges. It has also been presented during the NMRG session at IETF 111 in July 2021.

3.1.2 Year 2

In March 2022, INRIA co-chaired the NMRG session at IETF 113 and presented an update of the AI challenges. The document was reorganized to classify challenges according to 4 types: challenges purely related to AI techniques applied to network management, challenges related to underlying data used by ML algorithms and challenges about acceptability of using AI for network management. We also decided to not include use cases in this document as they will be focused on other ones produced potentially by NMRG. Also, in introduction we explicitly mention existing problem in NM through 5 main criteria:

- C1: A very large solution space, eventually infinite
- C2: Uncertainty and unpredictability of the context the solution
- C3: The need to deliver a solution in a constrained or deterministic time
- C4: Data-dependent solutions
- C5: Need to be integrated with human processes

In July 2022, INRIA co-chaired the NMRG session at IETF 114 and presented the AI challenges document formatted as an individual draft. The editorial team has been fixed to 5 editors. A 6th constraint has been added to classify the challenges:

- C6: Solutions MUST be cost-effective as resources (bandwidth, CPU, human, etc.) can be limited, notably when part of processing is distributed at the network edge or within the network.

In November 2022, **INRIA co-chaired the NMRG session at IETF 115.** Minor updates were made to the challenge document based on received feedback after IETF 114. INRIA asked for a call for adoption to make this document a group draft rather an individual draft as most of the group now consider it as rather stable. This call was sent out in January 2023 with expected result by February 2023.

3.1.3 Year 3

In March 2023, **INRIA co-chaired the NMRG session at IETF 116.** The document on AI challenges for Network Management has been adopted as a group documents. Few minor remarks have been raised by participants. In addition, we invited K. Wasielewska, MSCA fellow from University of Granada, to present about dataset quality problem on how to evaluate it and correct if possible.

In July 2023, INRIA co-chaired the NMRG session at IETF 117 and side sessions were organized. While the main document on AI was presented after an updated, the objectives of these meetings were to starting redefining the objectives and orientations of NMRG in the upcoming years. Supported by the effort of INRIA and the current AI document in NMRG, one orientation is clearly related to AI. Discussions have been engaged to define priorities for joint work. While methods and use cases are interesting to share, most of discussions were related to data sharing and data management in the context of a community-wide effort.

In October 2023, INRIA organized an interim meeting to start the definition of the NMRG of research agenda for the upcoming years. This meeting was dedicated to AI, and it was discussed about building the agenda of the group based on some AI challenges documented in the document edited by INRIA.

In November 2023, **INRIA co-chaired the NMRG session at IETF 118.** There was no dedicated presentation of the challenge document as it is considered stable. It is planned to start a last call phase before pursuing the RFC publication process with as first the IRSG (Internet Research Steering Group) review.

3.2 ITU-T FG autonomous networking

The ITU-T Focus Group on Autonomous Networks has as main objective to define an exploratory road on the requirements of future networks, real-time responsive experimentations and draft technical reports and specifications of autonomous future networks. Moreover, as a results of these specifications, the focus group aims to provide an open platform for experimentation where to perform pre-standards activities related to the topics of the groups.

3.2.1 Year 1

On April 15, 2021, the FG-AN organized a session where RISE and I2CAT presented the AI@EDGE project, putting special attention to the autonomous networking concepts that the project results would provide as output. On this basis, collaborations with the working group, PoC sharing and reproduction on the context of the working group.

In June 3 2021, RISE and I2CAT participated to a special session of the working group upon request of the FG-AN chairs to present the accepted paper in IEEE Communications Magazine entitled "AI-Empowered Software-Defined WLANs", where the taking as a basis de ITU-T Rec. Y3172 document on architectural framework for machine learning in future networks, an interpretable ML model is designed and deployed on an O-RAN architecture for wireless networks.

3.2.2 Year 2 (Discontinuation)

The ITU-T working group was more interested in the use cases demonstration, rather than on specific highlights or innovations of the project. Therefore, after presenting an initial paper cited in D6.2, we did not follow that focus group given the limited participation in the use cases.

3.3 ETSI Plugtests

For more than two decades, ETSI Plugtests have proved to be a valuable tool in the development of global standards. Plugtests events serve two main purposes:

- They provide essential feedback to ETSI technical committees to help improve standards and to accelerate the standards-making process.
- They enable engineers to get together to test the interoperability of their implementations – which can reduce a product's time-to-market.

The benefits of such events include:

- improving the interoperability of products and services
- supporting the deployment of new technologies
- enabling networking between partners, competitors, and other experts
- validating ETSI standards

Plugtests are organized by ETSI's Centre for Testing and Interoperability (CTI). The CTI offers a wide range of services for testing and interoperability and organizes an average of 12 Plugtests events every year, covering diverse technologies and offering a program of events that responds to market demand.

3.3.1 Year 1

From June 14th to 18th 2021, Athonet participated in the ETSI FRMCS (Future Railway Mobile Communication System) Plugtests that focused on interoperability and mission critical service harmonization, which are critical challenges for the successful deployment and operation of Mobile Communication System for various sectors. Athonet brought to the plugtests its most recent release of the 5G core network, which is now part of AI@EDGE connect-compute platform and will serve the project's use cases. Link to the event's report

From November 8th to 19th 2021, Athonet participated in the ETSI 6th MCX Plugtest event, held in hybrid mode. Athonet's core network deployed at the University of Malaga was used to support some demos and the plugtests' interoperability test sessions. Link to the event's report.

3.3.2 Year 2

From May 16th to 20th 2022, Athonet participated in the 2nd ETSI FRMCS Plugtests. As in the previous similar occasions, Athonet brought to the event (held online) its core network and made it available for interoperability tests with other vendor's solutions. The core network was also presented to observers in a dedicated demo session. Link to the event's report.

From November 7th to 11th 2022, Athonet participated in the ETSI 7th MCX Plugtest event, hosted by the University of Malaga with both in-person and remote participation of more than 100 attendees. Athonet's 5G core network was used during the event to support mission-critical services (MCX) and demonstrate the interaction of Application Functions with the 5G control plane for quality-of-service management. Link to the event's report.

3.3.3 Year 3

From July 3rd to 7th 2023, Athonet participated in the 3rd ETSI FRMCS Plugtests, held in Paris (France). As in the previous similar occasions, Athonet brought to the event its core network and made it available for interoperability tests with other vendor's solutions.

From October 9th to 13th, 2023, Athonet participated in the ETSI 8th MCX Plugtest event, hosted by the University of Malaga.

3.4 ETSI ISG MEC

ETSI's Industry Specification Group (ISG) on Multi-Access Edge Computing (MEC) aims at standardizing an open environment for multi-vendor MEC platforms, as a reference to the work of telecommunications equipment vendors, IT service providers and vendors, system integrators, and application developers. The MEC ISG specifies the necessary elements for the deployment and operations of MEC platforms and applications, including their integration with 5G access technologies. In this perspective, ETSI MEC is an important reference for AI@EDGE, because one of its ambitions is to effectively deploy AI Functions (AIFs) at the edge of the mobile telecommunication network. Leveraging the standard MEC architecture, AIFs will be able to exploit at best the seamlessly integrated 5G (and beyond) access network and edge computing facilities, providing ubiquitous low-latency services to mobile users. Maximizing the compliance of the project's reference architecture and of AIFs with the MEC framework will also improve the opportunities of exploitation of the project's results beyond the project's scope and lifetime.

3.4.1 Year 2

From June 13th to 17th, Athonet hosted the 30th ETSI ISG MEC plenary meeting, which took place in Venice, Italy. During the event, a presentation on the AI@EDGE project was given by Cristina Costa from FBK.

3.5 3GPP SA WG2

Within the 3GPP Technical Specification Group Service and System Aspects (TSG SA), the main objective of 3GPP TSG SA WG2 (SA2) is to develop the overall 3GPP system architecture and services

including User Equipment, Access Network, Core Network, and IP Multimedia Subsystem. SA2 has a system-wide view and defines the main entities of the system architecture, and how these entities are linked to each other. SA2 also defines the main functionality and the information exchange between these entities.

While Rel-17 5GS supports AI/ML training and inference within the 5G Core via NWDAF for network automation purposes, the support at the application AI/ML service client level running on the UE is not yet specified. Hence, an evolution of the 5GS is required to provide intelligent transmission support for application AI/ML-based services as proposed in the SA1 Release 18 study - *Study on traffic characteristics and performance requirements for AI/ML model transfer in 5GS*.

Further investigation and completing support for Edge Computing in 5GS together with the 5GS architectural and functional extensions where service providers can leverage 5GS as the intelligent transmission platform to support AI/ML-based services, are of particular interest for AI@EDGE project.

3.5.1 Year 1

TIM provided support for the approval of Release 18 3GPP Study Items relevant to the AI@EDGE Project activities:

- Study on 5G System Support for AI/ML-based Services (SP-211648)
- 5G System Enhancements for Edge Computing (SP-211638)

3.5.2 Year 2

TIM participated on behalf of AI@EDGE in the SA2 group discussions in the definition of the Key Issues for the above study activities.

TIM attended the following 3GPP SA WG2 online meetings:

- SA2 #149-e 14 - 25 February 2022
- SA2 #150-e 6 - 12 April 2022
- SA2 #151-e 16 - 20 May 2022

TIM participated in the discussions on the 3GPP Release 18 study activities with particular interest on:

- Study of Enablers for Network Automation for 5G System (5GS); Phase 3 (draft Technical Report 23.700-81)
    - This study focuses on solution to achieve further enhancement for network automation (i.e., Network Data Analytics and Data Collection), as documented in 3GPP TS 23.288.
- Study on 5G System Support for AI/ML-based Services (draft Technical Report 23.700-80)
    - This Technical Report will study 5GS assistance to support Artificial Intelligence (AI) / Machine Learning (ML) model distribution, transfer, training for various applications, e.g., video/speech recognition, robot control, automotive, etc.

The Technical Reports will be finalized by the end of the year and in 2023 will be done the corresponding normative work (e.g., new specifications).

3.5.3 Year 3

TIM participated in SA2 group discussions in the definition of the Key Issues for the above study activities.

TIM attended the following 3GPP SA WG2 meetings:

- SA2 #155 20 - 24 February 2023
- SA2 #157 22 - 26 May 2023
- SA2 #159 09 - 13 October 2023
- SA2 #160 13 - 17 November 2023

TIM participated in the discussions on the 3GPP Release 18 study activities with particular interest on:

- Study of Enablers for Network Automation for the 5G System (5GS) where Study Phase has been completed (TR 23.700-81-200) together with normative phase (TS 23.501 v18.3.0, TS 23.502 v18.3.0, TS 23.088 v18.3.0).
    - The activity focuses on solutions to achieve further AI/ML based enhancement for network automation (i.e., NWDAF can perform accuracy check to better reflect the model accuracy, new services in the NWDAF are used as entry point to exchange analytics in roaming, enhanced trained ML Model sharing, Supporting Federated Learning in 5GC).
- Study on 5G system support for AI/ML-based services where Study Phase has been completed (TR 23.700-80-200), together with normative phase (TS 23.501 v18.3.0, TS 23.502 v18.3.0, TS 23.088 v18.3.0).
    - The activity focuses on solutions to support AI/ML Application for various domains, e.g., video/speech recognition, robot control, automotive, etc. (i.e. 5GC information exposure to authorized 3rd party for Application Layer AI/ML Operations with User consent when needed; Network resource utilization monitoring for Application Layer AI/ML Operations; QoS and Policy enhancements for AI/ML traffic supported in a specific distinct QoS flow; Application Function can request NWDAF analytics to assist with federated learning operation)

In the final part of 2023, a new SID on “Core Network Enhanced Support for AI/ML” for Release 19 has been discussed. This study item builds on Release 18 work to support enhancements to 5GC intelligence, alignment, and convergence between SA2 and RAN WG for UE data collection framework, and ML model sharing. This may include 5GC NF operations (i.e. policy control and QoS) assisted by NWDAF, and support for AI/ML for air interface. Two main components are considered for Release 19:

- AI/ML alignment and convergence for Air Interface and 5G Core network where items such as study whether and how to support the alignment of model identification and model management between SA2 and RAN WG will be discussed.
- Architecture enhancement to support 5G Core intelligence, where items such as study whether and what potential enhancements are needed to enable 5G system to assist in collaborative

AI/ML operation involving 5GC/NWDAF and/or AF for "Vertical Federated Learning (VFL)" will be discussed.

3.6 ORAN WG1 and WG2

O-RAN WG1 is responsible for development of the overall O-RAN architecture, identification of key O-RAN uses cases and deployment scenarios. The three task groups under O-RAN WG1 are Architecture Task Group (ATG), Network Slicing Task Group (NSTG) and Use Case Task Group (UCTG). TIM is particularly active in WG1.ATG that has the following objectives:

- Specify the overall architecture of O-RAN.
- Provide high level description of the O-RAN functions and the associated interfaces that connect them.
- Illustrate relevant implementation options, as and when needed, to explain the O-RAN architecture.
- Facilitate and arbitrate the cross-WG architectural topics/discussions.

O-RAN WG2 is responsible for the non-RT RIC and the A1 interface. The primary goal of non-RT RIC is to support non-real-time intelligent radio resource management, higher layer procedure optimization, policy optimization in RAN, and providing AI/ML models to near-RT RIC and other RAN functions. The A1 interface supports communication & information exchange between non-RT RIC and near-RT RIC, key objective of A1 interface is to support policy-based guidance of near-RT RIC functions/use-cases, transmission of enrichment information in support of AI/ML models into near-RT RIC, and basic feedback mechanisms from near-RT RIC.

TIM is active in WG2 where AI/ML related features and support are one of the core innovative aspects.

In the last year, TIM and EAB participated to nGRG. The O-RAN nGRG mission is to:

- Provide a forum to facilitate O-RAN related 6G research efforts and to publish research findings
- Leverage industry and academic 6G research efforts and determine how O-RAN may evolve to support 6G and beyond, considering regional research efforts, ITU-R, and 3GPP development
- Achieve O-RAN sustainability from 4G/5G to 6G and beyond
- Consider the impact of 6G on O-RAN areas of interest and work with Industry Partners to unify the 6G technology path/timeline to avoid incompatibility b/w O-RAN and other SDOs

It is a more research-focused group aiming at promoting mid- and long-term research.

3.6.1 Year 1

TIM participated in ORAN WG2 regular weekly on-line meetings and provided support for the specification of the Non-RT RIC Architecture and R1 interface specifications (R1 – the interface between non-RT RIC and rApps) for March, July, and November 2021 releases of specifications.

In ORAN WG1, TIM, together with other players, initiated and supported the new work item (WI) "Decoupled SMO Architecture", the study on how to decouple Service Management and Orchestration

(SMO) Architecture, with the objective to recommend the grouping of various SMO functionalities in components that could be integrated in multi-vendor context via standardized interfaces.

3.6.2 Year 2

TIM continuously participated in ORAN WG2 regular weekly on-line meetings and provided support for the group discussions and for the specifications of the Non-RT Architecture and R1 interface. In the last quarter of 2022, O-RAN WG2 launched a new WI (AIML in O-RAN) with particular focus on AI/ML-related functionalities and services inside the non-RT RIC framework. TIM supported this new WI and actively participate in dedicated on-line meeting and drafting sessions. This activity is particularly related to the AI@EDGE project for the part regarding LCM of AI/ML models embedded in rApps and/or in non-RT RIC framework. Moreover, the AI/ML supporting functionalities such as AI/ML Model Performance Feedback and Monitoring, AI/ML Model Training are also topics to be addressed in this activity. The final objective is to produce O-RAN specifications regarding AI/ML functionalities and services.

In the first quarter of 2022, in ORAN WG1-ATG, activities on new WI (Decoupled SMO) started. TIM continuously participated in regular on-line meetings related to the grouping of various SMO functionalities, actively participating in the discussions, evaluating contributions. This activity is particularly related to the emerging discussions in the AI@EDGE project, particularly related to NSAP components and interfaces.

TIM participated in face-to-face meeting of O-RAN community, held in Madrid, from 17th to 21st of October 2022.

3.6.3 Year 3

TIM continuously participated in ORAN WG2 regular weekly on-line meetings and provided support for the group discussions and for the specifications of the Non-RT Architecture and R1 interface, for WI on AIML, with focus on AIM/ML-related functionalities and services inside the Non-RT RIC framework. TIM actively participate in dedicated on-line meeting and drafting sessions for this WI, considering the findings and achievements of AI@EDGE project.

Regarding WG1, TIM continuously participated in regular on-line meetings in ORAN WG1-ATG, WI Decoupled SMO, actively participating in the discussions, evaluating contributions, with particular attention to the NSAP components and interfaces defined in AI@EDGE overall architecture.

TIM participated in face-to-face meeting of O-RAN community, held in Prague, from 12th to 17th of February 2023.

TIM participated in face-to-face meeting of O-RAN community, held in Osaka, from 19th to 23rd June 2023. TIM presented AI@EDGE project during nGRG (next Generation Research Group) TOC meeting on 20th June 2023.

The AI@EDGE project has been invited to present its status and achievements but also challenges still to be addressed. The project presentation was well accepted and quite relevant for the activities/mission of the nGRG, such as already identified research topics: AI-Native, AI-Cross-domain, RAN/Core/Edge harmonization topics where AI@EDGE project already provided possible approaches and solutions to be part of the future O-RAN specification activities. nGRG co-chair, Ravi Sinha, agreed particularly with one of the challenges / open questions identified in the AI@EDGE project presentation: Software

development for intelligent edge. He also added that he had lot of talks with industries (verticals) around intelligent edge and many of them confirmed their concern: missing approaches, tools, and SDKs for SW development for intelligent edge.

The project was then invited in July 2023 by Deutsche Telekom. ATH gave a presentation entitled "Private Mobile Networks: Core network deployment options and use cases," in which they mentioned AI@EDGE's use cases while discussing possible distributed deployments of the 5G core network functions.

4. Contribution to 5G-PPP and Collaboration with Other Projects

The project has been active in the interactions with 5G-PPP/IA and with the other projects of the other calls, and especially those belonging to the call ICT-52. In this chapter the interactions are summarized in form of tables.

4.1 Interactions with Working Groups

T6.3 has supported the interaction with 5G-PPP and 5G-IA and with some of the working groups therein. Note that the table refers to the overall duration of the project. Some groups have meanwhile migrated to 6GIA, others have changed names or discontinued.

Table 2 AI@EDGE interactions with 5G-PPP/IA and related Working Groups

5GPPP/IA Group	Participants	Role/Notes
SB	FBK	Participation to the Steering Board calls and meetings.
TB	UNIVPM	Participation to the Technical Board activities, especially for the White Paper on the Beyond 5G/6G evolution.
WG Arch	ICCS, ATOS, FBK, TIM, CNAM	Overall attendance at the calls and participation to the activities of the WG. Participation of the project and of some project's partners to the preparations of the book on 6G, together with Hexa-X and other projects.
SW Netw	8BELLS, CNAM	CNAM contributed in 2021/2022 to the definition of research topics to be investigated by the 5GPPP community. Some of the inputs from CNAM were included in some of the 2022/2023 SNS calls.
Auto	8BELLS	Attendance and participation to the overall activities.
Network Management and QoS	I2CAT, CNAM	Attendance and participation to the overall activities. Mandate deemed completed and Working Group suspended
Vision	FBK, ATOS, WI3, SPI	FBK participates to the "Needs and Value Creation" subgroup.
Open SNS	TIM, CNAM, FBK	The WG has just started but it is of potential wide interest for AI@EDGE especially for the disaggregation of the architectures. INRIA has participated at SNS Webinar for Verticals webinar. TIM is active in the group, especially with reference to the Vision white paper.

WG Trials	TIM, SPI, CNAM	Potential interest for the Trials activities being carried on at European level.
5G-PPP - SNS	INRIA	INRIA has participated at SNS Webinar for Verticals webinar

4.2 Interactions with other 5GPPP Projects

AI@EDGE has had the clear objective to exchange views and information with the other projects that are dealing with concurrent and similar topics. A detailed list of the interactions is reported in the following Table 3. The activity in the Task has continued and progressed as in the previous years, with good relations with the H2020 projects in the context of 5GPPP and the initial interactions with 6GIA and the new Phase 1 and Phase 2 projects of the JU SNS in Horizon Europe. Very good interactions have been settled especially with the projects Hexa-X and Hexa-X-II, thanks to the active role of TIM, which is Impact Creation leader in those projects. AI@EDGE will leverage on the presence in the main groups previously in 5GPPP and now in 6GIA, as reported in Section 4.1, to interact with the new projects.

