



DETERMINISTIC6G

Intermediate Report on Dissemination and Exploitation Activities

D5.2

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Intermediate report on dissemination and exploitation activities

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| Contributor(s): | Joachim Sachs, Edgardo Montes de Oca, Jose Costa Requena, James Gross, Gourav Prateek Sharma, Frank Dürr, Janos Harmatos, Marilet De Andrade Jardim, David Puffer, Drissa Houatra, Giulia Bigoni, Emilio Trigili, Linus Thrybom. |
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| Reviewers | Damir Hamidovic (SAL) Emilio Trigili (SSSA) |
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Disclaimer

This work has been performed in the framework of the Horizon Europe project DETERMINISTIC6G co-funded by the EU. This information reflects the consortium's view, but the consortium is not liable for any use that may be made of any of the information contained therein. This deliverable has been submitted to the EU commission, but it has not been reviewed and it has not been accepted by the EU commission yet.

Executive summary

This deliverable provides a broad overview of the communication, dissemination, and exploitation activities implemented for the DETERMINISTIC6G project. DETERMINISTIC6G adopts a systematic communication and dissemination approach aimed at achieving a high impact on the project activities and results. So far, 7 papers have been published while some are in the preparation phase and are based on the technical deliverables of the project. In addition, 18 contributions to standards, 11 keynotes and talks in conferences, 3 panel discussions, and dissemination of project results to 5 Master courses have been made. Furthermore, 5 workshops, a special session, and 2 tutorials have been organized. These dissemination and exploitation activities show an impactful strategy to achieve dissemination results for the project. The communication and dissemination activities of the project aim to interact with both technical and non-technical audiences with the overall aim of spreading awareness on the 6G dependable communication technological concepts and architectures. This deliverable also provides information about the dissemination and exploitation activities planned for the remainder of the project.

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1 Introduction

This document presents the communication and dissemination activities carried out during the first 18 months of the project. Communication, dissemination, and exploitation on the outcomes of the DETERMINISTIC6G project are needed to create awareness on the technological developments to a wide range of stakeholders. In this report, important events, publications, contributions to standardization, and workshops organized and participated in by the consortium are presented. Then, this deliverable describes the project's exploitation strategy for the remainder of the project duration. The project's dissemination tasks are of high importance as it is recognized that they are crucial elements to increase the visibility and impact of the project.

In this deliverable, the following distinctions are made between *communication*, *dissemination*, and *exploitation* tasks.

The *communication* activities describe the efforts and channels by which the DETERMINISTIC6G project is reaching out to relevant stakeholders, including industry, academia, sister SNS projects, society, and standardization bodies. The goal is to reach out to society and show the impact and benefits of this project. This is achieved through different activities and communication channels, which are used to inform on and promote the project and its results to different audiences.

The *dissemination* activities present how knowledge and results obtained in DETERMINISTIC6G are transferred to potential users such as the scientific community, industrial partners, policymakers, and standardization bodies. In addition, key performance indicators, their corresponding targets, and achievements so far have been identified.

The *exploitation* plan provides a strategy on how the project results can be effectively used. Exploitation of the project results as a consortium, as well as by individual project partners, is outlined. DETERMINISTIC6G pays special emphasis on assuring a high impact of the project through standardization, publication of project results, and dissemination through various activities.

1.1 DETERMINISTIC6G approach

In the past, time-critical communication has been prevalent in industrial automation scenarios with specialized computing hardware such as programmable logic controllers (PLCs). The communication usually relies on wired communication systems, such as Powerlink and EtherCat, which are limited to local and isolated network domains configured for specific local applications. With the standardization of time-sensitive networking (TSN) and Deterministic Networking (DetNet), similar capabilities are being introduced into the Ethernet and IP networking technologies. This advancement provides a converged multi-service network that supports time-critical applications in a managed network infrastructure, allowing for consistent performance with zero packet loss and guaranteed low, bounded latency. The underlying principles are that the network elements (i.e., bridges or routers) and the PLCs can provide a consistent and known performance with negligible stochastic variation, which allows to manage the network configuration to the needs of time-critical applications with known traffic characteristics and requirements.