Table 3 AI@EDGE interactions with other projects

Project Name	**AI@EDGE partners**	**Interactions with AI@EDGE**
5G-DAEMON (H2020 5G-PPP)	AI@EDGE	With the DAEMON project, AI@EDGE is organising a series of activities in the next period: - Joint Booth at the MWC 2023, Barcelona, Spain - Joint Booth at the IEEE ICC 2023, Rome, Italy - Joint workshop to EUCNC 2023, Gothenborg, Sweden
Hexa-X, Rise-6G (ICT-52 Projects)	TIM EAB	Joint initiatives with the other projects of the same call of AI@EDGE are possible. TIM leads the dissemination and impact creation activities in Hexa-X, the "flagship" project in this phase of Beyond5G activities in Europe. EAB is the Hexa-X technical manager. AI@EDGE is organising a joint workshop together with HESA-X project at EUCNC 2023, Gothenborg, Sweden.
Hexa-X-II	TIM	TIM plays a liaison role with this project, since the T6.3 leader in AI@EDGE is also Work Package leader of Impact and Dissemination in this Hexa-X-II project, aiming to the definition of the future 6G standard.
5GENESIS, 5G-VICTORI, 5GVINNI, 5G EVE, 5G Tours, 5G SOLUTIONS, 5Growth (H2020 5G-PPP Phase 3)	I2CAT ATH SRS TIM	Until these projects will be active, they represent the European platform to run extensive trials on 5G and beyond, and as such they could be a good opportunity of cooperation for AI@EDGE. INRIA participated in the 5G GROWTH workshop. 5GENESIS has been concluded for some time now.
5G-DIVE	RISE EAB ULUND	5G-DIVE is an end-to-end Platform-as-a-Service (PaaS) build on top of an Edge and Fog computing platform (developed by the project 5G-CORAL). 5G-DIVE aims to enhance the management and automation of business processes of the 5G-CORAL platform using data analysis and Artificial Intelligence (AI) to maximize the value proposition of 5G for different type of vertical industries. 5G-DIVE targets end-to-end 5G trials aimed at proving the technical merits and business value proposition of 5G technologies in two vertical pilots, namely (i) Industry 4.0 and (ii) Autonomous Drone Scout. These trials will put in action a bespoke end-to-end 5G design tailored to the requirements of the applications targeted in each

		vertical pilot, such as digital twinning and drone fleet navigation applications. INRIA has participated at 5G-DIVE exploitation workshop in autumn 2021.
5G-PPP 8th Global 5G Event		INRIA has participated at the "5G empowers the digital economy" webinar
5G-HEART and 5G TOURS		INRIA has participated at the Workshop on "Tele-Health Solutions Powered by 5G"
ESA and PSCE		INRIA has participated at the Online Workshop: "Satellite Applications for Public Safety"
5G-SMART		INRIA has participated at the Online webinar "Demystifying 5G and Industrial Networks slicing, from theory to practice"
6G-XR	I2CAT	I2CAT will provide insights on capability placement using ML models
6G-SORUS (National Recovery, Transformation, and Resilience Plan, funded by NextGen EU)	AERO	AERO is leading the SORUS DRONE subproject in this Innovative project in the deployment of advanced 5G and 6G technologies. With major focus on Network deployment with drones and integration of RIS with drones, opening new opportunities to improve coverage and reduce energy consumption.
U-ELCOME (H2020 – SESAR) This project has received funding from European Climate, Infrastructure and Environment Executive Agency (CINEA)	AERO	U-ELCOME project is helping get Europe-wide U-space implementation off the ground by fostering a fully scalable market uptake of U1 and U2 U-space services through a set of tests and demonstrations in various operational environments across 15 locations in Spain, Italy, and France. AERO takes part as subcontractor for a partner of this project providing know-how in drones operation leveraged by advanced functionalities.

5. IPR Management

The aim of this section is to define the measures and methodologies, defined in the scope of T6.4, for managing the Intellectual Property Rights (IPR), to provide an appropriate foundation for the exploitation of project outcome. Within this context and considering the exploitation reports/plans (in D6.2, D6.3, and D6.4) and AI@EDGE business models presented in D2.4, as well as the Consortium Agreement (CA), this deliverable targets at ensuring that all project results are formulated and compiled into a protectable form.

5.1 Intellectual Property Rights in AI@EDGE

The following glossary consists of definitions of terms relevant to the IPR management in the Horizon 2020 context. The terms have been obtained through the combination of various sources, including the glossary of the European Commission Research & Innovation Participant Portal and the glossary available by the European IPR Helpdesk.

Term	Definition
Access rights	The H2020 grant agreements set out specific obligations to give other parties (e.g., other beneficiaries, affiliated entities of another beneficiary, EU bodies, etc.) access to use results or background related to the project.
Action (also: project)	Beneficiary activities funded by the EU (via grants, procurement, prizes, or financial instruments). In the present deliverable is used as a synonym for the term "project".
Background	Any data, know-how and/or information, whatever its form or nature (tangible or intangible) – including any rights such as Intellectual Property Rights – which is: (i) held by participants prior to their accession to the action; (ii) needed for carrying out the action or for exploiting the results of the action; and (iii) identified by the participants.
Beneficiary	Legal person, other than the European Union or a funding body, who is a party in the Grant Agreement.
Communication	A strategically planned process that starts at the outset of the action and continues throughout its entire lifetime, aimed at promoting the action and its results. It requires strategic and targeted measures for communicating about the action and its results to a multitude of audiences, including the media and the public and possibly engaging in a two-way exchange.
Confidential information	Any data, documents, or other material (in any form) of a confidential nature that may include information of a personal, scientific, industrial, business, or commercial nature, that is not available to the public.
Consortium	A group of institutions or companies acting together in the same project under common interest. In Horizon 2020 it refers to all the participants in the same project.
Dissemination	The public disclosure of the results by any appropriate means (other than resulting from protecting or exploiting the results), including by scientific publications via any medium.
Exploitation	The use of results in further research activities other than those covered by the action concerned, or in developing, creating, and marketing a product or process, or in creating and providing a service, or in standardization activities.
Foreground	The tangible and intangible results which are generated within a given project, including pieces of information, materials, and knowledge and whether they can be protected. It includes intellectual property rights (e.g., copyrights, industrial designs, patents, plant variety rights), similar forms of protection (e.g., rights for databases) and unprotected know-how (e.g., confidential material). Results generated outside a project are not foreground.
Intellectual Property (IP)	The creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce. Intellectual Property also includes patents, patent applications, copyrights, trademarks, trade secrets, and any other legally protectable information, including computer software. It is the rights of the Background and the rights of the Foreground.

Intellectual Property Rights (IPRs)	The private legal rights that protect the creation of the human mind: inventions, literary and artistic works, and symbols, names, images, and designs used in commerce. They are commonly divided into two categories: Industrial Property Rights (e.g., patents, trademarks, industrial designs, geographical indications), Copyright (e.g., rights of the authors/creators), and Related rights (e.g., rights of performers, producers, and broadcasting organisations).
Owner	A party, public or private, holds legal title to Intellectual Property, consistent with national or international laws and regulations.

5.2 Management of IPR

AI@EDGE project is committed to providing open access to new research data resulting from the project, thus addressing one of H2020's main objectives. Therefore, the AI@EDGE Consortium has openly made available the content and data produced within the project where possible.

In this sense, all partners have been encouraged to share their knowledge to improve the quality of the AI@EDGE work. Most of this sharing will normally be unproblematic, but sometimes the knowledge may represent a significant value for the owner and in these cases, one needs to consider the IP ownership issues.

Ownership can then be established as one of the following types:

- *Background knowledge* is brought into the project from other activities. The background has already been registered in the CA. The owners of the IP are registered together with the IP. It is normally a good idea to register the background knowledge as such before it is disclosed to anyone in the project. Note also that registration as background can be denied if it is thought that its ownership is unclear or that the knowledge is not necessary for the project. Registration of background knowledge should be denied for knowledge that can be proven to be already part of the public domain.
- *Results (or foreground)* are produced in the project, alone or in cooperation with other partners. Generally, the partners that have contributed to the development will have **joint ownership of the IP.**

5.3 Alignment with the legal framework

Knowledge and IPR management objectives, principles, and roles are generally foreseen in the Grant Agreement as well as in the Consortium Agreement. All knowledge and IPR management measures have been defined by AI@EDGE Consortium in pursuance of provisions contained in the Grant Agreement and in the Consortium Agreement, which are the main references in terms of legal framework. The Grant Agreement is the legal implementation of the project as agreed between the European Commission and the Consortium partners. All partners are signatories to the Grant Agreement. An important part of the Grant Agreement defines the rules for handling Intellectual Property Rights.

In specific areas, the Grant Agreement allows consortia to agree on their own rules. These individual rules are then included in the Consortium Agreement. As part of such an agreement, Consortium members specify or supplement – before the project commences – binding commitments among themselves in terms of roles, responsibilities, and mutual obligations.

5.4 Protection of the results

There are a few routes available to AI@EDGE partners to protect the Intellectual Property they have generated on the project. The most relevant to AI@EDGE are patents, copyright, and license.

- **Patent**: A patent is an exclusive right granted for the protection of inventions (products or processes) offering a new technical solution or facilitating a new way of doing something. The patent holder enjoys the exclusive right to prevent third parties from commercially exploiting their invention for a limited period. In return, the patent holder must disclose the invention to the public in the patent application.

  Patent registration can be performed at three different levels: national, regional, and international (through the Patent Cooperation Treaty (PCT) System [8]). The best route usually depends on the territories where a company intends to exploit the patent. A European patent can be obtained for all the European Patent Convention (EPC) contracting states by filing a single application, under a single set of fees with the European Patent Office (EPO).

  The exclusive right conferred by a patent allows its owner to prevent others from making, using, offering for sale, selling, or importing a product or a process based on the patented invention, without the owner's prior permission.

- **Copyright**: Copyright (or author's right) is the term used to describe the rights that creators have over their literary, scientific, and artistic works. There is not an exhaustive list containing the works that can be protected by copyright. However, there is several works usually covered by copyright at international level (the examples most relevant to AI@EDGE are highlighted in bold):
  - literary works such articles.
  - **computer programs, databases.**
  - films, musical compositions, and choreographies.
  - artistic works such as paintings, drawings, photographs.
  - and sculptures.
  - architecture; and
  - advertisements, maps, and **technical drawings**.

- **License**: For a license to be valid it must be granted by the owner of the work's intellectual property rights. Under the policies of most research institutions and commercial companies, developers who have created a piece of software are unlikely to own full rights to their work. Instead, the organization generally holds or shares legal rights to develop software. Policies on IPR ownership vary, but in most cases the organization will be the legal rights owner and will be the entity that grants the license chosen for the produced software.

Colloquially speaking, the spectrum of software licensing strategies can be divided into three categories: "free and open source", "proprietary" or a hybrid of the two.

- *Free and Open-Source Software (FOSS)* Licensing: Free and open-source software (FOSS) represents a fundamentally different approach from proprietary software licensing. The primary intent of FOSS is to give the licensor the ability to maximise the output of their software by breaching barriers to software use, dissemination, and follow-on innovation. There are some of the most used FOSS licenses, each with small but significant changes, but all grant free (as in freedom), open, and non- discriminatory access and rights to modify licensed software and associated source code. A common misconception is that FOSS is synonymous with "non-commercial." In fact, as described by the two most influential definitions of FOSS, "non-discriminatory" means that no category of user or distributor can be prohibited, including for-profit commercial entities. Due to this, FOSS-licensed software can be, and often is commercially exploited. Due to the simplicity of the FOSS licenses and their non-discriminatory nature, they offer continued development and collaboration when researchers switch organisations, and when they collaborate across organisations. FOSS can also help to extend the useful lifetime of a piece of software beyond the direct involvement of the creators.

5.5 Partner-IPR Management in AI@EDGE

In this subsection, we address the individual contributions and IPR management strategies of the involved partner within the AI@EDGE initiative. Our goal is to provide a clear overview of the distinct assets each partner contributes to, and the measures implemented to protect their respective IP rights. It is important to note that while many partners contribute tangible assets that are pertinent to IPR management, some contributions may not be subject to IPR due to their nature or the context of their use. Our objective is not only to catalogue these varied assets but also to understand the framework of IPR management applied where relevant.

Below, we present the contributions from partners who have provided IPR-manageable assets, including a summary of the protection measures they have adopted. This approach presents a detailed picture of the collaborative environment that AI@EDGE fosters, balancing innovation with the respect for and protection of IP rights.

ATOS

Intelligent Orchestrator (IOC)	
Asset Type	Platform Component
Description	The Intelligent Orchestrator is a software tool designed to manage and deploy Artificial Intelligence Frameworks (AIFs). It streamlines the process of deploying AI capabilities across various platforms.
Availability	The IOC is deployed within a dedicated testbed environment, where it interfaces with specific APIs to enable the orchestration functionality.

Protection	The software is licensed under the Apache License, Version 2.0, which provides a flexible open-source license that allows users to freely use, modify, and distribute the software while also protecting the authors' intellectual property.

Model Monitoring	
Asset Type	Application
Description	This application is designed to monitor AI and ML models that are deployed through AIFs. It ensures that the performance and health of these models are maintained while in operation.
Availability	Like the IOC, this monitoring tool is deployed on the testbed and exposed to certain APIs to facilitate its monitoring functions.
Protection	The Model Monitoring application is likewise licensed under the Apache License, Version 2.0, ensuring consistent IP protection and open-source collaboration.

Ground Station Interface	
Asset Type	Web Application
Description	The Ground Station Interface is a web application for controlling the position and viewpoint of drones, as well as managing the outputs from Artificial Intelligence functions.
Availability	The application is deployed on computers utilized for testing and on AIFs within the Kubernetes cluster environment.
Protection	It is also protected under the Apache License, Version 2.0, facilitating open-source distribution and contributions while safeguarding the author's contributions.

CNAM

Federated Learning-Based Anomaly Detection Framework	
Asset Type	Building Block
Description	This framework offers a federated learning solution for real-time anomaly detection using auto-encoders to establish the normal state of the system. It involves a central federated learning server AIF and several edge AIFs, distributing the monitoring data for balanced processing across the edge AIFs.
Availability	Available as open-source software, accompanied by a research paper detailing its design and implementation. The open-source nature
Protection	

	encourages collaboration and innovation while facilitating broad dissemination.
Limitations for Dissemination/Exploitation	The model's reliance on large LSTM structures increases memory usage, which may introduce communication delays between the federated learning server and client AIFs.

Federated Learning AIF Placement Framework	
Asset Type	Building Block
Description	A control scheme for the strategic placement of AIFs in distributed in-network learning systems, focusing on minimizing delays and optimizing the location of AIFs within the federated learning environment.
Availability	The placement framework is open source, supported by research documentation, enabling transparent and adaptive use.
Protection	
Limitations for Dissemination/Exploitation	System changes necessitate retriggering the framework, which may impact responsiveness and adaptability.

Data Pipeline System	
Asset Type	Building Block
Description	A conceptual system designed for data pipelining, integrated with the federated learning-based anomaly detection framework to enhance the efficiency of data handling.
Availability	This system is available as open-source and is further detailed in an associated research paper.
Protection	
Limitations for Dissemination/Exploitation	The current data arrival time measurement in seconds is not optimal for real-time anomaly detection, where millisecond precision is required.

NetFPGA Anomaly Detection	
Asset Type	Application
Description	An FPGA-based application for network telemetry, this tool supports anomaly detection and attack mitigation directly on the data plane.
Availability	The application and its research findings are open source, facilitating widespread access and collaborative development.
Protection	

Limitations for Dissemination/Exploitation	The current design is limited to monitoring a single TCP/UDP port due to hardware resource constraints on the NetFPGA platform.

Multi-path TCP Predict	
Asset Type	Application
Description	This application uses machine learning to predict network link status, such as packet loss, and adjusts the Multi-path TCP (MPTCP) scheduler based on these predictions.
Availability	The software is in the process of being published as open source, which will allow for community engagement and iterative improvement.
Protection	
Limitations for Dissemination/Exploitation	The current reliance on MPTCP's default scheduler, albeit with minor adjustments, suggests a need for a more advanced and efficient scheduling algorithm.

5G3E Dataset	
Asset Type	Dataset
Description	A 5G platform dataset created for network automation testing, which simulates the data-plane behaviour of a regionally limited region (TAC) for system monitoring and algorithm evaluation.
Availability	The dataset is open and is complemented by research papers that discuss its development and application.
Protection	
Limitations for Dissemination/Exploitation	The initial version's perfect connectivity on the test platform did not accurately reflect real system conditions, and data collection at the 5G core function level was missing. These issues are being addressed in an upcoming version.

FBK

LightEdge	
Asset Type	Platform Component
Description	LightEdge, open-source Edge Computing (MEC) platform, extended with Serverless integration functionality, providing an abstraction layer over serverless platform for the AIF deployment.
Availability	Open source
Protection	Apache2.0-license

Limitations for Dissemination/Exploitation	Licensed under the Apache2.0-license, a permissive license whose main conditions require preservations of copyright and license notices. Contributors provide an express grant of patent rights.

Model Updater for AIF	
Asset Type	Building Block
Description	Reference implementation for the sidecar architecture for the AIF functions based on Seldon Core model managers to enable automated ML model update to ensure zero downtime.
Availability	Open source
Protection	Apache2.0-license
Limitations for Dissemination/Exploitation	Licensed under the Apache2.0-license, a permissive license whose main conditions require preservations of copyright and license notices. Contributors provide an express grant of patent rights.

Hotspot placement prediction	
Asset Type	Building Block
Description	An ML algorithm, and a service (AIF) to predict hotspot user placement for the zero-touch platform automation.
Availability	Open source
Protection	Apache2.0-license
Limitations for Dissemination/Exploitation	Licensed under the Apache2.0-license, a permissive license whose main conditions require preservations of copyright and license notices. Contributors provide an express grant of patent rights.

RL-based algorithm for autonomous vehicles control	
Asset Type	Application
Description	A RL algorithm implementation (training and policy implementation) for autonomous car control in hybrid environments relying on SUMO-based simulator.
Availability	Open source
Protection	Apache2.0-license
Limitations for Dissemination/Exploitation	Licensed under the Apache2.0-license, a permissive license whose main conditions require preservations of copyright and license notices. Contributors provide an express grant of patent rights.

I2CAT

Multi-Tier Orchestrator	
Asset Type	Platform Component, Building Block
Description	A cloud-native orchestrator designed to boost the functionality of current open-source modules, acting as a pivotal element in the orchestration and management of multiple Mobile Edge Computing (MEC) systems.
Availability	The Multi-Tier Orchestrator is available upon request.
Protection	The tool is licensed under the Affero GNU General Public License, which assures that derivative works will also be openly shared with the community.
Limitations for Dissemination/Exploitation	Specific limitations for the implementation or exploitation should be detailed to inform potential users of any constraints.

MEC Orchestrator	
Asset Type	Platform Component, Building Block
Description	This orchestrator is a cloud-native Mobile Edge Computing Orchestrator (MEO) that leverages existing open-source modules and serves as the core component in MEC system-level management.
Availability	Access to the MEC Orchestrator is granted upon request.
Protection	It is also protected under the Affero GNU General Public License, ensuring that enhancements and modifications remain open.
Limitations for Dissemination/Exploitation	Details on any specific limitations for the implementation or exploitation need to be articulated for clarity.

Application Placement Model	
Asset Type	Software (SW)
Description	An innovative Machine Learning model that employs Distributed Deep Reinforcement Learning to optimally position applications in multi MEC system networks, aiming to reduce the number of active nodes required.
Availability	This model can be accessed upon request.
Protection	The Application Placement Model is under the Affero GNU General Public License.
Limitations for Dissemination/Exploitation	The model is still in the prototype phase, indicating that it may not yet be ready for widespread deployment.

Non-RT RIC / RIC Manager	
Asset Type	Software (SW)
Description	Software focused on the O-RAN non-Real-Time Radio Intelligent Controller (RIC), dedicated to facilitating RAN control and monitoring for rApps.
Availability	The software is available upon request.
Protection	The IP protection strategy for this asset has not yet been decided.
Limitations for Dissemination/Exploitation	Currently a prototype, its early-stage development status implies that further work is required before it can be considered for full implementation.

ICCS

Acceleration Testbed for Edge Computing Studies	
Asset Type	Hardware-Software (HW+SW) Building Block
Description	This asset is a sophisticated testbed comprised of an integrated Kubernetes cluster with three servers and two Edge devices, including five accelerators (FPGAs and GPUs). It serves as a platform for researching and developing acceleration techniques as well as resource management within edge computing environments.
Availability	Access to the testbed is provided on a free, ad-hoc basis. Interested parties can request time slots for usage, subject to the scheduled availability of ICCS's nodes. This scheduling approach is designed to ensure efficient time-sharing of the hardware, which is also used for other activities.
Protection	Not applicable. The hardware's shared nature and the open access for time-sharing mean that traditional IP protections do not directly apply. However, the knowledge and data generated from using the testbed are likely subject to ICCS's IP policies.

INRIA

Data Augmentation of Network Traffic Dataset	
Asset Type	Application and Test Report
Description	This asset comprises software capable of generating artificial traffic data from an existing dataset. It serves an important role as a pre-processor for datasets in scenarios where sufficient original data is not available.
Availability	The software is made available under an open-source license, encouraging widespread use and collaboration.

Protection	As an open-source asset, the protection strategy involves sharing the software with the public, allowing free access and modification in accordance with the terms of the open-source license it is distributed under.
Limitations for Dissemination/Exploitation	Currently, the asset is a prototype in its early stages. Its use is primarily intended for further development and refinement within the AI@EDGE community before being deployed in production environments.

Autoconfiguration of ML Hyper-parameters for IDS	
Asset Type	Application
Description	This software is designed to automatically determine the optimal set of machine learning (ML) hyper-parameters for intrusion detection systems (IDS), based on the data being analysed.
Availability	The software will be available upon request, with plans to publicly disclose it once the associated research publication is accepted and made public.
Protection	The intention is to release the software as open-source, which will allow for community contributions and enhancement while providing legal protection through an open-source license.
Limitations for Dissemination/Exploitation	The software is versatile and can be adapted for various types of ML applications. However, it will require manual refinement to fit the specific needs of a project or research initiative.

SPI

An Aero-edge/cloud Testrack	
Asset Type	Hardware and Software (HW+SW)
Description	This testrack is a comprehensive edge/cloud infrastructure that comprises aero-certified seatback screens, servers, and Commercial Off-The-Shelf (COTS) servers. It is fully integrated with Kubernetes (K8S) as the Virtualized Infrastructure Manager, along with a suite of Mobile Edge Computing (MEC) applications and Artificial Intelligence Frameworks (AIFs).
Availability	The testrack is integrated with the AI@EDGE project components and is available for use at SPI's premises.
Protection	The asset is classified as SPI's proprietary assets, indicating that SPI holds the intellectual property rights, and they are not open source.

Recommendation System	
Asset Type	Software (SW)
Description	This software asset is an ML-based recommendation system tailored for Inflight Entertainment and Connectivity (IFEC) systems, aiming to enhance passenger experience.
Availability	The recommendation system is proprietary and not available as open source.
Protection	As with the testrack, the recommendation system is protected as SPI's intellectual property.

Predictable Maintenance	
Asset Type	Software (SW)
Description	An ML-based predictive maintenance software that anticipates seatback screen failures within IFEC systems, potentially improving maintenance operations and reducing downtime.
Availability	This predictive maintenance software is also proprietary to SPI and is not distributed as open source.
Protection	The asset is safeguarded as part of SPI's intellectual property, ensuring control over its usage and distribution.

SRS

srsRAN Project E2SM_KPM Service Model	
Asset Type	N.A.
Description	The asset represents an enhancement to the srsRAN project, introducing the E2SM_KPM service model functionality into the E2 interface. This feature facilitates the reporting of five O-RAN defined metrics essential for near Real-Time RIC and xApp operations. These metrics, crucial for the project's objectives, include UL packet success rate, UE UL throughput, RLC DL packet drop rate, RLC DL transmitted SDU volume, and RLC UL transmitted SDU volume.
Availability	This asset is a part of the open source srsRAN Project codebase and is accessible to the public through the srsRAN Project's GitHub repository.
Protection	The feature is protected under the Affero General Public License version 3 (AGPLv3), ensuring that it remains free and open source while requiring that any modifications and derivative works are also made available to the community under the same license.

UPC

Edge Computing Testbed	
Asset Type	Hardware-Software Building Block
Description	UPC's testbed is an integrated edge computing environment that consists of a Kubernetes cluster with three master nodes, three servers, and four edge AI devices, which include six GPU accelerators. This infrastructure is designed to simulate an edge-cloud network, featuring a 100 Gbps Ethernet backbone for high-speed connectivity. The setup includes Mobile Edge Computing (MEC) components with wireless access capabilities and a connected vehicle model at a 6:1 scale for practical applications.
Availability	UPC provides free access to this testbed upon request. Users can reserve storage and computational resources managed via Kubernetes. The testbed can be accessed through either the public network or UPC's private research network. Use of the testbed is subject to regulations concerning the terms and duration of access to ensure equitable utilization of resources.
Protection	The testbed is an infrastructure asset available to researchers and does not fall under traditional IP protection categories. However, any software or data developed using the testbed would be subject to UPC's IP policies.

6. Impact Assessment and Exploitation

This final exploitation for the AI@EDGE project encapsulates a process that is inherently dynamic and continuously evolving, influenced not only by the project's technological progress but also by the ever-changing landscape of the market. Factors such as global health events, energy sector fluctuations, and supply chain interruptions have considerably impacted market conditions and projections, necessitating a flexible and responsive approach to our exploitation strategies. In this context, we have revisited and meticulously updated the initial exploitation plans developed by the use case leaders, considering the latest market statuses and forecasts, the integral role of AI/ML technologies, and communication advancements. The revised exploitation plans are reflective of these insights and have been adapted to maintain alignment with the current market environment and prospects.

Academic and research partners have been integral to the exploitation strategy, with a commitment to sharing the AI@EDGE project’s results as they emerged. The dissemination of findings from the use cases has been a key priority, with efforts focused on ensuring that outcomes are communicated promptly and effectively, maximizing the project's reach and impact in the scientific community and industry at large. This approach underscored the importance of knowledge exchange and the value of collaborative innovation in the project's wider exploitation efforts.

6.1 UCs initial exploitation plans

In D6.4 Section 6.1 we included the exploitation plans for the Use Case Leaders, namely CRF, DFKI, EAB and SPI. We briefly review them herewith.

Stellantis-CRF focus is on advanced connectivity for virtual validation of Connected Vehicles communication modules. Stellantis defined and validated the methodology to test applications and services through C-V2X communication based on 5G network in a virtual scenario that combined emulated vehicles and real time human driving in different traffic scenarios. The validation environment was a Hardware in Loop for the early-stage evaluation of C-V2X enabled applications and services. The automotive application links the C-V2X simulator (via a radio network emulator) to a driving simulator to reproduce in the C-V2X simulator the manoeuvres of a vehicle driven by a human. Stellantis has prepared the technological building blocks of the in-Lab network-level data exchange (required to build the cooperative perception layer) and fully tested the functionalities of the Telematic Box Module (device used to transmit data to driving simulator). Correspondingly, the exploitation plan is the transfer of AI@EDGE Stellantis outcomes to our Stellantis departments, dealing with the pre-development in line with the Stellantis Strategic Plan Dare Forward 2030 for connected vehicles.

DFKI plans to transfer and adapt the AI@EDGE outcomes, especially new security insights, to other application areas, such as industrial networks and Cyber Physical Production Systems. AI@EDGE results will also serve as input for the development of new technologies in forthcoming projects. The results can also be commercialized, e.g., through new start-ups (56 currently running DFKI spin-offs). Results of AI@EDGE will also be exploited at the academic level and be integrated in teaching and training courses at the University of Kaiserslautern as well as help to educate PhD students. Also, the dissemination of the results through the publication of scientific articles in relevant journals and international conferences is an important aspect.

EAB Ericsson Research drives technology leadership for Ericsson Mobile Networks impacting product design in the 3-5 years perspective. Ericsson's leading market position is based on providing world-class system concepts, technology innovations, and methodologies. The rapidly increasing demands for mobile broadband access in combination with needs for new technology and solutions for the digitalization of industries and societies create challenging and exciting opportunities. Within AI@EDGE, the Research Area Networks - Management and Automation intends to explore AI-based operations and "AI by design" network architectures, applying, e.g., reinforcement learning towards automation of network operations. To strengthen Ericsson's position in the competitive global market, AI@EDGE's outcomes should support new service offerings over existing commercial products and solutions, but particularly pave the way edge computing-based service offerings on future edge infrastructure. The project results are also to be used as input to relevant standardization organizations' work, such as 3GPP, ONAP, O-RAN, etc., where EAB is an active contributor.

SPI is a worldwide leading company in In-flight Entertainment & Connectivity solutions to aircraft. To ensure continued leadership in this market segment SPI intends to trial full-fledged 5G technology and network slicing capabilities. Therefore, SPI will leverage the knowledge gathered through AI@EDGE to scout the next generation of connectivity solutions trailing URLLC and eMBB services for the purpose of in-flight entertainment and on-flight work. This will allow SPI to put IFEC devices aeronautically certified with 5G connectivity in the product roadmap and on the market.

6.2 Market research/potential for use cases, the impact of the pandemic and the role of AI/ML

Due to the pandemic and the energy crisis over the past two years, the potential of markets for all use cases has been re-examined. Exploitation plans of the companies might be affected due to the slowdown and the decreased growth rate (or CAGR) compared with plans two and a half years ago. We have also examined the role of AI/ML.

6.2.1 Vehicle Cooperative perception: market penetration (UC1)

The Worldwide Autonomous Driving Market's value in 2021 was roughly 23 million euro, and by 2030 will reach USD 185 million Euro. Autonomous cars use cameras, sensors, artificial intelligence, and radar to travel without human drivers.

The vehicle sensors are responsible for perceiving the surrounding environment and a set of actuators that control its longitudinal and lateral movements, but they have limitations that might degrade the performance of automated vehicles (e.g., in adverse weather conditions, sensor's field of vision blocked by other vehicles or buildings...) To overcome these limitations and improve the perception capabilities of the vehicles, cooperative perception enables the wireless exchange of sensor information between vehicles and between vehicles and infrastructure nodes.

Vehicle-to-everything (V2X) is an important technology for realizing the cooperative perception of automatic driving. Information interaction between autonomous vehicles and edge nodes is the basis for realizing cooperative perception. The transmission of cooperative perception messages (CPMs) between vehicles and edge nodes requires a certain bandwidth and has strict latency constraints, which sets higher requirements for network performance. Vehicle mobility and market penetration have a great negative impact on cooperative perception effectiveness and network communication quality. In addition, a reasonable CPM-sharing strategy is also very important, which defines how often vehicles share perception data and which perception data to share. Therefore, reasonable network communication technology and sharing strategies are necessary. Usually, it is necessary to select an appropriate communication network and traffic scenarios.

At present, the penetration rate of intelligent networked vehicles is low, and the deployment of intelligent equipment and infrastructure construction still needs continuous efforts. Therefore, market penetration is an important factor that cannot be ignored for synergistic perception effects and communication quality. When the penetration rate is too low, the communication link supporting data transmission may be unstable due to the distance, and it may even be difficult to match a suitable edge node. Using cooperative perception information interaction, the impact of the low penetration rate can be effectively reduced, and the range of perception can be improved. When the market penetration rate is 50%, the estimated accuracy of vehicle positioning, and speed is 80–90%.

6.2.2 Industrial IoT market (UC2)

The Industrial IoT Market was valued at USD 76.7 billion in 2021 and it is expected to reach USD 106.1 billion by 2026, at a CAGR of 6,7%. The growth of the IIoT industry is driven by factors such as technological advancements in semiconductor and electronic devices, increased use of cloud computing platforms, standardization of IPv6 and support from governments of different countries for R & D activities related to IIoT.

Increased use of the *industrial IoT market*[1] due to the adoption of artificial intelligence (AI) and machine learning (ML) in the end-user industry, it is also driving the market's growth. The higher probability of device theft and data breaches is expected to restrain the industrial IoT market. Growing internet penetration and digitalization across the globe are an opportunity for the industrial IoT market. High installation costs and difficulties in integrating IoT devices are challenging the global industrial IoT market.

6.2.3 *BVLOS drone market (UC3)*

The autonomous BVLOS drones' market is projected to register a CAGR of more than 10% during the forecast period (2022 - 2027). The demand for BVLOS drone operations in the commercial sector is growing sharply, and over the past five years, several commercial drone operators received approval from their respective airspace governing agencies for BVLOS operation. The COVID-19 pandemic initially slowed the BVLOS approvals, but the companies are resuming their plans to continue work on long-term BVLOS operations.

Currently, several drone operators are robustly expanding their BVLOS operations to cater to the demand of various end-users, which will enhance efficiency and industrial productivity. This is expected to propel the growth of the market during the forecast period. The law enforcement and armed forces have been using unmanned aerial vehicles (UAVs) for long-range intelligence, surveillance, and reconnaissance, and combat applications.

Also, the armed forces are collaborating with companies to increase the autonomous capabilities of the UAVs with the introduction of artificial intelligence[2], big data, and other technologies. Despite the high levels of growth, the lack of comprehensive regulatory standards for the use of these drones in civilian airspace is challenging the widespread adoption of these drones.

6.2.4 *In-flight entrainment services (UC4)*

The global In-flight entertainment & connectivity market size was valued at USD 5.2 billion in 2021 and is anticipated to witness substantial growth, registering a CAGR of 9.0% between 2022 and 2030. Technological advancements in terms of wireless connectivity have enabled passengers to use personal electronic devices in airlines, consequently driving the growth of the in-flight entertainment & connectivity market. The ever-increasing customers' need for bug-free connectivity onboard is one of the important factors driving the market growth.

The aviation sector is experiencing a massive technological transition, making it necessary for market players to onboard updated solutions and services. In-flight entertainment and connectivity (IFEC) systems play an important role in delivering customers updated onboard wireless connectivity solutions and services, substituting the traditional seatback screens, and presenting a restricted entertainment

[1] More information to be found herewith.
[2] More information to be found herewith and at this link.

range with a moderately personalized model catering to individual passenger needs. Furthermore, advancements in seat design, connectivity, and real-time data positively influence the market for in-flight entertainment and connectivity. The major players are concentrating on improvising the broad range of delivery services, further increase in demand.

The in-flight entertainment & connectivity market has been severely impacted and is expected to face difficult times soon. Governments across the globe enforced lockdown restrictions to curb the spread of coronavirus, resulting in a sharp decline in airline flights. The airline industry has seen significant losses in revenue throughout 2020 and 2021. The companies operating in the in-flight entertainment & connectivity market were adversely affected by inactive markets and unstable economic conditions on the global level owing to the Covid-19 scenario throughout 2020 and 2021.

6.3 Final exploitation plans

Based on an exploitation questionnaire that was sent to AI@EDGE partners (focusing mainly on the commercial exploitation of the outcomes of the project), the individual partner exploitation strategies have been revised as follows.

6.3.1 Telecom operators and Vendors

TIM

"AI@EDGE story"	TIM's Route-To-Market strategy targets the deployment of distributed TIM Edge Nodes from national peering down to the On-premises deployments in an Edge continuum. TIM Edge Node, providing connectivity to all end-customers through public (or even private, such as 5G Private Network) coverage, will either locally break out the traffic on an appropriate service component or will allow the non-Edge traffic to flow to centralized cloud instances or the internet, based on the specific application requirements.
Business opportunities	The primary business approach for TIM is to leverage customer proximity and tight integration of the Telco and Service components to develop appealing Edge computing Use Cases exploiting isolation, security, and connectivity capabilities. Edge computing represents the opportunity for TIM to gain the role in the value chain by providing an infrastructure with connectivity, computing, and storage capacity that meet the requirements for the creation and deployment of Telco and Service capabilities for end-users. TIM distributed Edge computing infrastructure offerings will target Enterprises operating in vertical industries (B2B) and Public Authorities as final customers.
Potential products and services	TIM offers a variety of products targeting both Public Administration (PA), such as Municipalities, and Enterprises. Several products available in TIM's product portfolio are designed to offer a centralized control system for collecting, aggregating, managing, and analysing data coming from heterogeneous sources to support PA and

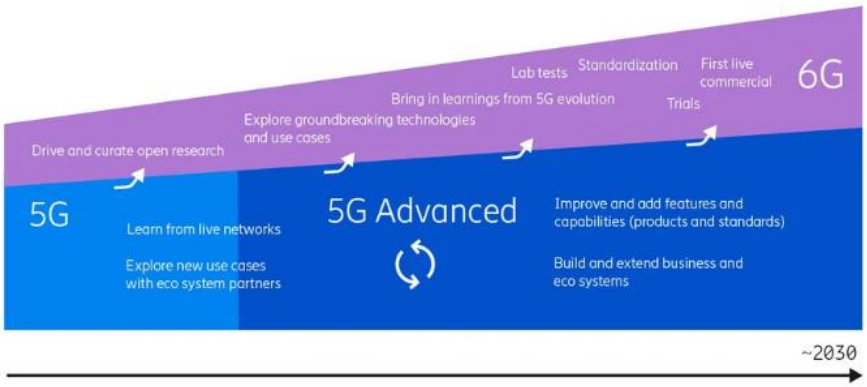
	Enterprises in their decisions, with adequate and comprehensive information. In future scenarios, with the deployment of distributed TIM Edge Nodes across Italian territory, current or future products can integrate AI@EDGE capabilities such as Machine Learning for prediction of urban mobility, performed at the Edge Nodes level and sharing meta-data between Edges and the centralized system. Distributed artificial intelligence systems permit more sophisticated forecasting techniques and optimize decisions making process for PA and Enterprises.
Credible path	TIM was involved in AI@EDGE WP2 and mainly focused on use case requirements analysis and definition of the overall consolidated AI@EDGE Architecture. With the deployment of distributed TIM Edge Nodes across Italian territory current or future products can be integrated with AI@EDGE capabilities related to Edge Intelligence such as: distributed connect-compute platform with Standalone (SA) and Non-Standalone (NSA) deployment options, Data and Model Pipeline Management, Real-Time requirements and online training, Distributed training, and deployment
Technology for near term applications	AI@EDGE platform capabilities related to Edge Intelligence can be integrated in TIM's distributed Edge computing infrastructure to create innovative data service platforms by allowing customers from various verticals (automotive, fleet management…) to deploy their own Artificial Intelligence algorithms and autonomic systems, including self-managing physical or software systems that learn from their environments
Total Addressable Market (TAM)	TIM Addressable Market is represented by current PA and Enterprise clients of TIM in Italy and Brazil in addition to prospect PA and Enterprise clients in both countries. TIM could potentially be the first provider in Italy offering distributed and intelligent platforms (based on Intelligent Edges) and potentially extending its use to all Italian territory, such as municipalities and Enterprises. Moreover, TIM Brazil will benefit from the innovation and exploitation done in Italy by TIM.
Position in the market	TIM is the leading group in Italy and in Brazil in the ICT sector by developing fixed, mobile, cloud and data center infrastructures and offering services and products for communications and entertainment. TIM offers integrated digital solutions for citizens, businesses/enterprises, and PA. In September 2022, TIM Italy had a market share of 24.9% for mobile network (considering only human SIM) and 41.9% for fixed network (*source:* www.agcom.it)
Market standing	With these Intelligent Edge Platform, new services (such as intelligent fleet management) can be added in the TIM's portfolio, enabling TIM to enforce its market position and customer base leading to an increase in revenues. Moreover, TIM is currently holding a leading position for services designed for PA and Enterprises. In this context, TIM focuses on building and maintaining current customer loyalty to strengthen its market share and revenues.