It has been observed that several elements in the digitalization journey introduce characteristics that deviate from the baseline assumptions typically considered in the planning of deterministic networks. A common assumption for computing and communication elements, as well as applications, is that any stochastic behavior can be minimized such that the time characteristics of these elements can be clearly associated with tight minimum and maximum bounds. Cloud computing provides efficient and scalable computing, but introduces uncertainty in execution times. Wireless communications provide flexibility and simplicity, but with inherently stochastic components that lead to packet delay variations exceeding significantly those found in wired counterparts. Lastly, applications embrace

novel technologies (e.g., machine-learning-based or machine-vision-based control) where the traffic characteristics deviate from the strictly deterministic behavior of traditional control systems. In addition, there will be an increase in dynamic behavior, where the characteristics of computing, communication and applications elements may change over time, in contrast to a static behavior that does not change during runtime. These deviations of stochastic characteristics highlight shortcomings in traditional approaches to planning and configuration of end-to-end time-critical communication networks, such as TSN or DetNet, specifically in terms of service performance, scalability, and efficiency. Instead, a revolutionary approach to the design, planning and operation of time-critical networks is needed to fully embrace the variability, but also the dynamic changes introduced by wireless connectivity, cloud computing and application innovation. DETERMINISTIC6G has the objective to address these challenges, including the planning of resource allocation for diverse time-critical end-to-end services over multiple domains, providing efficient resource usage and a scalable solution [SPS+23].

DETERMINISTIC6G adopts a novel approach towards future converged infrastructures for the deployment of scalable cyber-physical systems. Compared to networked infrastructures, DETERMINISTIC6G advocates for the acceptance and integration of stochastic elements (like wireless links and computational elements), considering their stochastic behavior captured through either short-term or longer-term envelopes. Monitoring and prediction of KPIs, such as latency or reliability, can be leveraged to make individual elements plannable, despite a remaining stochastic variance. System enhancements to mitigate stochastic variances in communication and computing elements are also developed. In addition, DETERMINISTIC6G attempts to manage the entire end-to-end interaction loop (e.g., the control loop) with its underlying stochastic characteristics, particularly focusing on the integration of computing elements. Finally, due to unavoidable stochastic degradations of individual elements, DETERMINISTIC6G advocates for enabling adaptation between applications running on top of such converged and managed network infrastructures. The idea is to introduce flexibility into application operation, such that its requirements can be adjusted at runtime based on prevailing system conditions. This encompasses a larger set of application requirements that can also accept stochastic end-to-end KPIs and adapt end-to-end KPI requirements at run-time in harmonization with the networked infrastructure. DETERMINISTIC6G builds on a notion of time-awareness, by ensuring accurate and reliable time synchronicity while also ensuring security-by-design for such dependable time-critical communications. Generally, we extend a notion of deterministic communication (where the behavior of network, computing nodes and applications is pre-determined) towards dependable time-critical communication, where the focus is on ensuring that the communication and computing characteristics are managed to meet the KPIs and provide the reliability levels required by the application.

In summary, DETERMINISTIC6G facilitates architectures and algorithms for scalable and converged future network infrastructures that enable dependable time-critical communication end-to-end across domains, including 6G.

1.2 Relation to other work packages

This deliverable is part of WP5 on impact and dissemination. WP5 gets inputs from all technical WPs of the project contributing to communication, dissemination, and exploitation activities.

1.3 Objective of the document

This document is an intermediate report on the communication, dissemination, and exploitation activities with the purpose of providing a thorough overview of such activities from the start of the project until June 2024. The document shows the dissemination of project outcomes through various channels as a result of a close collaboration between all consortium partners and interlinked project

tasks. Further plans on communication, dissemination, and exploitation activities for the remainder of the project are also outlined.