Roadmap	After the deployment of distributed TIM Edge Nodes across Italian territory, it is expected to demonstrate AI@EDGE capabilities for Intelligent Edges to TIM management board. Once approval from management is obtained, engineering teams will be involved to design and implement AI@EDGE capabilities.
Competitor organizations	In Italy, main TIM competitors are Vodafone, Wind Tre, and Iliad. - TIM, Wind Tre, and Vodafone dominate the Italian network operator market. The newcomer Iliad accounted for approximately 10 percent of the market. - TIM, Vodafone, and Wind Tre dominate the mobile data and voice market. - With the deployment of distributed and intelligent Edge Nodes, TIM could potentially invest in other segments such as VR, Metaverse, Video Games, Automotive, B2B… to obtain a leading position in offering new services in these segments. This would allow TIM to take business from its main competitors. - Introducing AI@EDGE capabilities in the Intelligent Edge Nodes, TIM could potentially become the first provider of Intelligent Edge Platforms. In future scenarios, TIM can offer these platforms to all Italian municipalities (approximately 824 cities in Italy) and to Italian Enterprises (more than 1 million active businesses in Italy).
Standards	TIM supports 3GPP, ETSI MEC and O-RAN standardization activities relevant for the standardization of an intelligent edge infrastructure with connectivity, computing, and storage capacities that meet the requirements for the creation and deployment of new innovative services for end-users.
Publications (Journal/Conference Papers), or published IP	5G-AI, 5G-PPP Projects White Papers.
Opportunities or threats	Thanks to a potential "AIFs Marketplace" providing new opportunities for AIF Developers to offer their solutions (as AIFs) for various domains and sectors. The acquired AIFs could be than deployed on top of intelligent edge platform with AI@EDGE capabilities
Exploitation plan	Edge Computing represents the opportunity for TIM to gain the role in the value chain by leveraging customer proximity and tight integration of the telco and service components. Intelligent Edge Platforms can potentially target Public Authorities and verticals, such as Automotive and Construction industries. TIM is interested in providing Intelligent Edge Platforms for different vertical industries by reusing AI@EDGE platform capabilities. TIM is interested in highly distributed and intelligent Cloud Edges Continuum, providing that Intelligent Infrastructure as a Service, suitable for the following use cases initially identified: • **Intelligent Edge Platform with AI@EDGE capabilities for Public Authorities.** Video surveillance cameras connected to the platform, used by public authorities, to detect incidents by applying AI for video analysis. Once incidents are detected, public authorities can send drones on the

	accident site to obtain high-quality video and images to understand what actions can be taken to provide a quick resolution and next actions. Since drones need to have a guaranteed coverage to be guided through the accident site, the platform can predict the quality of the network and compute the optimal route for the drones to reduce the time needed to reach the site. • **Intelligent Edge Platform with AI@EDGE capabilities for Automotive**. Automotive industries are interested in developing adequate systems to guarantee a secure autonomous driving experience. This is possible by combining data coming from different sources (i.e., roads, video cameras, vehicles, road operators…) and Telco data. Using Telco data to predict QoS changes, the platform can provide advance notifications about the predicted QoS to allow the computation of the optimal route which would guarantee the network QoS needed to sustain autonomous driving. • **Intelligent Edge Platform with AI@EDGE capabilities for Construction.** Construction industries need to monitor their building sites to reduce potential incidents and guarantee workplace safety for workers. The platform can be used to monitor distributed building sites across the territory and, through video analysis obtained by video cameras installed at the building sites, artificial intelligence can be used to detect if workers use correctly personal protective equipment (such as head protection, masks respirators, goggles, gloves…) to prevent and reduce risks of accidents. If personal protective equipment is not used adequately, the platform can send a notification to the central offices and to the manager that has the responsibility to guarantee the safety of the workers. Actions can be taken to encourage workers to use personal protective equipment following provided guidelines.

EAB

"AI@EDGE story"	Ericsson Research, organization part of EAB that works in AI@EDGE, drives technology leadership and the future vision for Ericsson Mobile Networks in the 5-7 years research timeframe, i.e., the 6G/2030 telecom vision. Within AI@EDGE, Research Area Networks - Management and Automation team members worked on the research of new architecture concepts and automation solutions with focus on AI-based network operations and "AI by design" E2E network architectures.
Business opportunities	It's too early to determine AI in edge computing impact on future business models.
Potential products and services	No specific product or service, but long-term adoption is expected of system architecture principles to support AI demands in edge and E2E networks, including and AI based automation concepts for network operation and management.
Credible path	Telecommunication network businesses are mainly focused on network evolution, i.e., several intermediated steps for time to market. Network evolution is motivated, for example, due to the importance of industry consensus in standardization organizations (e.g. 3GPP, O-RAN) to provide

	global reach, high level of investments in infrastructure with an expected several years equipment life cycle until renewal of hardware, etc. The path for truly AI Native telecom networks is commonly associated to next generation telecom technologies, i.e., 6G in 2030 timeframe.
Technology for near term applications	The principles regarding data driven architecture in relation to support AI/ML requirements can start to be used in the design of efficient data pipelines and ML models life cycle management driven by model managers concepts.
Total Addressable Market (TAM)	It's difficult to precise, but there are public reference on market indicators, such as, AI in Telecommunications Market Just under $40 Billion by 2031 - Global Research - UC Today
Position in the market	NA. We are a research organization in the project.
Market standing	Main effect is on research of technology enablers, AI4Networks and Networks4AI, for 5G Beyond/6G timeframe.
Roadmap	The organization does not have a roadmap to AI@EDGE-related products. As a research organization thought, below is a 6G research roadmap in the 2030 timeframe that can be considering that 6G requires an intelligent network platform as exploited by AI@EDGE.  *Figure 18 6G research roadmap: Growing from 5G to 6G* It is too early yet to define a detailed roadmap for 6G. Research into new technology areas, such and AI/ML enabling network intelligent platforms, is ongoing in parallel with the evolution of 5G. Learnings from live 5G networks and interactions with the user ecosystems will continuously feed into the research, standardization, and development of 6G.
AI@EDGE Technologies	Research learnings from AI@EDGE project are disseminated in Ericsson Research and broadly through publications.
Competitor organizations	Broadly in the telecommunication networks vendors landscape, example of competitors are: Nokia, Huawei, Samsung, etc. a) & b) telecommunication equipment and solution vendors; c) continuously strive for a high performance and competitive portfolio. d) EAB engagements in EU projects like AI@EDGE, working in early stage of research technologies supports,

	e.g. understanding of new concepts as AI and its application in Telecom, fostering of industry and academia discussions and communication of benefits more the public, long term to acceptance of new technology, etc.
Standards	Examples of telecom standards organizations relevant to AI@EDGE and support by Ericsson are 3GPP, O-RAN, ETSI, etc.
Publications (Journal/Conference Papers), or published IP	Telecom related academia publication in IEEE, 5G PPP white papers, standardization publications, etc.
Opportunities or threats	Public acceptance of AI technology can still be an opportunity or a threat, since we are still in early stages of AI regulation, data privacy and security principles, development of products and solution based on trustworthy AI, Explainability, AI liability, etc.
Exploitation Plan	In 6G – Connecting a cyber-physical world - Ericsson[3] white paper, a vision of the 6G-powered world of 2030 is outlined, with the research focusing on what future networks should be able to deliver and what candidate technologies should be developed to get there. AI@EDGE results on intelligent edge platforms are part of an exploitation phase toward a 6G vision, where cognitive networks need to be understood in terms of realization, capabilities, and network evolution challenges to be faced. - *What are Cognitive networks? A 6G 2030 vision* 6G future networks are expected to support and manage many deployed services without exponentially increase cost and complexity, claiming for a higher level of network intelligence and autonomy in operations. Such cognitive networks will help improve energy efficiency, optimize performance, and ensure service availability, including critical services. The realization intelligent networks will likely occur in two basic ways: applying optimizations that are difficult to achieve with traditional algorithms, where AI/ML can support, and in evolving the operations systems to handle most of today's system management tasks autonomously, where AI/ML is also a game changer. - *The importance of Autonomous systems: exploitation of AI@EDGE NSAP principles* 6G Cognitive networks will push the boundaries of how far we can automate telecom systems, i.e., how zero can we touch? A cognitive system requires AI native capabilities to adjust to its environment, constantly observing and learning from previous actions. Lessons from operations and service performance are fed back in short cycles or in near real time to improve configurations, processes, and software. Within the network logic, a continuous improvement in algorithms will be seen driving runtime

[3] More information at this link.

	decisions distributed across physical locations and logical functions. This continuous optimization will make the system much more dynamic compared to today's system. Intelligence, in different forms, will be available all over a geographically distributed network. - *Data-driven architecture as a foundation: exploitation of AI@EDGE Data Pipeline and Model Manager* Intelligence in networks involves making decisions based on facts or data, and with more data available, better decisions can be made. Data-driven architecture is the infrastructure that enables the use of AI/ML algorithms, i.e., intelligent data pipelines, as proposed by AI@EDGE, are crucial for taking care of moving, storing, processing, visualizing, and exposing data from inside service provider networks as well as external data sources in a format adapted for the consumer of the pipeline. This allows the deployment of different AI/ML learning algorithms anywhere in the network, for both training and inference, including the AI/ML model lifecycle management capabilities and proposed by the AI@EDGE model manager solution.

ITL

"AI@EDGE story"	Italtel's history is closely connected to telecommunications innovation. Among the first companies in the world to develop VoIP (Voice over IP), today Italtel is positioned on the most advanced communication segments. Italtel operates as an advanced system integrator able to integrate and manage different vendor technologies and to use its software development capabilities on key network infrastructure components to build the most suitable solutions for the characteristics of the customer business. Its R&D activities and the planning of new solutions are carried out following the logic of open innovation. 5G, Edge computing, and AI are among the traditional areas or Italtel's research and innovation. Moreover, Italtel R&D is following the evolution of telecommunications considering several vertical markets to which offer solutions and services including Telco, Media & Cloud, Enterprise, Energy & Utilities, Banking & Insurance, Health, and Public Administration. In the context of AI@EDGE, the integration of innovative technologies that enable running AI at the edge is a topic of major interest. Edge nodes powered by connect-compute platform, can be proposed as platform not only to run AI based application for the telecom providers market but also for hosting AI based services and verticals, in line with the Italtel objective to expand its business in new market sectors.
Business opportunities	Edge computing infrastructure targeting Enterprises operating in vertical industries and Public Authorities.
Potential products and services	AI adoption for network automation and management in telco network is expected as a potential growing business in next year. Edge nodes powered by connect-compute platform, can be proposed as platform not only to run AI based application for the telecom providers market but also for hosting AI based services and verticals, in line with the Italtel objective to expand its business in new market sectors.
Credible path	ITL can acts as system integrator for the AI@EDGE platform.

Roadmap	We are evaluating AI@EDGE results in research labs and investigating possible roadmap for potential customers.
Competitor organizations	System integrators. Increasing knowledge on new technologies developed by AI@EDGE can improve our impact towards customers.
Exploitation plan	Edge nodes powered by connect-compute platform, can be proposed as platform not only to run AI based application for the telecom providers market but also for hosting AI based services and verticals, in line with the Italtel objective to expand its business in new market sectors.

6.3.2 Large Industries

Stellantis-CRF

"AI@EDGE story"	Create a new validation environment for 5G Connected Vehicles Telematic Boxes.
Business opportunities	As an Automotive OEM the company sees a new field of applications for connected vehicles, as validation platforms for 5G are essential in the development process of connected vehicles.
Potential products and services	Project outcome for Stellantis-CRF is a new in LAB validation platform for 5G, correspondingly it is not a product to be deployed on vehicles rather an essential tool and enabling methodology that can accelerate the deployment of 5G connected vehicles.
Credible path	Beyond project activities, the new in LAB validation platform and methodology will be exploited in the Company, namely it will be made available for the 5G connected vehicles tests allowing the related enabling technology to ramp up the Technology Readiness Level scale.
Technology for near term applications	Yes, with relation to the validation of new connected services.
Position in the market	Stellantis-CRF will deploy project outcome internally, as the outcome is an in-LAB validation platform and methodology.
Market standing	NA in terms of estimated revenues and market standing, as the impact on the Company is related to the development process itself.
Roadmap	NA as Stellantis-CRF project outcome is not a product, and the validation platform and methodology will be ready to be deployed internally to the Company after the project ends.
Targeted fields	Totally (100%)
AI@EDGE Technologies	Stellantis-CRF core activities in AI@EDGE are in the WP2, WP5, WP6 work packages focusing on use case design development and test.

State of the art	5G Emulators are available on the market, and Stellantis-CRF is using a 5G Emulator as part of the validation platform. Other OEMs and automotive suppliers are creating similar validation platforms, given the importance of LAB testing.
Competitor organizations	About the validation platform and related methodology, the information related to other OEMs and automotive suppliers in terms of "competition" is not made available.
Opportunities or threats	Opportunities are related to the Company internal development process, no threats, IP, standardization issues have been identified yet.
Exploitation plan	For Stellantis-CRF the AI@EDGE project represents an important step forward on the following topics related to connected vehicles to facilitate the design and development of new connected services; to reduce physical testing (cost and time) and reduce time to market; and to assess KPIs (latency, reliability, mobility, device density, type of traffic). Stellantis-CRF, acting for Stellantis, will take care of transferring the project results to the relevant Stellantis engineering teams for their exploitation. Stellantis focus is on advanced connectivity for virtual validation of Connected Vehicles communication modules. Stellantis defined and validated the methodology to test applications and services through C-V2X communication based on 5G network in a virtual scenario that combined emulated vehicles and real time human driving in different traffic scenarios. The validation environment was a Hardware In Loop for the early-stage evaluation of C-V2X enabled applications and services. The automotive application links the C-V2X simulator (via a radio network emulator) to a driving simulator to reproduce in the C-V2X simulator the manoeuvres of a vehicle driven by a human. Stellantis has prepared the technological building blocks of the in-Lab network-level data exchange (required to build the cooperative perception layer) and fully tested the functionalities of the Telematic Box Module (device used to transmit data to driving simulator). Correspondingly, our exploitation plan is the transfer of AI@EDGE Stellantis outcomes to our Stellantis departments, dealing with the pre-development in line with the Stellantis Strategic Plan Dare Forward 2030[4] for connected vehicles.

[4] Stellantis Strategic Plan Dare Forward 2030 is available here.

SPI

"AI@EDGE story"	An Edge/Cloud environment for In-Flight Entertainment and Connectivity (IFEC) system (UC4).
Business opportunities	Safran Passenger Innovations (SPI), as one of the worldwide leading companies in IFEC, is currently involved in an enduring Research & Technology program to scout and trial new connectivity solutions. This embraces the ongoing endeavour of the digital transformation of the aviation sector. SPI is also member of the Seamless Air Alliance, an organization of vendors for aviation that aims to develop guidelines for new products, well in line with the scope of AI@EDGE. In a landscape of a post-COVID 19 fast changing market, AI@EDGE stands thus as one of the key projects to enable the next generation of IFEC systems. One goal of SPI is to unravel all the potentials of 5G technology in an aircraft cabin. If successful, SPI can plan the development of a new generation of connectivity products, which thus expand the existing offer portfolio for the airlines.
Potential products and services	The AI/ML-based applications that run in the aircraft edge-cloud can potentially lead SPI to develop a first generation of software products around predictable maintenance and content recommendation systems to be offered as software bundles to airlines and aircraft OEMs like Airbus and Boeing. Moreover, the onboard 5G if combined with new satellite constellations such as LEO can potentially lead to a new generation of connectivity system.
Credible path	The Aviation market exhibits peculiarities that are unlike to be found in the mass market. The complex certification process typically extends the Time-To-Market compared to other sectors. Anyway, it can be expected that after a preliminary design toll gate, there will follow a critical design review and first prototype development (both software and hardware wise). Afterwards, a complex qualification process shall follow against line fit and retrofit aircraft programs.
Technology for near term applications	The AI@EDGE Use Case 4 led by SPI brings into the picture aero certified, SPI manufactured cabin servers and seatback screens to enable the computational power required by the 5G system and edge-cloud. Despite some key components are already available a necessary repurpose will be required, including new aeronautical qualifications. In addition, feedback from airlines and OEMs is still required, which is not practical to obtain a short timeframe. Therefore, they cannot expect a new generation of products in the near term.
Total Addressable Market (TAM)	The SPI Business Unit has two main offices located in Wessling (Germany) and in Brea (California). The market to be addressed is those of airlines in post COVID-19 peak of pandemic.
Position in the market	SPI, part of the Safran Group, stands with Panasonic and Thales as the largest provider of IFEC systems and one of the aviation companies in the target market segment that is most awarded with new programs.

Market standing	Given the leading position of SPI in the related market segment, SPI can continue reinforcing its position towards airlines and OEMs, thus with a potential revenue of several million. A more exact projection would require a forecast about the market uptake. (e.g., recent EU announcement about 5G on-board airplanes in November 2022).
Roadmap	The project helps the R&T team to develop a PoC to investigate the possibility of using the outcomes in future aviation products. It is expected that the outcomes of AI@EDGE will be demonstrated to the SPI management, as well as to the management of the Safran group. Anyway, they should not expect a TRL level higher than 4/5 since the above TRLs are developed by the company when doing the final products.
Targeted fields	The tasks of people who work on AI@EDGE in SPI are perfectly aligned with our R&T roadmap, and the project fits well with future business perspectives that sought after by the Business Unit.
AI@EDGE Technologies	SPI is developing edge-cloud infrastructures, two IFEC applications that are served within the edge-cloud, 5G RAN and 5G core UPF in the cabin, as well as MPTCP. Their contribution is mostly on WP5, while they also are involved in WP2, WP4, and WP6.
State of the art	In the field of aviation, for IFEC, they should notice a quite conservative approach and a market in which connectivity is dominated by WiFi on-board and by Geostationary connectivity offboard. None of the technologies currently developed within AI@EDGE has predecessors in the market, apart for an aero certified 3G cell that SPI still offers to airlines.
Competitor organizations	Thales Group, Panasonic, Intelsat a. In-flight Entertainment and Connectivity Market b. Reliable, affordable, and very easy IFEC system for both airlines and passenger. c. By investigation on the new technologies such as AI/ML, B5G/6G, LEO satellite communication, etc. d. Participation in AI@EDGE was extremely helpful the take advantages of the new technologies mentioned above while exchanging knowledge with the experienced partners of the project.
Standards	ARINC standard series are the most relevant in aviation. 5G has been tackled until now by the Seamless Air alliance (SAA).
Publications (Journal/Conference Papers), or published IP	- E. Temprado et al., "In-Flight Entertainment and Connectivity in the 5G Era: The 5G ESSENCE Experimental Platform," in Proceedings of European Conference on Networks and Communications (EuCNC). IEEE, 2019. - Mafakheri, Babak, et al. "Edge Intelligence in 5G and Beyond Aeronautical Network with LEO Satellite Backhaul." 2023 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit). IEEE, 2023.

Application environment	A monolithic, single-purpose IFEC infrastructure can become a self-driving, self-healing network open to host third-party services in App store fashion.
Opportunities or threats	While this questionnaire is exhaustive, SPI will continue monitoring the IFEC market and will continuously consider airlines and OEMs feedback about 5G technology and its evolution applied to aviation.

ATOS

"AI@EDGE story"	AI@EDGE participation, or the main components developed during the project lifetime, allows ATOS (EVIDEN) to strength its positioning in the AI market offering added-value and cutting-edge solutions for their customers.
Business opportunities	As for the components developed, they can be integrated within the GenAI current portfolio offering.
Potential products and services	As it has been said before, ATOS (EVIDEN) is offering GenAI consulting services and solutions to support businesses, from all sectors, growth while increasing their potential using tailored AI solutions.
Credible path	As research results, neither the Intelligent Orchestrator nor the Model Monitoring can be directly exploited. Furthermore, based on the offered functionalities they must be incorporated to any existent, or under development, product. Thus, it is necessary to do a deeper technical and business analysis and map them with the current portfolio of solutions and provide this information to the corresponding Product Owner to develop the appropriate integration (and further implementation) roadmap.
Technology for near term applications	This mainly relies on the Product Owner decision.
Total Addressable Market (TAM)	None of the components developed have value on their own as they need to be integrated with other tools, it is not possible to estimate the TAM.
Market standing	Increased positioning, while economic figures are not public.
Roadmap	As it has explained before, this is a discussion to be held with the corresponding Product Owner.
Targeted fields	It is something that can be incorporated to the GenAI solutions.
AI@EDGE Technologies	Intelligent Orchestrator and Model Monitoring
State of the art	There are plenty of solutions for orchestrating and monitoring, however, doing it with AIFs is a new topic.

Competitor organizations	As our solutions are tailored to specific customers, rather than more generic ones, independent of the sector they operate, this provides a specific advantage ahead competition.
Opportunities or threats	Agnosticism of the appliance domain.
Exploitation plan	ATOS is now operating under the EVIDEN brand, which will soon become a new player in the market. However, it is still a global leader in digital transformation aiming to provide tailored and cutting-edge solutions to its customers supporting them in their journey to maximize their potential and foster their businesses growth. ATOS is offering a Generative AI (GenAI) Consulting service to its current customers, and any other that may be interested in, to support them in the design of tailored AI solutions that help them to maximize the benefits from their data while supporting the decision-making processes. Within this service, ATOS develops solutions, based on each customer needs, that will be further integrated within customer's existing solutions. Considering that research results must be further implemented to transform them into commercial solutions, there is a clear basic roadmap that must be performed in advance: - Deep analysis of the technical requirements and potential business impact to highlight the future demand and impact of this kind of solutions and the potential benefits for the company. - Present the results of these analysis to the Product Owners to determine to which solution they will fit better and how. - Agree an implementation/integration roadmap with the Product Owner for these specific components. Once these steps are complete and the implementation/integration plan is finished, the information will be included into the solutions catalogue so the new features can be introduced to customers.

HPE

"AI@EDGE story"	AI@EDGE focuses on a "connect-compute" platform that supports AI-enabled network applications and that leverages edge computing. This framework highly benefits from Athonet's technological solutions that support the 5G connectivity of such a platform, interconnecting different edge nodes and the cloud, instantiating, and managing dedicated network slices, supporting local traffic breakout for edge computing, and enabling cross-site orchestration of MEC applications. Exploitation opportunities in this framework have increased after the recent acquisition of Athonet by HPE, which offers in its portfolio HPE GreenLake, the open and secure edge-to-cloud platform, already devoted to interconnect data sources and support networked intelligence from edge to cloud. The AI@EDGE project is set to serve as a key driving force in our future endeavours, particularly as we look towards engaging with the Horizon Europe Framework Programme and the Next Generation Internet (NGI) initiative. We believe that these frameworks provide an ideal platform for us to showcase the results and innovations stemming from AI@EDGE. In doing so, we aim to position UNIVPM as a prominent player in the ongoing

	transformation of the technological landscape, capitalizing on the immense potential that lies within these collaborative initiatives. In essence, UNIVPM views the AI@EDGE project as a transformative force with far-reaching implications. It underpins our dedication to innovation and collaboration, setting the stage for a future where technological advancements are not just an aspiration but a reality with tangible economic and societal benefits.
Business opportunities	For what concerns HPE, the experience gathered with AI@EDGE has contributed to consolidate our expertise in edge-computing-oriented software and hardware 5G solutions that allow a simple and straightforward end-to-end deployment of the aforementioned "connect-compute" platform. Business opportunities for HPE leverage such 5G solutions and combine: - A full set of 5G core network functions to support 5G connectivity. - A set of multiple "edge nodes" with dedicated user plane functions and customizable with further distributed network functions (e.g, Network Data Analytics Function), as needed by a customer. - A centralized management platform with a Graphical User Interface (GUI) to manage all the involved software and nodes. - Interfaces (GUI, Application Programming Interfaces - APIs) that allow ETSI-MEC-compliant elements (MEC applications, MEC platform, etc.) to interact with the core network functions (e.g., Policy Control Function, Network Exposure Function) to enable core network re-configuration and traffic policy re-definition.
Potential products and services	See Business opportunities
Credible path	The 5G core network components that underlie the abovementioned solutions and that HPE brought to the project are already commercial.
Technology for near term applications	See Credible path
Total Addressable Market (TAM)	We cannot reveal our internal information and targets for HPE-specific solutions; however, we believe AI@EDGE's outcome might be a valuable insight for the long-term R&I strategy.
Position in the market	With the acquisition of Athonet, HPE is now a market leader for what concerns private mobile networking, including 5G.
Market standing	Since the effect of the technology will be in the long-term, we are not able to provide detailed estimations.
Roadmap	The 5G core network components that underlie the abovementioned solutions and that Athonet brought to the project are already commercial. Further details on long-term strategy cannot be shared.
Targeted fields	See Roadmap.

AI@EDGE Technologies	HPE and formerly Athonet brought 4G and 5G core network solutions to the project, especially for the purposes of WP4 and WP5. Other contributions concerned WP2 (architectural designs) and WP3 (functional and performance metric collection from the 5G core network).
State of the art	Private 4G and 5G networking is commercially leveraged by several vertical sectors: governmental and public entities (for instance, for public protection and disaster relief - PPDR), transports (airports, naval ports), companies that operate in atypical environments (e.g., underground mining, open-sea energy plants), mobile network operators that deploy private slices for private customers, etc. State-of-the-art solutions leverage the most advanced techniques of networking and network function design and virtualization to develop core network solutions with form factors adapted to the different applications (transportable infrastructure for PPDR, distributed architectures for multi-site private connectivity, etc.).
Competitor organizations	Leading competitors are major core network vendors (for what concerns the telecommunication infrastructure market) and mobile network operators and service providers (for what concerns the offer of private networking to vertical sectors).
Standards	3GPP (for 5G architecture) and ETSI (for MEC and mission-critical communications) standards. They do not negatively affect the adoption of HPE's solutions; on the contrary, since they are standard-compliant, the standards foster their diffusion. N/A
Exploitation plan	HPE intends to build upon the project's results for its research and innovation activities and utilize the gathered expertise in other subsidized European or national projects. Further, HPE plans to exploit the technological and operational insight obtained from the project's activities and prototypes to improve its commercial solutions and products. The results obtained by HPE within AI@EDGE are replicable, and the project has been a successful testbed to experiment with solutions that can be applied to future commercial and research contexts. AI@EDGE was successful in validating innovative 5G architectures (like the distributed architecture that joins FBK, SPI, and DFKI for WP5's purposes) and satisfactorily proving that HPE's solutions can enable and support the corresponding use cases. Such results will be exploited by HPE for dissemination, education, and promotion purposes, with both customers and academic/industrial partners. As a high-tech company, HPE expects to benefit from the results of AI@EDGE not only to promote top level private 5G/B5G products, but also to accelerate its growth in this market sector and, to a broader extent, to increase the awareness and business opportunities of private cellular networks for the vertical sectors like those addressed by AI@EDGE (automotive, industrial IoT, air transports). **Innovation**: Distributed 5G network solutions and deployments of Athonet 5G core network adapted to the project's use cases **Competition**: Network infrastructure vendors; mobile network operators; service providers. **Targeted market:** Private vertical sectors; mobile network

	Strengths: Flexible solution, adapted to very different deployments scenarios and available as several different solutions from the point of view of utilized hardware and target performance. **Weaknesses**: Customers are still not fully aware of the advantages of private mobile networking solutions and are still sometimes reluctant to abandon other wireless technologies like WiFi. **Risks:** Non-negligible competition; globally slow adoption of 5G technologies compared to the initial previsions of the international community.	operators offering private networking solutions.

6.3.3 Small and medium enterprises

8BELLS

"AI@EDGE story"	8BELLS leverages its expertise in telecommunications and techno-economic analysis to identify market opportunities, barriers, regulatory considerations, and competitor characteristics for AI@EDGE technologies. One standout route to market is the development of serverless architecture across the cloud-terminal continuum with hardware acceleration solutions, which is a key innovation in AI@EDGE.
Business opportunities	The business opportunities for 8BELLS in AI@EDGE include consultancy for techno-economic assessments of 5G and edge computing deployments, and the integration of AI technologies for automated network management and orchestration.
Potential products and services	8BELLS could integrate AI@EDGE outcomes into its existing portfolio of cloud management solutions and consultancy services, enhancing offerings in 5G and edge computing markets.
Credible path	The path to market involves aligning AI@EDGE technologies with 8BELLS' strategic direction in cloud-native solutions and 5G services. Intermediate steps include product development, market analysis, and regulatory compliance.
Position in the market	As a startup, 8BELLS is currently establishing its market presence. Its market share in specific segments is influenced by its participation in EU projects and the emerging 5G market.
Roadmap	8BELLS's roadmap includes the continued development of 5G and edge consulting solutions, with a focus on integrating AI@EDGE technologies.

Competitor organizations	8BELLS faces competition from firms specializing in digital transformation, 5G deployment, and cloud services. To differentiate itself, 8BELLS must leverage its AI@EDGE experience to offer uniquely integrated AI and edge computing insights.
Opportunities or threats	8BELLS finds opportunities in guiding the adoption of 5G and edge computing, responding to increasing market demand. The main threats are the pace of technological innovation and the evolving regulatory frameworks within the sector.
Exploitation plan	8BELLS intends to extend its exploitation plan for AI@EDGE primarily through its consulting services. 8BELLS will focus on enhancing its consultancy offerings by integrating the expertise and insights gained from the AI@EDGE project. This will involve providing specialized advice to clients on the effective deployment and optimization of 5G and edge computing technologies. In this approach, 8BELLS aims to meet the specific needs of businesses seeking to utilize emerging technologies by providing customized solutions that align to their unique operational demands. The company's involvement in various European projects will further enhance its consulting services, ensuring that the guidance provided is based on the most recent industry developments and trends. By focusing on consultancy, 8BELLS aims to establish itself as a go-to expert in the field of 5G and edge computing, thereby expanding its client base and strengthening its position in the market.

AEROTOOLS

"AI@EDGE story"	AEROTOOLS aims to be a prominent supplier for the industrial sector by offering advanced surveying services for infrastructures and industrial assets, with a strong commitment to incorporating cutting-edge technologies into these services leveraged by 5G network communication and Edge-based AI functions.
Business opportunities	Identified opportunities as summarized as follows: - Provide an advanced communication network enabling the consistent and safe operation of drones in BVLOS mode for U-Space scenarios. - Contribute with advanced functionalities to the concept of UAM scenarios. - Deliver advanced inspection services for industrial assets and infrastructures, enabling access to a repository of AI functions deployable on the EDGE
Potential products and services	Two potential services or products are identified: - The ATOM tool, developed by AEROTOOLS, enhancing AI@EDGE functionalities and systems developed in the project for the provision of innovative industrial services. - Manufacture of drones with embedded systems that enable connectivity to 5G networks and access to repositories in the EDGE. Both developments are strategically aligned with AEROTOOLS' respective lines of business in these areas:

	- SERVICE & OPERATION: Empowered by ATOM, with a presence in more than 12 countries and annual business growth of 20%. - DRONES & SYSTEMS: Manufacturing drones with embedded systems, facilitating connectivity to 5G networks, and providing access to EDGE repositories.
Credible path	The access-to-market process could be planned as follows: - Optimization of processes, protocols, and software. - Industrialization of hardware and protocols. - Progressive incorporation into ATOM as a Service Suite, initial presentations to potential clients. - Final definition of service proposal with ATOM + AI@EDGE services. - Certification of drones and systems, customer testing, inclusion in the portfolio.
Technology for near term applications	The work carried out for the integration of AI@EDGE can be used in short-term applications, subject to the optimization of certain processes and the consolidation of specific aspects of 5G technology. In the EDGE part, access to functions repositories with different degrees of proximity to the end user is a service that may be accessible in the short term.
Total Addressable Market (TAM)	In terms of AEROTOOLS' domain of expertise, drones, and associated services, it is a sector expected to experience strong growth in the coming years. The AI@EDGE project can have an impact on various components, such as communications and access to advanced functions for innovative services. The document published by the European Commission[5], 'Drone Strategy 2.0,' outlines the sector's current state, development prospects in different areas and applications, and provides an estimate of market typology and size. The market for services provided with drones Is defined in three segments: - IAS (Innovative Aerial Services): Currently covered by UAS operations (surveillance, inspection, mapping, imaging, etc.). - IAM (Innovative Air Mobility): Covering international, regional, and Urban Air Mobility (UAM), i.e., cargo and passenger transport services between populated areas. - U-Space: The concept that encompasses the coordination of operations in airspace shared by manned and unmanned aviation, facilitating drone traffic management, and providing the framework for the development of the drone industry and its services.

[5] "A Drone Strategy 2.0 for a Smart and Sustainable Unmanned Aircraft Eco-System in Europe", COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. November 2022, link.

	According to studies conducted during the preparation of this document, it is expected that the drone services market will reach €14 billion in 2030, with annual growth of 12%. The estimated segment distribution is 70% for IAS/UAS, 20% for IAM, and 10% for U-Space. A reverse projection would estimate the current market size at around €6 billion, primarily concentrated in the UAS Operations segment, as the other two segments are still in their early stages (estimated segment distribution: 90% IAS/UAS, 9% IAM, and 1% U-Space). The contribution of AI@EDGE to the development of devices and work environments that facilitate this growth could entail access to a significant portion of this market volume, as it influences two crucial technologies for this sector: communications and advanced functions supported by AI and Edge Computing.
Position in the market	The position of AEROTOOLS in this market corresponds to that of an innovative SME positioning itself in a growing market. Currently, it is estimated to hold a market share of 0.2% in Spain (€300 million), with a projected growth to 1% in Spain (€725 million) and 0.2% of the EU market in the IAS-UAS Operations segment by 2030. This growth is leveraged through the provision of differential advanced services, thanks to the AI@EDGE project
Market standing	Current values for AEROTOOLS business are as follows: - Revenue: around 700 k€ - Gross margin: 46% - Net Profit: around 60 k€ The knowledge generated by the AI@EDGE Project will enable access to new projects and the development of differentiated services from the competition, allowing the achievement of estimated values in 2030: - Revenue: around 7,5 M€ - Gross margin: 52% - Net Profit: around 800 M€
Roadmap	The steps to integrate AI@EDGE into AEROTOOLS services have been designed as follows: - Optimization of processes, protocols, and software, integrating them into an identifiable and sellable package. Tested in real environments. - Simultaneously, the industrialization of hardware and protocols will take place. - Progressive incorporation into the ATOM tool as a service suite will begin, presenting it to clients and developing marketing materials. - The specific offering to clients of ATOM + AI@EDGE services will be defined, along with its market entry. Timeline: - 2024: Optimization - 2024-25: Industrialization - 2025: Final tests and integration into portfolio - 2026: Service offering in the market
Targeted fields	AEROTOOLS' tasks in the AI@EDGE project have been primarily focused on the integration of systems and technologies to configure an operational environment. This environment allows for testing and

	validating various ongoing developments, all geared towards industrial applications. Simultaneously, efforts have been made to keep this environment open to adapt to new advances or technologies, enabling the necessary optimization process to launch associated services in different industrial sectors. It is understood that the alignment is complete with sectors such as: - Road infrastructure and the monitoring of its activity. - Surveying industrial assets
AI@EDGE Technologies	AEROTOOLS' participation focuses on WP5 dedicated to validating the AI@EDGE developments in the Use Cases. To achieve this validation, it was necessary to configure a testbed that integrates the technologies under development in the project with other necessary technologies and tools for the operation of the use case. This includes drones and their operation in 5G networks, AI applied to computer vision (CV), and the deployment and operation of functions at the Edge.
State of the art	The existence of services like those being configured because of the AI@EDGE project is limited by aspects of technology that the project aims to evolve, overcoming these limitations. Currently, the model for industrial services based on drone technology revolves around: - Visual Line of Sight (VLOS) operations - Limited use of communications (radio and 3G-4G) - Limited interaction with Cloud applications, without access to Edge Limited process automation due to the limited use of AI
Competitor organizations	In the identified sectors, the main competitors are companies either in the drone services sector or technology firms. - They operate in Provision of inspection services with drones / Development of software tools for the inspection and maintenance of industrial assets. - The key factor are Drones, which is like AEROTOOLS, with little differentiation. - Need for gaining capability of integrating different technologies to offer a complete service with built-in advanced functionalities. - Participation in AI@EDGE increases the know-how and technical capabilities of AEROTOOLS to offer differential services
Publications (Journal/Conference Papers), or published IP	Related to drones: - ETSI MEC for Drones Panel: Unlocking 5G Edge Value for the Drone Industry. Series of Multi-access Edge Computing live panels. ETSI MEC meets vertical markets: APIs exposure helping the Drones Business. - European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace.
Application environment	On drones' side: Propulsion systems limitations (Batteries, hydrogen generation and storage…) On 5G Networks side: Capability to support C2 communication and real time applications

Opportunities or threats	Opportunities: UAM and collaborative scenarios for drone swarms. Threats: 5G network deployment rate and Drones regulation to operate in urban areas (UAM)
Exploitation plan	AEROTOOLS' plan for exploiting the project's results aligns with the outlined roadmap: - An initial phase involves optimizing systems, reviewing procedures, defining working flows, and designing services. - The second stage focuses on testing and presenting the outcomes to potential customers, many of whom are already engaged or existing clients. - In the third stage, there will be a final definition of the product/service, determining pricing strategies, and developing marketing plans. - The goal is a final push towards the industrial market with a global approach, utilizing a mix of direct sales and indirect sales through strategic partners.

6.3.4 Research centers and universities

FBK

"AI@EDGE story"	The "AI@EDGE story" in FBK has been characterized by the development of techniques and tools for AI-intensive application management exploiting Serverless and Cloud-native technologies. This experience enabled FBK also to build upon the proposed declarative approach and solutions in other Cloud-related and automation-related platforms in different national and EU projects.
Business opportunities	No direct business opportunities. As research organization we plan to reuse the gained knowledge and further extend it through new research projects. Given FBK's mission of facilitating the adoption by industry and society (see Position in the market), we also plan to reuse the AI@EDGE results in digital transitions projects (e.g., within the scope of the Digital Europe Programme and of the IPCEI on Cloud and Edge Computing) as well as in technology transfer projects with companies.
Total Addressable Market (TAM)	Given that the global 5G Technology market was valued at 5.13 billion EUR in 2020 and is expected to reach a CAGR of 65.8% in the period 2021-2030, the potentiality for AI@EDGE is huge. Additionally, and zooming in, the size of the European 5G services market is expected to reach 31.26 billion EUR by 2025 (annual compound rate of 96.8% by 2024). These figures show how the market is increasingly expanding, with new applications becoming available.
Position in the market	FBK is a non-profit research organization with the mission to deliver innovative research results and facilitate their adoption by industry and society.
AI@EDGE Technologies	Within the scope of WP4 FBK has been working on adoption of the declarative approach to the AI-intensive application management. The approach aims at covering the aspects related to the ML Ops activities (e.g.,

	monitoring, training, distribution) following zero-touch automation paradigm. To support the realization of this approach FBK has been also working on engagement of the Serverless technologies, specifically focusing on AI-related tools and solutions. Besides, FBK has been working on a set of advanced AI-based techniques for the platform automation (in WP3) and autonomous vehicle coordination in a distributed manner (in UC1).
Publications (Journal/Conference Papers), or published IP	- Coronado E., Behravesh R., Subramanya T., Fernández-Ferńandez A., Siddiqui S., Costa-Pérez X., Riggio R. "Zero Touch Management: A Survey of Network Automation Solutions for 5G and 6G Networks." - Behravesh R., Rao A., Perez-Ramirez D.F., Harutyunyan D., Riggio R., Boman M. "Machine Learning at the Mobile Edge: The Case of Dynamic Adaptive Streaming Over HTTP (DASH)." - Previati G., Campi E., Uccello L., Gobbi M., Albanese A., Roccasalva A., Santin G., Luca M., Lepri B., Ferrarotti L., di Pietro N., Mastinu G. "Future roundabouts relying on 5G, edge computing and artificial intelligence." - Mastinu G., Previati G., Campi E., Gobbi M., Uccello L., Varela Daniel A., Albanese A., Roccasalva A., Santin G., Luca M., Lepri B., di Pietro N. "Roundabout Traffic: Simulation With Automated Vehicles, Ai, 5g, Edge Computing and Human in the Loop."