1.4 Target audience of DETERMINISTIC6G

The communication and dissemination activities involve several measures to promote project developments and the results achieved during the course of the project. The objective is to reach out to a wide range of audiences and show the benefits of the research outcomes of the project. Therefore, communication campaigns are designed and implemented throughout the project lifetime, capitalizing on the multilingual nature of the consortium to reach an international audience. Such campaigns utilize multiple channels, including digital, print, scientific, and non-scientific media to raise awareness about the project. Table 1 presents a summary of the communication channels and mechanisms to target different audiences. The target audiences of DETERMINISTIC6G can be divided into five potentially overlapping categories. Communication channels related to each category have been identified.

Table 1: Target audience and channels to disseminate DETERMINISTIC6G activities

| Target audience | Mechanisms | Channels |
|--|---|---|
| Academia, Public R&D | Peer reviewed scientific and technology conferences | Journal and conference publications |
| Advanced vertical industries | Industry workshops, industrial alliances | White papers, industry blogs, talks |
| General public | Press releases, social media | LinkedIn, X, YouTube |
| Sister SNS project | Common white paper and workshop | 6G IA working groups |
| Standardization bodies and 6G technical forums | Standards contribution | Means to reach standards development organization (SDO), and 6G global forums |

The overall efficiency and impact of the DETERMINISTIC6G communication activities are being maximized by a coordinated approach. Emphasis is given to joint activities, including joint publication in world-class conferences, journals, keynote speeches, invited talks to expert groups, contribution towards standardization, and organization of joint events.

1.5 Dissemination goals

The dissemination targets proposed for the DETERMINISTIC6G project are presented in Table 2. In relation to the target audience and channels presented in Table 1, the dissemination goals indicate ways the consortium intends to create an impact of the project along with corresponding target values and attributes. The measures identified by the project to achieve high impact includes promotion of the project technical activities towards standardization bodies and industrial alliances, dissemination of the project outcomes towards academic groups, and communication towards a wider audience.

Table 2: DETERMINISTIC6G dissemination goals

| Category | KPI | Target |
|------------------------|--|--------|
| Standard contributions | Standards and impact to standards groups including 3GPP (SA1, SA2, RAN1, RAN2), future | 30 |

| | | |
|--|---|--|
| | revision of IEC/IEEE 60802, new amendment to IEEE 802.1Q, and OPC UA FX framework | |
| Industry and scientific community | Keynotes and panels in major conferences | at least 6 keynotes at least 2 panels |
| | Number of publications (journals, conferences) | 30 |
| | Workshops in major conferences | at least 2 |
| | 5GPPP/6GIA activities | Contribution to steering board, technology board, pre-standardization, architecture, vision, and societal challenges |
| Influence towards academia | Training activities (summer schools) | 2 |
| | Graduate, PhD courses | 3 |
| Communication towards the general public | Website visits outside consortium | 1000+ |
| | Press release, research blog | 10+ |
| | Social media channel used | Twitter, LinkedIn, YouTube |

1.6 Structure of the document

The structure of the document is as follows. Section 1 introduced the document specifying the relation with other work packages, objectives, and target audience of the DETERMINISTIC6G project. Section 2 explains the outreach strategy focusing on communication and exploitation activities. The exploitation activities correspond to scientific publications, contributions to standardizations, organization of workshops, special session, tutorial, and talks at industrial and academic events. Section 3 presents the exploitation strategies as a consortium, as well as individual partners. Finally, Section 4 concludes the deliverable.

2 Outreach strategy

The DETERMINISTIC6G outreach and communication strategy aims to share the activities, goals, and outcomes of the project with the targeted audience. Table 1 lists the target audience and the mechanisms used to disseminate the project results and activities. Communication towards a wider audience is important to ensure visibility of project vision, aims, and activities. DETERMINISTIC6G developments are communicated towards a wide range of audiences including academia, standardization bodies, industry verticals, sister SNS projects, and public to promote knowledge exchange and dissemination of project results. The following considerations were made in designing the communication strategy to:

- Communicate relevance of DETERMINISTIC6G results to a wider audience.
- Gain project visibility through dissemination of activities and results at all levels.
- Promote knowledge exchange with sister SNS projects and beyond.
- Raise public awareness about the project’s key facts and findings.
- Reach targeted audience where the project results are most relevant.