RISE

"AI@EDGE story"	RISE, Research Institutes of Sweden, as a government-owned research institute has the overall purpose to promote innovation and competitiveness of industry and society. In general, we exploit the results from research projects by knowledge transfer in close collaboration with partners, by publishing open-source software, by spin-offs and by scientific publications. In AI@EDGE, RISE has published scientific papers, published a dataset with mobile access network performance data for training data-driven network automation algorithms, and plan to publish software components as open source.
Position in the market	RISE is a government-owned research institute with the overall purpose to innovate in close collaboration with industry and society.
AI@EDGE Technologies	- Data-collecting pipeline software (WP3) - Bitrate prediction algorithm for prefetching next video chunk (WP3) - Tools for generating simulated performance data sets for mobile access networks (WP3) - ML-based algorithms for solving scheduling problems (WP3)
Exploitation plan	RISE, Research Institutes of Sweden, as a government-owned research institute has the overall purpose to promote innovation and competitiveness of industry and society. In general, we exploit the results from research projects by knowledge transfer in close collaboration with partners, by publishing open-source software, by spin-offs and by scientific publications. In AI@EDGE, RISE has published scientific papers, published a dataset with mobile access network performance data for

	training data-driven network automation algorithms, and plan to publish software components as open source. The results of the project will be used in our continued research, including in future collaborative projects with industry and society.

POLIMI

"AI@EDGE story"	We have other projects developing automated transportation and artificial intelligence. The AI@EDGE project has shown the potential of AI at the edge for safe traffic management and pollution reduction. Thanks to the project, we have been able to improve our knowledge and develop new tools for traffic simulation with human in the loop. We have also been able to spread the new technology and allow for new studies in traffic management and automated vehicles.
Business opportunities	The AI@EDGE technology has proven to be able to effectively manage traffic and automated vehicles. We already contacted stakeholders of urban transportation to further develop the technology and for the application in real urban scenarios.
Potential products and services	As a state university, we do not make products.
Credible path	Thanks to UC1 we have shown the potential of technology in traffic management. We think that we can involve institutions and stakeholders for applying this technology to real urban situations.
Technology for near term applications	In the UC1 of AI@EDGE we have developed a new simulation tool that can be applied soon to study human interactions with automated vehicles and other relevant traffic situations. Pilot applications to real urban scenarios are also foreseen.
Targeted fields	AI, edge computing, and traffic simulation and testing are taught in several courses and are exploited for research and industry collaboration activities.
Exploitation plan	The exploitation plan is simply that the results and knowledge from AI@EDGE should continue to improve our other projects and the course we teach.

I2CAT

"AI@EDGE story"	The AI@EDGE story in i2CAT has been characterised by the development of the technologies described in the project documents. The development of the non-RT RIC has fuelled the participation of i2CAT in new SNS projects, such as NANCY and BeGREEN, and it is being presented as i2CAT's asset to new consortiums for the next SNS calls. The incorporation of the MTO and MEC Orchestrator into other projects has allowed them to be presented as i2CAT's assets, such as Zero-Swarm and 6GSMART. In the framework of 6GSMART, a use case will utilize the application placement ML model.

Business opportunities	The development of the non-RT RIC has allowed us to start conversations with the industrial sector, starting with the members of our board of trustees that include MNOs like Orange, Vodafone, Telefonica, and Parlem and vendors like Juniper, Cisco, and Fujitsu. These conversations are leading to the creation of two projects related to O-RAN with two different members. Finally, Neutroon (www.neutroon.com) is an I2CAT spin off developing a cloud-based management system for private 5G network. Neutroon is thus a clear recipient of some of the innovations developed in AI@EDGE.
AI@EDGE Technologies	Within the framework of WP4, we have designed and implemented a non-RT RIC which can host rApps implementing RAN optimizations through automated control-loops. We have implemented a rApp managing the resources of multi-RAT slices according to defined SLAs. In addition to WP4, Multi-Tier Orchestrator and a MEC Orchestrator have been designed as platform components to enhance the capabilities of existing open-source modules as central components at multi-MEC system and MEC system level respectively. Regarding WP3, we developed an ML model using Distributed Deep Reinforcement Learning to place applications in multi-MEC system networks, reducing the number of active nodes.
Standards	O-RAN alliance oversees the specification of non-RT RIC its interfaces. It may impact our implementation in case new interfaces or components are specified.
Publications (Journal/Conference Papers), or published IP	- R. Riggio et al., "AI@EDGE: A Secure and Reusable Artificial Intelligence Platform for Edge Computing," 2021 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit), Porto, Portugal, 2021, pp. 610-615, Doi: 10.1109/EuCNC/6GSummit51104.2021.9482440. - E. Coronado, B. Gómez, J. Villalón, A. Garrido, S. Siddiqui and R. Riggio, "Delay-Sensitive Wireless Content Delivery: An Interpretable Artificial Intelligence Approach," 2021 17th International Conference on Network and Service Management (CNSM), Izmir, Turkey, 2021, pp. 8-13, Doi: 10.23919/CNSM52442.2021.9615533. - E. Coronado, S. Siddiqui and R. Riggio, "Roadrunner: O-RAN-based Cell Selection in Beyond 5G Networks," NOMS 2022-2022 IEEE/IFIP Network Operations and Management Symposium, Budapest, Hungary, 2022, pp. 1-7, Doi: 10.1109/NOMS54207.2022.9789832. - J. Palomares, E. Coronado, D. Rincón, S. Siddiqui, "Design and Evaluation of a K8s-based System for Distributed Open-Source Cellular Networks", in International Wireless Communications and Mobile Computing (IWCMC), in Marrakesh, Morocco, 2023, pp. 7-12, Doi: 10.1109/IWCMC58020.2023.10183111. - J. Palomares, E. Coronado, C. Cervelló-Pastor and S. Siddiqui, "Enabling Intelligence Inclusiveness in Edge to Cloud Continuum: Challenges and Opportunities," 2023 IEEE 9th International Conference on Network Softwarization (NetSoft), Madrid, Spain, 2023, pp. 362-365, Doi: 10.1109/NetSoft57336.2023.10175414. - J. S. Camargo, E. Coronado, C. Torres-Pérez, J. Palomares, S. Siddiqui, "DQN-based Intelligent Application Placement with Delay-Priority in Multi MEC Systems", in Joint European Conference on

	Networks and Communications & 6G Summit (EuCNC/6G Summit), in Gothenburg, Sweden, 2023, pp.460-465, Doi: 10.1109/EuCNC/6GSummit58263.2023.10188300 - C. Torres-Pérez, E. Coronado, C. Cervelló-Pastor, J. S. Camargo, S. Siddiqui, "Distributed Learning for Application Placement at the Edge Minimizing Active Nodes", in 2nd International Conference on 6G Networking (6GNet), Paris, France, 2023, Doi: 10.1109/6GNet58894.2023.10317692 - Torres-Pérez C., Coronado E., Cervelló-Pastor C, Siddiqui M. S., "Service Management in Dynamic Edge Environments", in Euro-Par PhD Symposium, in Limassol, Cyprus, 2023 - F. Brito et. al, "A Network Architecture for Scalable End-to-End Management of Reusable AI-based Applications", in International Conference on Network of the Future NoF, in Izmir, Turkey, 2023
Exploitation plan	I2CAT is a non-profit technology and innovation centre located in Barcelona, Spain, which promotes RDI activities in Internet Technologies within the ICT industry. The centre stands up for a new model in a new conception of innovation: the collaboration between companies, public administration, the academic environment, and end-users. Thus, it eases an open innovation framework, characteristic of the Internet culture. The vision of I2CAT is to achieve Internet excellence in research and innovation activities applied to the market needs and become an international strategic partner driving the deployment of the Internet across the economic, industrial, and social sectors. Its board is based on an open innovation collaboration model ranging in all sectors mentioned before. Some board members are Cisco, Orange, Fujitsu, Juniper, Interoute and Vodafone, plus four Catalan government departments and the three main technical universities of Catalonia, led by Universitat Politècnica de Catalunya (UPC). I2CAT's activities are concentrated around, but not limited to, novel network services and technologies (fixed and mobile), open-access networks, sensor networks, e-health, networked media systems and industrial Internet, with special focus on NFV and SDW/N technologies, new clean slate architectures, Future Internet experimentation, sensor networks, IoT, M2M, with heavy EC footprint in over 68 projects. i2CAT aims at generating Research and Innovation activities according to the market needs by developing new value-added products and encouraging the creation of new technology-based start-ups which generate social and economic impact. i2CAT eases collaboration between companies, public administration, universities, and users to deploy new advanced experimental infrastructures and fosters co-creation in a quadruple helix model (university, company, public administration, and users). From these activities, business opportunities are intended to arise for both the academic and consulting/commercial oriented lines of work. The research and academics from universities, research institutes and R&D industry departments form part of the addressable market for i2CAT. i2CAT explores these possibilities by delivering specific solutions to customers and by initiating new collaborations or projects with partners from the addressable market.

DFKI

DFKI and **Ericsson** have worked on the revised exploitation plan and their final exploitation plan. DFKI as a research institute is focusing mainly on the dissemination of the results through presentations in conferences and publications in journals. Ericsson has contributed a lot to the architecture of the Connect-Compute Platform (presented in D2.3) and as soon as some results are produced in the third year of the project's execution, they will revise their exploitation plan. The focus from Ericsson is also on the contribution to standards and it is expected that the company will contribute to the year 2023.

INRIA

"AI@EDGE story"	AI@EDGE has allowed INRIA to acquire additional competencies in AI focusing on Hyper-Parameter Optimization (HPO). This is a core topic for research in AI as configuration of AI is considered as a main enabler to really benefit from the use of AI.
Business opportunities	No direct business opportunities but as academic partner we want to reuse the gained knowledge and further extend it through new project proposal submission.
Credible path	AI tools are highly present in the market of cybersecurity (main INRIA team expertise). One major issue that is raised is the difficulty to configure properly AI tools. The work INRIA did offers a way to alleviate the user from this tedious task.
Roadmap	Include the configuration/optimization problem of AI algorithm into the research team roadmap for mid-term research.
AI@EDGE Technologies	- Auto-configuration of Hyper-parameters (WP4) - Dataset augmentation (WP3)
State of the art	State-of-the-art is rich in the AI field, but HPO applied to networking is relatively new (for example no method to derive a configuration from network traffic feature)
Competitor organizations	AutoML.org: Freiburg-Hannover-Tübingen
Opportunities or threats	Competitive research (scientific results and papers) but this will create more opportunities to collaborate than threats as Inria has already a recognized expertise in the applied AI to network field.
Exploitation plan	The expertise INRIA gained in this project will be reused for other collaborative projects with academia and industry as this brings a new original asset since many other partners have known also developed competencies in a more general AI field. Mastering some aspects is thus a competitive advantage. In addition, this is a first step towards enhancing our expertise in AutoML which includes topics such as network architecture search.

ULUND

"AI@EDGE story"	We have other projects developing autonomous transportation and data-drive self-care for elderly. Thanks to AI@EDGE, we have realised the tremendous potential of edge computing and AI and have been able to improve all our other projects. We have also been able to spread this message to others, in particular actors in rural Sweden. It has helped considerably in creating a positive outlook on the future and been very well received.
Business opportunities	We believe that the best identified business opportunity is to use AI and edge computing to dynamically reconfigure cellular networks to improve rural coverage, capacity, and sustainability.
Potential products and services	As a state university, we do not make products.
Credible path	We believe that once we can show that it is more cost effective to increase the capacity of the cellular networks through AI-driven management than building new base stations, edge computing will be universally deployed.
Technology for near term applications	For the near-term, the value creation is dominated by how other projects have been improved by the knowledge created in AI@EDGE.
Position in the market	We are a state university.
Roadmap	No products.
Targeted fields	AI and edge computing are increasingly important parts of our projects and the courses we teach.
AI@EDGE Technologies	We assist Ericsson in developing AI-management of cellular networks.
State of the art	Ericsson is the state-of-the-art.
Competitor organizations	Other vendors like Nokia and Huawei.
Standards	This is handled by Ericsson, so we do not have detailed knowledge.
Application environment	We must ensure that edge computing is deployed.
Exploitation plan	The exploitation plan is simply that the results and knowledge from AI@EDGE should continue to improve out other projects and the course we teach.

CNAM

"AI@EDGE story"	Based on contributions and learnings from this project, CAM established a European master program called Artificial Intelligence for Connected Industries (AI4CI) in collaboration Universitat Politècnica de Catalunya (UPC) and I2CAT. Besides, we published an open dataset for beyond 5G network automation experiments. Such a dataset can be exploited by other contributors to test their proposed data driven models (https://ai4ci.roc.cnam.fr).
AI@EDGE Technologies	- WP2: data pipeline system - WP3: FL-based AD + AIF placement
State of the art	Based on the SYRROCA (SYstem Radiography and ROot Cause Analysis) framework, a centralized anomaly detection framework from the state of the art, we propose a distributed anomaly detection framework based on federated learning to (i) scale with the increasing size of data, (ii) ensure low latency training and inference to ensure real-time anomaly detection and (iii) guarantee data privacy and locality. The placement of the federated learning AIF agents (FL clients and server) for containerized-based solution is done by an orchestrator (e.g., kubernetes) where the placement plan may not respect the imposed target learning time. Our proposal allows a more efficient placement of AIFs while taking into consideration the expected end-to-end learning time. The original federated learning-based anomaly detection framework emulates the data arrival to the AIF clients using data lake, i.e., a single repository to save the collected metrics, where each AIF uses a subset of the resulting dataset. We propose to integrate the data pipeline system to collect, pre-process and send data to the client AIFs in real-time.
Publications (Journal/Conference Papers), or published IP	- Salah Bin Ruba, Nour-El-Houda Yellas, Stefano Secci. "Anomaly Detection for 5G Softwarized Infrastructures with Federated Learning." 2022 1st International Conference on 6G Networking (6GNet), Jul 2022, Paris, France. ⟨10.1109/6GNet54646.2022.9830390⟩. ⟨hal-03712114⟩ - Nour-El-Houda Yellas, Bernardetta Addis, Roberto Riggio, Stefano Secci. "Function Placement and Acceleration for In-Network Federated Learning Services." 2022 18th International Conference on Network and Service Management (CNSM), Oct 2022, Thessaloniki, Greece. pp.212-218, ⟨10.23919/CNSM55787.2022.9964625⟩. ⟨hal-03883727⟩ - Dung Chi Phung, Nour-El-Houda Yellas, Salah Bin Ruba, Stefano Secci. "An Open Dataset for Beyond-5G Data-driven Network Automation Experiments." 2022 1st International Conference on 6G Networking (6GNet), Jul 2022, Paris, France. ⟨10.1109/6GNet54646.2022.9830292⟩. ⟨hal-03698732v2⟩

ICCS

Business opportunities	Spin-off / startup to optimize the acceleration of AIFs (or other SW functions) on various heterogeneous HW platforms, upon customer request; create in-house library, sell acceleration services. Develop resource management SW targeting heterogeneous datacenter providers/owners.

Potential products and services	Customized AIF acceleration services targeting unique end-users, intelligent resource management services for datacenter providers/owners
Credible path	- Enhance library of AIFs and demo scenarios and/or improve reliability of resource management SW - Develop 2-3 customer-oriented demos - Create spin-off /startup - Pitch to industry/funds
Technology for near term applications	Our framework that automates the implementation of high-level SW-accelerated AIFs to a given HW platform (any to any).
AI@EDGE Technologies	Heterogeneous HW acceleration for AIFs at the edge (WP4), intelligent acceleration resources management (WP4)
Exploitation plan	The main results to be exploited will be the hardware accelerators of critical AI/ML algorithms as well as the resource management of multiple accelerators in an edge server. In addition, ICCS will focus on the automated framework that transforms a high-level AIF SW code from tensorflow to implementation files per unique accelerator. As an academic partner, the exploitation activities of ICCS focus on three main directions. - Academic exploitation: ICCS members plan to offer internal and external seminars presenting contents related to its activity and results within the projects. - Research contracts and technology transfer: ICCS considers the possible exploitable results at the end of the project a strategic resource. - Research projects: the implemented accelerators and intelligent resources management SW will be exploited for upcoming research activities giving ICCS a knowledge lead in this area.

UPC

"AI@EDGE story"	AI@EDGE has proposed and developed an AI/ML architecture, methodology, and a set of algorithms that enable automated edge management through AIF. These proposals have been evaluated in proofs of concept and use cases. For the UPC, AI@EDGE has meant increasing and consolidating our knowledge in this high-impact area. This know-how has been essential to win a national project to create an open experimental laboratory beyond 5G/6G, Open6GLab, with an investment of 2 million euros. Open6GLab is an experimental platform deployed in the laboratories and adjacent streets of the Castelldefels Campus and Campus Nord of Barcelona, with over 10,000 m2 of coverage. The infrastructure is composed of a cellular access network, wireless networks, sensor networks, and a high-capacity optical network, which links the different components and MECs distributed along the campus streets. The technology developed in AI@EDGE has been a fundamental element in creating a large test bed that will be open to the scientific community and companies to design, test, and evaluate protocols, services, devices, and verticals within the 6G framework. Likewise, the platform allows us to

	deploy the technology developed in the project in the field, put it at the service of the community, and value research.
Business opportunities	To offer an extensive test bed to companies that will allow the development of new services based on AIFs that evolve towards the configuration and management of the network, services, and devices with minimal human intervention (zero Touch). At the regional and perhaps national level, it is the first environment based on open standards, heterogeneous, large, available to the research laboratories of companies, universities, and administrations. Open6G is developing continuum cloud services (cloud-edge) based on centralized and distributed architectures managed by AIF applications.
Potential products and services	Automated management of services, based on the specific development of the AIF. Furthermore, the extension of the AIFs will allow us to automate part of the management and dynamic self-configuration functions of the 6G access network.
Credible path	They are carrying out the following steps: Develop and customize AIFs for concept tests and verticals. Deploy the beyond 5G access network in the field (UPC Castelldefels Campus) based on MECs Establish a centralized and distributed open architecture (federated learning) based on AIF by applying Deep Reinforcement Learning Deploy use cases for different verticals. Currently, we have developed an environment that operates with assisted-driving vehicles.
Technology for near term applications	They have deployed the AIFs in the MECs that allow us for assisted driving of a vehicle between an origin and a destination. Through a slice, it maintains the quality of service that the service demands by managing the computing, storage, and communication resources over the set of MECs in a distributed manner (dynamic offloading). .
Total Addressable Market (TAM)	Offer research services to companies and administration. Network operators, service operators, and SMEs.
AI@EDGE Technologies	Within the framework of WP3, the design, development, and validation of the AIFs have been of great value to be able to develop the proofs of concept of the algorithms and services. These outings have allowed us to develop a prototype of an assisted driving vehicle and test it in the Open6G Lab.
Publications (Journal/Conference Papers), or published IP	- C. Ruiz de Mendoza, C. Cervelló-Pastor. "Zero-Touch MEC Resources for Connected Autonomous Vehicles Managed by Federated Learning," in *IEEE 9th International Conference on Network Softwarization (NetSoft)*, Madrid, Spain, June 19-23, 2023, pp. 1-4. - A. Llorens-Carrodeguas, C. Cervelló-Pastor, F. Valera, "DQN-based intelligent controller for multiple edge domains," *Journal of Network and Computer Applications*, vol. 218, pp. 1-14, Sep. 2023. **Code**. - I. Leyva-Pupo, C. Cervelló-Pastor, "An intelligent scheduling for 5G user plane function placement and chaining reconfiguration," *Computer Networks*, vol. 237, pp. 1-15, Sep. 2023. - C. Ruiz de Mendoza, C. Cervelló-Pastor, S. Sallent, "Optimal Resource Placement in 5G/6G MEC for Connected Autonomous Vehicles Routes

	Powered by Deep Reinforcement Learning," in *IEEE LCN*, Daytona Beach, Florida, USA, Oct. 2-5, 2023, pp. 1-4. **Code**.

UNIVPM

"AI@EDGE story"	UNIVPM has made it a core objective to actively pursue innovation in various domains, with a strong focus on the cutting-edge fields of edge computing and artificial intelligence (AI). Under the umbrella of AI@EDGE, we are poised to make significant strides in our vision for harnessing AI in the realm of network resource management. This initiative not only signifies our commitment to pushing the boundaries of AI research and development but also highlights our dedication to strengthening our existing partnerships with industrial collaborators and creating novel avenues for business expansion. The AI@EDGE project is set to serve as a key driving force in our future endeavours, particularly as we look towards engaging with the Horizon Europe Framework Programme and the Next Generation Internet (NGI) initiative. We believe that these frameworks provide an ideal platform for us to showcase the results and innovations stemming from AI@EDGE. In doing so, we aim to position UNIVPM as a prominent player in the ongoing transformation of the technological landscape, capitalizing on the immense potential that lies within these collaborative initiatives. In essence, UNIVPM views the AI@EDGE project as a transformative force with far-reaching implications. It underpins our dedication to innovation and collaboration, setting the stage for a future where technological advancements are not just an aspiration but a reality with tangible economic and societal benefits.
Business opportunities	Moreover, UNIVPM envisions the AI@EDGE project as a catalyst for various downstream activities. We anticipate that the outcomes and insights gained from this project will lay the foundation for the creation of potential commercial spin-offs, which in turn will contribute to economic growth and job creation. Furthermore, we are enthusiastic about the prospect of establishing new academic collaborations and research partnerships, thus reinforcing our position as a hub for cutting-edge innovation. These collaborations will not only benefit our institution but will also serve to advance knowledge dissemination and facilitate the exchange of ideas, thus contributing to the greater good of society.
Publications (Journal/Conference Papers), or published IP	- Estefania Coronado, Rasoul Behravesh, Tejas Subramanya, Adriana Fernandez-Fernandez, Shuaib Siddiqui, Xavier Costa-Perez, and Roberto Riggio, "Zero Touch Management: A Survey of Network Automation Solutions for 5G and 6G Networks," in IEEE Communications Surveys & Tutorials, vol. 24, no. 4, pp. 2535-2578, Fourthquarter 2022, Doi: 10.1109/COMST.2022.3212586.

6.3.5 Exploitation Plans Summary

The AI@EDGE project enc an exploitation process influenced by technological progress and market changes, including global health events, energy sector fluctuations, and supply chain interruptions. The

revised exploitation plans are adapted to maintain alignment with the current market environment and prospects.

Here's an overview of possible paths to exploitation for each partner in the AI@EDGE project:

1. **Academic and Research Partners**: Focus on sharing AI@EDGE project results, ensuring effective dissemination in the scientific community and industry, highlighting the value of collaborative innovation.
2. **Use Case Leaders** (CRF, DFKI, EAB, SPI):
    - **Stellantis-CRF**: Concentrates on advanced connectivity for virtual validation of Connected Vehicles communication modules. The exploitation plan involves transferring AI@EDGE outcomes to Stellantis departments for connected vehicles development.
    - **DFKI**: Plans to transfer AI@EDGE outcomes to other application areas like industrial networks and Cyber Physical Production Systems. Dissemination of results through scientific articles and integration in teaching and training courses.
    - **EAB (Ericsson Research)**: Focuses on AI-based operations and "AI by design" network architectures, aiming to strengthen Ericsson's position in the global market with new service offerings and contributions to relevant standardization organizations.
    - **SPI**: A leader in In-flight Entertainment & Connectivity solutions, aiming to trial 5G technology and network slicing capabilities for in-flight services.
3. **Market Research and Impact of the Pandemic on AI/ML**: The exploitation plans were revisited considering market changes due to the pandemic and energy crisis, affecting growth rates and market potential across all use cases.
4. **Telecom Operators and Vendors (e.g., TIM)**: Focus on leveraging customer proximity and integration of Telco and Service components to develop Edge computing use cases. This includes a variety of products for public administration and enterprises, integrating AI@EDGE capabilities like machine learning for urban mobility prediction.
5. **Other Large Industries**:
    - **Stellantis-CRF**: Developing a new in-LAB validation platform for 5G connected vehicles, which is essential in the development process of these vehicles.
    - **SPI (Safran Passenger Innovations)**: Working on an Edge/Cloud environment for In-Flight Entertainment and Connectivity (IFEC) systems, focusing on the potentials of 5G technology in aircraft cabins.
    - **ATOS (EVIDEN)**: Focusing on integrating AI@EDGE components into its GenAI portfolio, offering consulting services and solutions to support businesses across sectors.
    - **HPE**: Leveraging AI@EDGE's connect-compute platform for edge-computing-oriented software and hardware 5G solutions, enhancing HPE's portfolio in edge computing.
    - **8BELLS**: Concentrating on consultancy for techno-economic assessments of 5G and edge computing deployments, integrating AI technologies for automated network management and orchestration.

- **AEROTOOLS**: Aiming to be a supplier for the industrial sector by offering advanced surveying services for infrastructures and industrial assets, leveraging 5G network communication and Edge-based AI functions.

6. **Overall Exploitation Goals**: The project focuses on driving technology enablers for intelligent edge platforms, with a vision towards future networks like 6G. It seeks to support a wide range of deployed services, emphasizing network intelligence, autonomy in operations, and continuous optimization.

These paths to exploitation demonstrate the diverse applications and impact of the AI@EDGE project across various sectors, emphasizing the integration of AI and edge computing technologies in different market segments.

7. Future

7.1 Future on dissemination

The project AI@EDGE has developed a plan of activities for continuing the dissemination and exploitation of the project results also after the end of AI@EDGE. Participation in scientific events and preparation of scientific publications have been planned.

Table 4 AI@EDGE Future dissemination activities

Event	Additional information
Transport Research Arena (TRA) 2024	**When**: 15-18 April 2024 **Where**: Dublin, Ireland **Details**: Paper **accepted** "Future roundabouts relying on 5G, edge computing and artificial intelligence". Previati G., Campi E., Uccello L., Gobbi M., Albanese A., Roccasalva A., Santin G., Luca M., Lepri B., Ferrarotti L., di Pietro N., Mastinu G.
21st USENIX Symposium on Networked Systems Design and Implementation 2024	**When**: 16-18 April 2024 **Where**: Santa Clara, CA, United States **Details**: Conference paper (submitted): "Anomaly Detection with P4-NetFPGA Boards". Patetta M., Taktak S., Secci S.
SAE International 2024	**When**: 16-18 April 2024 **Where**: Detroit, Michigan, United States **Details**: Conference paper (submitted): "Cooperative Connected and Automated Mobility in a Roundabout". Previati G., Uccello L., Mastinu G., Gobbi M., Albanese A., Roccasalva A., Santin G., Luca M., Lepri B., Ferrarotti L., di Pietro N.
IEEE International Conference on Machine Learning for Communication and Networking 2024	**When**: 5-8 May 2024 **Where**: Stockholm, Sweden **Details**: Conference paper (submitted): "Model Manager: A MLOps Component for Performance and Resources Optimization". Brito F., Castaneda Cisneros J., Ghebretensaé Z., Linder N., Ödling P.
IEEE/IFIP Network Operations and Management Symposium 2024	**When**: 06-10 May 2024 **Where**: Seoul, South Korea **Details**: Conference papers (submitted): - "Data Pipeline Systems for In-network Learning". Ntumba P., Del-Pozo M., Yellas N., Abdesslem F., Secci S.

	- "FLADxG: Federated Learning based Anomaly Detection Framework for xG Systems". Bin-Ruba S., Modina N., Braconnot Velloso P., Secci S. - "Generalizable One-Way Delay Prediction Models for Heterogeneous UEs in 5G Networks". Rao A., Riaz H., Zavodovski A., Mochaourab R., Berggren V., Johnsson A.
AIRSPACE INTEGRATION WEEK MADRID & EXPODRONICA AIR SHOW	**When**: 23-26 September 2024 **Where**: Madrid, Spain **Details**: AERO intending to exhibit with a booth dedicated to AI@EDGE and other R&D projects. And make presentations of AI@EDGE project and its contribution for the development of U-SPACE and UAM operations.
IEEE Transactions on Network and Service Management (journal)	**Details**: Paper (submitted): "In-network Federated Learning Control". Yellas N., Addis B., Boumerdassi S., Riggio R., Secci S.
Venue to be defined	**Details**: Conference paper (submitted): "Enabling Federation at the Edge: A Cloud-Native MEC Orchestrator for Federated MEC Systems". Palomares J., Coronado E., Cervelló-Pastor C., Siddiqui S.
Venue to be defined	**Details**: Conference paper (submitted): "Multi-Tier Edge Computing Orchestration for Data-driven AI-enabled Applications Lifecycle". Palomares J., Coronado E., Leftheriotis A., Lentaris G., Kazhamiakin R., Siddiqui S.
Venue to be defined	**Details**: Conference paper (to be submitted): "Simulated Datasets and Data Generation Framework for Generalizable Machine Learning in Mobile Networks". Rao A., Singhal C., Kostic D., Boman M.

7.2 Future on standardisation

From a standardization perspective, publishing the NMRG draft as an RFC will be targeted for mid-2024. Besides, the objective of T6.2 was to impact on the upcoming standards with the research outcomes of the projects on a longer-term perspective. We thus expect that parts of our research results which we have disseminated in the different standardization groups we interact with will create some impact either on architectural or protocol level discussions or on the applicability of 5G and further extensions to certain use cases. As some partners will continue to be involved in standardization, organisation (especially TIM, EAB, INRIA, ATH), they will be contact points for AI@EDGE to facilitate that when some groups will be interesting in the future to consider some AI@EDGE results.

7.3 Future on 6GIA

The continuous interaction of AI@EDGE with the 6GIA and the Working Groups in that context will continue through the direct involvement of the partners in those groups, thanks to the presence of other projects that have started or will start soon on topics related to the AI at the EDGE. In such a way, roles and contributions could benefit of the expected continuity.

7.4 Future for AI@EDGE: Impact through Transfer and Exploitation of Results

The AI@EDGE project, an innovative venture in AI and edge computing, is poised to continue its influence beyond the life of the project. This subchapter outlines the strategic roadmap for the ongoing

transfer and exploitation of the project's results, ensuring that the groundbreaking work within AI@EDGE resonates well into the future.

The plan is to make sure that the work done in the AI@EDGE project does not stop when the project ends. The project is designed not as a finite endeavour but as a launchpad for sustained technological influence and market presence.

Transfer Mechanisms

- **Open-Source Platforms**: In addition to contributing to open-source communities, AI@EDGE will ensure that specific technologies such as the ones developed by academic partners like DFKI for industrial networks and cyber-physical systems are openly accessible for community enhancement and innovation.
- **Knowledge Repositories**: Documentation efforts will include detailed methodologies from use cases like Stellantis-CRF's advanced connectivity and virtual validation of Connected Vehicles, offering a rich learning resource for similar industrial applications.

Exploitation Pathways

- **Commercialization**: Commercial pathways will include market-specific strategies, such as SPI's leveraging of 5G technology in the in-flight entertainment sector, ensuring that AI@EDGE's innovations are effectively transitioned into viable market products.
- **Academic Partnerships**: Ongoing collaborations will focus on translating AI@EDGE advancements into educational content, as seen in DFKI's integration of project outcomes into University of Kaiserslautern's courses and PhD programs and the recently started European AI4CI Master Artificial Intelligence for Connected Industries from CNAM, in which AI@EDGE approaches and results are being integrated.
- **Industry Collaboration**: Long-term partnerships will be strengthened with entities like EAB Ericsson Research, focusing on AI-based network operations and "AI by design" network architectures, ensuring the project's adaptability to evolving technological and market needs.

Ensuring Continuity

- **Sustained Engagement**: Post-project engagement will include regular updates and feedback sessions with stakeholders from different sectors, including the automotive and telecommunication industries, as represented by partners like Stellantis-CRF and TIM**.**
- **Iterative Development**: Emphasis will be on refining outputs such as the AI@EDGE capabilities integrated into TIM's Edge Nodes, ensuring they remain effective and relevant to evolving market needs.

Nurturing Innovation Ecosystems

- **Startup Incubation**: Support will extend to startups in sectors like in-flight entertainment (inspired by SPI's contributions) and advanced connectivity (drawing from Stellantis-CRF's innovations), fostering entrepreneurship based on AI@EDGE technologies.
- **Policy Advocacy**: Policy engagement will draw on experiences like those of EAB in contributing to standardization organizations (3GPP, ONAP, O-RAN), advocating for regulatory frameworks that support AI and edge computing technologies in various sectors.

Addressed Communities

- **Academic Community**: Enhanced through partnerships with institutions like DFKI and University of Kaiserslautern, ensuring that AI@EDGE's findings contribute to academic advancement and research.
- **Industrial Sectors**: Automotive (through Stellantis-CRF), Telecommunications (via EAB and TIM), and In-flight Entertainment (by SPI), showing the project's diverse market impact.
- **Startups and SMEs**: Encouraging the adoption of AI@EDGE technologies in emerging sectors, fostering innovation and new business opportunities.

Commitment to Continuous Evolution

The AI@EDGE future exploitation plan is not just an extension of the project but a roadmap for continuous growth and innovation, leveraging collaborations, market insights, and technological advancements to ensure long-lasting impact across diverse communities and sectors. This strategy ensures that AI@EDGE's influence extends far beyond the project's timeline, contributing to the advancement of AI and edge computing in society.

8. Conclusion

As it has been highlighted in this document, the AI@EDGE project has worked throughout the project life to offer:

- the organisation and participation to the widest number of events. As highlighted within section 2.1, 12 have been the events organised by the project (workshops and webinars), and a total of 59 conference presentations have been carried out (between international conferences, local seminars standardisation events and workshops).
- as highlighted within Section 2.5, a high number of strong scientific publications of the project and of its results have been obtained: 40 in total.
- a strong focus on standardization efforts to priority SDO/SDA groups identified based on project outcomes, as shown within Section 3;
- the cooperation with other projects to ensure synergies with other selected collaborative 5G-PPP projects, in particular DAEMON, 5G-IANA, and HEXA-X (Section 4) to improve the project's visibility towards a large audience.
- an updated exploitation plan in Section 0 to present the partner exploitation plans and a summary of the project exploitation plan, to look beyond the natural end of the AI@EDGE project.

Annex 1 – Conference presentations

2021

	Conference	Date		Venue	Type	Link	Notes	Number of participants
		Year	Date					
1	@5GPPP webinar Europe accelerates towards #6G	2021	16 March	Virtual		Link	Presentation	310
2	ITU-T / FG AN	2021	April	Virtual	Standard.		Presentation of the project to 20 people	20
3	ITU-T / FG AN	2022	May	Virtual	Standard.		Project breakthroughs + presentation on AI-based control loops in Wi-Fi networks "AI@EDGE + AI-Empowered Software-Defined WLANs" - 20 participants	20
4	2021 EuCNC & 6G Summit - 6GV	2021	08-11 June	Porto (Portugal), virtual	C	Link		N.A.
5	International Supercomputing Conference - High Performance (ISC) 2021, Workshop VHPC'21	2021	02 July	Virtual	W	Link		N.A.
6	Int'l Mediterranean Conf. on Communications and Networking (meditcom 2021), Workshop 1 on Acceleration for Edge Computing	2021	07-10 September	Athens, Greece, and virtual	C	Link		N.A.
7	Expodronica	2021	22-23 September	Madrid, Spain, Virtual	C	Link		N.A.
8	Webinar Fondos EU	2021	6 October	Virtual	C	Link	Presentation of AI@EDGE from AERO. Focus was to exchange best practices in H2020 projects.	N.A.
9	1st International Workshop on Network Programmability (NetP 2021) co-located with CNSM 2021	2021	25-29 October	Virtual	C	Link		N.A.

10	"5G Network Slicing: Athonet's Perspective and Testing Tools"	2021	December	Bicocca University, Milan, Italy (remote connection)	Seminar	-	Seminar for university students including ideas and results from the project.	20

2022

	Conference	Date		Venue	Type	Link	Notes	Number of participants (if known)
		Year	Date					
11	UPTIME 2022	2022	January	Bologna, Italy, and online	C	Link	Organized and hosted by Athonet. Event dedicated to the private 5G world community. A dedicated presentation focused on 5G-PPP projects, including AI@EDGE.	500
12	Mobile World Congress (MWC)	2022	28 February - 03 March	Barcelona, Spain	C - Fair	-	Distribution of project flyers and projection of project videos at booth	50
13	6th Franco-Japanese Cybersecurity Workshop	2022	20-22 April	Virtual	W	Link		30
14	IEEE/IFIP Network Operations and Management Symposium	2022	25-29 April	Budapest, Hungary	C	Link	Paper "Roadrunner: O-RAN-based Cell Selection in Beyond 5G Networks" + presentation	300
15	RESSI (Rendez-Vous de la Recherche et de l'Enseignement de la Sécurité des Systèmes d'Information) 2022	2022	10-12 May	Chambon-sur-Lac (France)	C	Link	Short presentation + Poster	50
16	ICC2022 IEEE International Conference on Communications	2022	16-20 May	Seoul, Korea, Hybrid: In-Person and Virtual	C	Link		
17	"5G Networks in Action – The Private Mobile Era"	2022	May	Federico II University, Naples, Italy (remote connection)	Seminar	-	Seminar for master and PhD students including ideas and results frame the project.	30
18	"5G Networks in Action – The Private Mobile Era"	2022	May	Bicocca University, Milan, Italy (remote connection)	Seminar	-	Seminar for university students including ideas and results Frome the project.	20

19	European Conference on Networks and Communications (EuCNC) & 6G Summit	2022	07-10 June	Grenoble, France	C	Link		
20	Critical Communications World (CCW)	2022	June	Vienna, Austria	C- Fair	-	Distribution of project flyers and projection of project videos at booth	50
21	IEEE International Conference on Network Softwarization 2022	2022	27 June - 01 July	Milan, Italy	C	Link		
22	SAMOS 2022: 22nd International Conference on embedded computer Systems: Architectures, MOdeling, and Simulation	2022	03-07 July	Samos, Greece	C	Link		
23	6GNET 2022 conference	2022	06-08 July	Paris, France	C	Link		
24	IEEE INTERNATIONAL CONFERENCE ON CLOUD COMPUTING 2022	2022	11-15 July	Barcelona, Spain	C	Link		
25	CIDRE weekly seminars	2022	06 October	Rennes, France, Virtual	W	Link		
26	18th International Conference on Network and Service Management	2022	31 October - 04 November	Thessaloniki, Greece	C	Link	Presentation of a conference paper on AIF optimal placement for federated learning-based services.	
27	IEEE Cloudnet 2022	2022	07-10 November	Paris, France	C + W	Link	Conference keynotes 60 + workshop 35	60
28	Franco-Japanese Cybersecurity Workshop	2023	24-26 October	Tokyo, Japan	W	Link	Auto-configuration of Intrusion Detection Systems Based on Past Experiences (INRIA, J. François)	50
29	2022 Latincom	2022	30 Nov / 2 Dec	Rio de Janeiro, Brazil	C	Link	Presentation of the Paper	50

2023

	Conference	Date		Venue	Type	Link	Notes	Number of participants (if known)
		Year	Date					
30	HIPEAC 2023, Toulouse	2023	16-18 January	Toulouse, France	C	Link	Poster	
31	VIRTUAL ICT-52 Workshop on 6G 2023	2023	19 January	Virtual	W	Link	Presentation	
32	Mobile World Congress (MWC)	2023	27 February - 02 March	Barcelona, Spain	C	Link	Distribution of project flyers and projection of project videos at booth	
33	SUMO User Conference 2023	2023	02-04 May	Berlin, Germany	C	Link		
34	IEEE International Conference on Communications 2023	2023	28 May - 01 June	Rome, Italy	C	Link	Booth + industrial talks	
35	"Cloud deployments of 5G core networks - The power of private 5G"	2023	May	Bicocca University, Milan, Italy	Seminar	-	Seminar for university students including ideas and results from the project.	10
36	22nd IFIP Networking Conference	2023	12-15 June	Barcelona, Spain	C	Link		
37	PhD Symposium on Next-Generation Networks: AI, Architectures, Interfaces, and Implementations (IFIP Networking)	2023	13 June	Barcelona, Spain	C	Link		
38	International Wireless Communications & Mobile Computing Conference (IWCMC 2023)	2023	19-23 June	Marrakesh, Morocco	C	Link	Paper + presentation	25
39	IEEE 9th International Conference on Network Softwarization (NetSoft)	2023	19-23 June	Madrid, Spain		Link		
40	16th HiPEAC Workshop on Reconfigurable Computing (WRC'2022)	2023	20 June	Budapest, Hungary	C	Link		
41	O-RAN nGRG (research branch) OSAKA F2F meeting	2023	21st June	Osaka, Japan	Standard	-	Invited Presentation of the AI@EDGE Project (architecture, main achievements and challanges still to be addressed) to 50 people during nGRG TOC F2F meeting.	50

42	2023 12th International Conference on Modern Circuits and Systems Technologies (MOCAST)	2023	28-30 June	Athens, Greece	C	Link	Paper + presentation	
43	UPTIME 2023	2023	June	Bologna, Italy, and online	C	Link	Organized and hosted by Athonet. Event dedicated to the private 5G world community. A dedicated presentation focused on 5G-PPP projects, including AI@EDGE.	500
44	"Private Mobile Networks: Core network deployment options and use cases"	2023	July	Meeting of the next Generation Research Group (nGRG) of the O-RAN Alliance (online)	Seminar	-	Invited presentation, focused on private network deployments, and use cases. AI@EDGE was mentioned as supporting one of the cited use cases and as collaboration venue with an O-RAN member (SRS).	30
45	IEEE INTERNATIONAL CONFERENCE ON CLOUD COMPUTING 2023	2023	02-08 July	Chicago, USA	C	Link	Paper	
46	IEEE 14th International Conference on Network of the Future	2023	04-06 October	Izmir, Turkey	C	Link	Paper presentation	
47	International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (IDETC-CIE 2023)	2023	20-23 August	Boston Park Plaza, Boston MA	C	Link	Paper presented	
48	International European Conference on Parallel and Distributed Computing (Euro-Par PhD Symposium) 2023	2023	28 August - 01 September	Limassol, Cyprus	C	Link		
49	22nd Driving Simulation & Virtual Reality Conference & Exhibition - DSC 2023 Europe VR	2023	06-08 September	Antibes, France	C	Link		
50	Fisita World Congress 2023 - Technology of Mobility Conference	2023	12-15 September	Barcelona, Spain	C	Link		
51	Festival dell'ingegneria	2023	23 September	Milan, Italy	C	-		

52	AIRSPACE INTEGRATION WEEK MADRID & EXPODRONICA AIR SHOW 2023	2023	27-28 September	Madrid, Spain	C	Link	AERO exhibited with a booth dedicated to AI@EDGE and other R&D projects. Presentation of AI@EDGE project and its contribution to the newly introduced U-SPACE and UAM concepts for drones' operation.	
53	48th Annual IEEE Conference on Local Computer Networks (LCN)	2023	2-5 October	Daytona Beach, Florida, USA	C	Link	https://github.com/carlos-UPC-AI/zero-touch-FEC	
54	14th International Conference on Network of the Future NoF 2023	2023	04-06 October	Izmir, Turkey	C	Link		
55	4th EARPA Form Forum - Future of road mobility 2023	2023	17-18 October	Bruxelles, Belgium	C	Link		
56	IEEE/IFIP Network Operations and Management Symposium	2023	8-12 May	Miami, USA	C + W	Link	Paper: Auto-tuning of Hyper-parameters for Detecting Network Intrusions via Meta-learning	50
57	International Conference on 6G Networking (6GNET)	2023	18-20 October	Paris, France	C	Link		
58	Seminar at the University of Padova, Italy, "On private 5G networks: Use cases, architectures, and technological considerations"	2023	13-nov	Padova, Italy	Seminar		Seminar for master students	10

Annex 2 – Opportunity-based dissemination

2021

No.	Type of publication	Title	Authors/affiliation	Month	URL	Number of downloads/views/impressions?
1	News	Dr Roberto Riggio @RISEsweden presents @AIatEdgeH2020 project	RISE	March, 16	Link	
2	News	The #H2020 project AI@EDGE started on January 1st. 19 partners from 8 countries committed to achieve an EU-wide impact on industry-relevant aspects of the AI-for-networks and networks-for-AI paradigms in beyond #5G systems	FBK	April, 7	Link	1856
3	News	AI@EDGE: the artificial intelligence of the future - safer, faster, more open AI@EDGE: the artificial intelligence of the future - safer, faster, more open, INRIA website, https://www.inria.fr/en/aiedge-artificial-intelligence-future-safer-faster-more-open, March 2021 (last accessed April 2021)	INRIA	March	Link	
4	News	A secure and reusable #ArtificialIntelligence platform for #EdgeComputing in beyond #5G Networks: this is the goal of the project @AIatEdgeH2020	ITL (Italtel)	April, 8	Link	
5	Press Release	Italtel among the partners of AI@EDGE	ITL (Italtel)	April	Link	
6	News	AI@EDGE : une super IA au service des réseaux de communication de demain, https://recherche.cnam.fr/au-c-oelig-ur-des-labos/ai-edge-une-super-ia-au-service-des-reseaux-de-communication-de-demain-1252326.kjsp?RH=1444134186303, April 2021 (last accessed April 2021)	CNAM	April	Link	
7	News	Our Use Case 1 is on #cooperativeperception: several vehicles exchange data related to their trajectories. This data is used to build a high-definition map of the surrounding environment to predict potential collisions and support #autonomousdriving operations	FBK	April, 7	Link	1560
8	News	On March 16th we took part to the @5GPPP webinar Europe accelerates towards #6G. With the other 8 new Smart Connectivity beyond #5G projects, we shared our vision of 6G and the technical challenges we are addressing to move towards it. Check the recording	FBK	April, 8	Link	395
9	News	In our Use Case 2, we focus on #smartfactory #5G environments, making use of 5G mMTC slices to interconnect #IIoT and standard #IoTdevices, and exploiting augmented edge equipment and devices augmented with AI/ML solutions to detect anomalies and attacks	FBK	April, 12	Link	1483
10	News	We are glad to announce that our paper "AI@EDGE: A Secure and Reusable AI Platform for Edge Computing" has been accepted for presentation at the 2021 @EuCNC & 6G Summit #6GV, to be held on June 8 -11.	FBK	April, 13	Link	1107

11	News	I sistemi di #ArtificialIntelligence sono un elemento chiave della quarta rivoluzione industriale: @AIatEdgeH2020 prevede lo sviluppo di una piattaforma di #AI sicura per l'#Edge Computing oltre il #5G Siamo orgogliosi di essere partner del progetto!	ITALTEL	April, 15	Link	
12	News	Through our Use Case 3, leveraging #5G to support faster data transfer as well as the advanced AI-enabled edge image and video processing solution supported by the AI@EDGE distributed and decentralised #connectcompute, we will boost the efficiency of drones	FBK	April, 19	Link	1307
13	News	In our Use Case 4, @SAFRAN will leverage the know how gathered through AI@EDGE to trial innovative #connectivity solutions and #edgecomputing paradigms for delivering smart content & data curation for in-flight	FBK	April, 26	Link	401
14	News	#AI a bordo del #5G @FBK_research nel progetto europeo AI@EDGE	FBK	April, 27	Link	
15	News	We have great news! From June 2021 and every 6 months, you can learn more about the AI@EDGE activities and results reading our newsletter	FBK	April, 28	Link	589
16	Press release	#MercrediRecherches Focus sur un projet de recherche, AI@EDGE	CNAM	May, 19	Link	
17	News	#Savethedate to attend the presentation of our paper "AI@EDGE: A Secure and Reusable AI Platform for Edge Computing" at the Joint @EuCNC & 6G Summit #6GV on June 10th 9.30-11 CET.	FBK	May, 26	Link	375
18	European 5G Annual Journal	The sixth issue of the European #5G Annual Journal is out! This year's edition contains contributions from 52 active projects. Read more about our @AIatEdgeH2020 project on pages 110-112	FBK	May, 28	Link	322
19	Press Release	Introducing AI@EDGE: A secure and reusable Artificial Intelligence platform for Edge computing in beyond 5G Networks	ICCS	May	Link	https://www.hipeac.net/news/#/magazine/
20	Press release	REUSABLE, SECURE AND TRUSTWORTHY AI SOLUTIONS IN THE NETWORK EDGE	FBK	May	Link	
21	News	Reusable, secure and trustworthy #AI solutions in the Network Edge	FBK	May, 28	Link	
22	5G-PPP Publication	A Secure and Reusable Artificial Intelligence Platform for Edge Computing in Beyond 5G Networks	FBK	June	Link	
23	News	The May issue of the @5GPPP Newsflash is available	FBK	June, 1	Link	632
24	HiPEACinfo 63 - June 2021	@AIatEdgeH2020 project is out in the #HiPEACinfo 63 - June 2021. Read more about our research on page 10	FBK	June, 18	Link	344
25	Press release	Edge Computing and Artificial Intelligence for the mobile networks of the future	TIM	July	Link	
26	News	The second consortium meeting of the @AIatEdgeH2020 project is ongoing: 3 days of technical workshops and interactive discussions to assess the results achieved in the first 6 months and plan the next important steps	FBK	July, 6	Link	2618

27	News	Intense days in the 2nd Consortium Meeting of the @AIatEdgeH2020. Great to work with such powerful and motivated team. Thanks to all the partners.	AERO	July, 6	Link	
28	News	i2CAT participates in AI@EDGE	i2CAT	August, 12	Link	
29	News	#AI is one pillar of the 4th industrial revolution, but the integration of AI-enabled platforms in potentially autonomous decision-making systems or critical infrastructures requires assuring end-to-end quality. This is the goal of the @AIatEdgeH2020	i2CAT	August, 12	Link	
30	News	I am happy to share that our paper "Delay-Sensitive Wireless Content Delivery: An Interpretable Artificial Intelligence Approach" has been accepted at NetP 2021 co-located with #CNSM 2021.	i2CAT	September, 14	Link	
31	News	Dim400 is the driving simulator that will create in @AIatEdgeH2020 the 'digital twin' of a typical city traffic situation: a roundabout with a traffic warden directing in the middle, projecting itself into a future in which human-driven vehicles will be joined by auto-robots	FBK	September, 22	Link	831
32	News	We have released this summer the 1st technical Deliverable D2.1 “Use cases, requirements, and preliminary system architecture" which details the activity performed to characterize and specify the four AI@EDGE use cases.	FBK	September, 24	Link	714
33	News	Today at the #CNSM 2021, "Delay-Sensitive Wireless Content Delivery: An Interpretable Artificial Intelligence Approach" has been presented!	i2CAT	October, 25	Link	
34	News	Come and meet us at @ExpoDronicaMAD in the context of the ongoing WorldATM_now	FBK	October, 27	Link	121
35	News	Participation in Webinar "Fondos Europeos Sesión #4: Financiación de la UE para proyectos de I+D+I" organizado por CEIM - Confederación Empresarial de Madrid-CEOE	AERO	October	Link	

2022

No.	Type of publication	Title	Authors/affiliation	Month	URL	Number of downloads/views/impressions?
36	News	The H2020 Project AI@EDGE brings Intelligence to the Edge of the Mobile network following the paradigms of AI-for-networks and networks-for-AI in Beyond 5G systems.	AERO	February	Link	
37	News	AI@EDGE @ VIRTUAL ICT-52 Workshop on 6G. Join us at the 2 pm session of the VIRTUAL ICT-52 Workshop on 6G.	FBK	February, 4	Link	109
38	News	Sesiones de calibración de sensores y de generación de datasets para proyectos de Inteligencia Artificial	AERO	February	Link	
39	News	AI@EDGE has been presented @ UPTIME 2022 (26-27 January).	FBK	February, 28	Link	71

40	Video	AI@EDGE H2020 project	FBK	March, 2	Link	383
41	News	AI@EDGE project is being showcased at MWC (Mobile World Congress) 2022 (Barcelona, Spain)	FBK	March, 4	Link	380
42	News	AeroTools-UAV drones in large infrastructures monitoring is one of the planned Use Cases.	AERO	March	Link	
43	News	AI@EDGE showcased at MWC2022	AERO	March	Link	
44	News	Workshop ICT	AERO	May	Link	
45	News	RT Newsletter	AERO	May	Link	
46	News	RT Poster INRIA at RESSI 2022	AERO	May	Link	
47	News	A poster entitled “Auto-configuration of Intrusion Detection Systems Based on Past Experiences” has been presented by INRIA at RESSI 2022	FBK	May, 12	Link	111
48	News	The second issue of the AI@EDGE newsletter, presenting an update on the 1st year of activities, is now ready.	FBK	May, 12	Link	90
49	News	AI@EDGE will be presented at the “1st Open Annual Workshop on Future ICT”, held in Athens, Greece (25/05/22).	FBK	May, 24	Link	205
50	News	RT of Video prepared by AI@EDGE	AERO	June	Link	
51	News	Plenary Meeting at Grenoble	AERO	June	Link	
52	News	Plenary Meeting at Grenoble	AERO	June	Link	
53	News	Take a look at the AI@EDGE video, a quick introduction to the project	FBK	June, 7	Link	112
54	News	The plenary meeting of the AI@EDGE project is reaching its conclusion after 2 days of face-to-face meetings. We are ready for next months' project activities.	FBK	June, 8	Link	235
55	News	AI@EDGE has contributed to the “Beyond 5G/6G KPIs and Target Values. A white paper from the Test, Measurement and KPIs Validation Working Group” (June 2022)	FBK	August, 8	Link	432
56	News	AI@EDGE at the 5G-PPP "Workshop on 6G KPIs and how to measure them"	AERO	September	Link	
57	News	The AI@EDGE consortium has been invited to present the work for the white paper on “Beyond 5G/6G KPIs and Target Values” at the 5G-PPP "Workshop on 6G KPIs and how to measure them"	FBK	September, 26	Linkv	199
58	News	1st workshop organized by the AI@EDGE Project	AERO	November	Link	
59	News	We are glad to present the 1st workshop organized by the AI@EDGE Project: Platforms and Mathematical Optimization for Secure and Resilient Future Networks.	FBK	November 2	Link	128
60	News	Plenary Meeting at Milan	AERO	November, 28	Link	

2023

No.	Type of publication	Title	Authors/affiliation	Month	URL	Number of downloads/views/impressions?
61	News	AI@EDGE @ “VIRTUAL ICT-52 Workshop on 6G 2023"	FBK	January, 10	Link	199
62	News	AI@EDGE @ Mobile World Congress 2023	FBK	February, 14	Link	388
63	News	Join AI@EDGE team at the Mobile World Congress 2023	FBK	February, 27	Link	479
64	News	The project PO at the project booth at MWC in Barcelona	FBK	February, 28	Link	681
65	News	Join AI@EDGE team at the MWC 2023 in Barcelona! You can find us in Hall 5 Stand 5I84.	FBK	March, 1	Link	185
66	News	Flying drones based on 5G network. A feasible UseCase we are working on with @5TONIC under the @AIatEdgeH2020 project.	AERO	March, 10	Link	68
67	News	Nuestro AT6-5G en pleno #Vuelo5G:	AERO	April, 26	Link	209
68	News	AI@EDGE is preparing for its consortium meeting to be held at the premises of Ericsson in Stockholm, Sweden	FBK	May, 8	Link	278
69	News	AI@EDGE is preparing for its consortium meeting to be held at the premises of Ericsson in Stockholm, Sweden	FBK	May, 8	Link	49
70	News	Omar Anser from Inria presented his work on auto-configuration of ML-based intrusion detection at IEEE/IFIP Network Operations and Management Symposium (#NOMS, 2023, Miami, FL, USA).	FBK	May, 9	Link	178
71	News	#AIatedge will be at the #EuCNC 2023 with the workshop “Exploring the Intersection of 6G and Artificial Intelligence	FBK	May, 9	Link	55
72	News	Omar Anser from INRIA presented his work on auto-configuration of ML-based intrusion detection at IEEE/IFIP Network Operations and Management Symposium (#NOMS, 2023, Miami, FL, USA).	FBK	May, 9	Link	64
73	News	Plenary Meeting Stockholm	AERO	May, 10	Link	35
74	News	AI@EDGE at the #EuCNC 2023	FBK	May, 10	Link	132
75	News	Plenary Meeting Stockholm	AERO	May, 10	Link	
76	News	AI@EDGE will participate at the IEEE International Conference on Communication (ICC) 2023, in Rome,	FBK	May, 16	Link	247
77	News	AI@EDGE is at the IEEE International Conference on Communication (ICC) 2023, in Rome, Italy	FBK	May, 29	Link	591
78	News	IECC 2023 Rome	AERO	May, 29	Link	246
79	News	The IEEE International Conference on Communication (ICC) 2022 continues.	FBK	May, 31	Link	634

80	News	On the 6th of June 2023, AI@EDGE will hold a half-day workshop titled “Exploring the Intersection of 6G and Artificial Intelligence: Unleashing the Potential of Next-Gen Technologies” at the EUCNC 2023 in Gothenburg, Sweden.	FBK	June, 1	Link	190
81	News	Workshop at EUCNC 2023	FBK	June, 6	Link	215
82	News	A big thanks to Jovanka Adzic, PMP® that has work as mediator and, for the great work done, to all the speakers of the #EUCNC2023 workshop	FBK	June, 8	Link	302
83	News	The Department of Mechanical Engineering MECCPolimi of Politecnico di Milano is one of the partners involved in the #EuropeanProject #AI@EDGE (https://aiatedge.eu/) which aims to virtually validate the behaviour of #cooperative #connected and #automated #vehicles #CCAVs.	PoliMi	July	Link	
84	News	AI@EDGE has successfully contributed to the book on "Towards Sustainable and Trustworthy 6G – Challenges, Enables and Architectural Design	FBK	July, 19	Link	60
85	News	The #AIatEDGE project has successfully contributed to the book on "Towards Sustainable and Trustworthy 6G – Challenges, Enables and Architectural Design"	FBK	July, 26	Link	371
86	News	Our booth at @airspaceweek and @expodronicaMAD in Madrid. Showcasing R&D projects currently ongoing, as the #H2020 @aiatedgeH2020 on advanced 5G. And our skills for innovation on technology of drones.	AERO	September, 25	Link	51
87	News	AI@EDGE has been presented by Previati Giorgio at Festival dell’ingegneria at the Politecnico di Milano	FBK	September, 27	Link	222
88	News	Our booth at #AirspaceIntegrationWeek and Air Show Expodronica in Madrid. Showcasing R&D projects currently ongoing, as the #H2020 @aiatedge on advanced 5G. And our skills for innovation on technology of drones.	AERO	September, 25	Link	167
89	News	Plenary Meeting Stockholm	AERO	September, 25	Link	
90	News	Second day of #AirspaceWeek2023 in Madrid. Very fruitful contacts and interesting opportunities for collaborations.	AERO	September, 26	Link	130
91	News	Many thanks 5TONIC for shining the spotlight on the work we are carry on within the #H2020 @aiatedge project for "A Secure and Reusable Artificial Intelligence Platform for Edge Computing in Beyond 5G Networks".	AERO	September, 29	Link	126
92	News	Plenary Meeting of the AI@EDGE Project in Torino (Italy).	AERO	October, 24	Link	192
93	News	Second day of Plenary Meeting of the AI@EDGE Project in Torino (Italy).	AERO	October, 25	Link	70
94	News	The last plenary meeting of the #AIatEDGE project is ending and with it our 3 years of project.	FBK	October, 25	Link	236
95	News	Animaos a conocer en detalle los resultados del proyecto AI@EDGE y las nuevas funcionalidades	AERO	November	Link	
96	Press release	Notiziario Tecnico n.3 del 2023 (in Italian)	TIM	December, 21	Link	30000