- Create liaisons and relationships with other projects in Europe and abroad with special focus on 6GIA and SNS projects.

In the following, activities, communication channels, and the material for communication and dissemination of the project are presented.

2.1 Communication activities

The communication activities outlined in this section aim at promoting the project activities and results attained during the project. The objective of the proposed communication activities is to reach out to a critical mass and show the benefits of the research and innovation performed by the partners involved in the DETERMINISTIC6G project. The widespread knowledge sharing about the project will help supporting the adoption of the project results and ideas at various research and industrial organizations. In addition, it will help the public understand newer technological advancements applicable to various use case scenarios. Joint webinar sessions are being organized in conjunction with sister SNS projects to communicate the project outcomes to a wider audience. Workshops, tutorials, and special sessions are being organized as well, highlighting the importance and relevance of the project topics targeting their need for future visionary use cases. Furthermore, summer / training schools will be organized by the academic partners to have an in-depth discussion of the project targeting young PhD students and researchers. We expect that Master's and PhD students will be able to find ideas during these events and can steer their research and career toward 6G technologies and beyond. The exploitation and innovation manager coordinates the communication activities of DETERMINISTIC6G. The planned communication activities are closely aligned with the dissemination activities and are described further in Section 2.2.

2.1.1 Communication channels

To communicate the project outcomes and activities, several communication means are being used. Depending on the communication activity, a particular channel is used, as presented in Table 1. All project activities are updated on the project webpage and disseminated via social media platforms. The technical outcomes are published in the form of project deliverables as well as peer-reviewed scientific journals and conferences. In addition, contributions towards white papers of industrial alliances are being carried out. Communication and dissemination are also carried out via talks at scientific and industrial workshops, panel discussions, poster presentations, and customer meetings. Furthermore, contributions towards 3GPP, IEEE, and IETF standardization are being made. Lastly, collaboration activities through 6G IA working groups are also being targeted. Details on the current progress on dissemination using these communication channels are formulated in Section 2.2.

2.1.2 Communication material

At the start of the project, a basic set of communication material was prepared including the project logo, a general project presentation, poster, and leaflet. The project is identified by its name "DETERMINISTIC6G" and its logo. Figure 1 presents the logo of the project.



Figure 1: DETERMINISTIC6G project logo

The project logo was created for better recognition and visibility, as well as for branding purposes. Therefore, all dissemination tools and activities refer to or include the name and logo of the project. In addition, an EU emblem and the following funding text is included in all presentations, deliverables, and scientific publications:

“The DETERMINISTIC6G project has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement no 1010965604”.

For the sake of project branding and visibility, templates for project slides, reports, and deliverables have been prepared as well. These templates are used, wherever possible, for the representation and dissemination of the project activities. Moreover, press news disseminating the scope and objectives of the project have been released for dissemination to a larger audience. A newsletter has also been published that includes information on the latest achievements, links to recent public deliverables, and forthcoming events. The newsletter is available on the project website and social media channels.

2.1.3 Website

The project webpage was set up at the start of the project. The webpage is regularly updated presenting information on DETERMINISTIC6G vision, objectives, work plan, consortium description, public deliverables, simulation frameworks, publications, newsletters, and latest updates. The webpage serves as the central hub for disseminating DETERMINISTIC6G project activities. Information about the project is provided on different levels of technical detail, thus addressing multiple audiences at the same time.

A snapshot of the project webpage is presented in Figure 2. The website is accessible at “www.deterministic6g.eu”. Since the launch of the webpage, it has received 1619 hits from unique visitors.

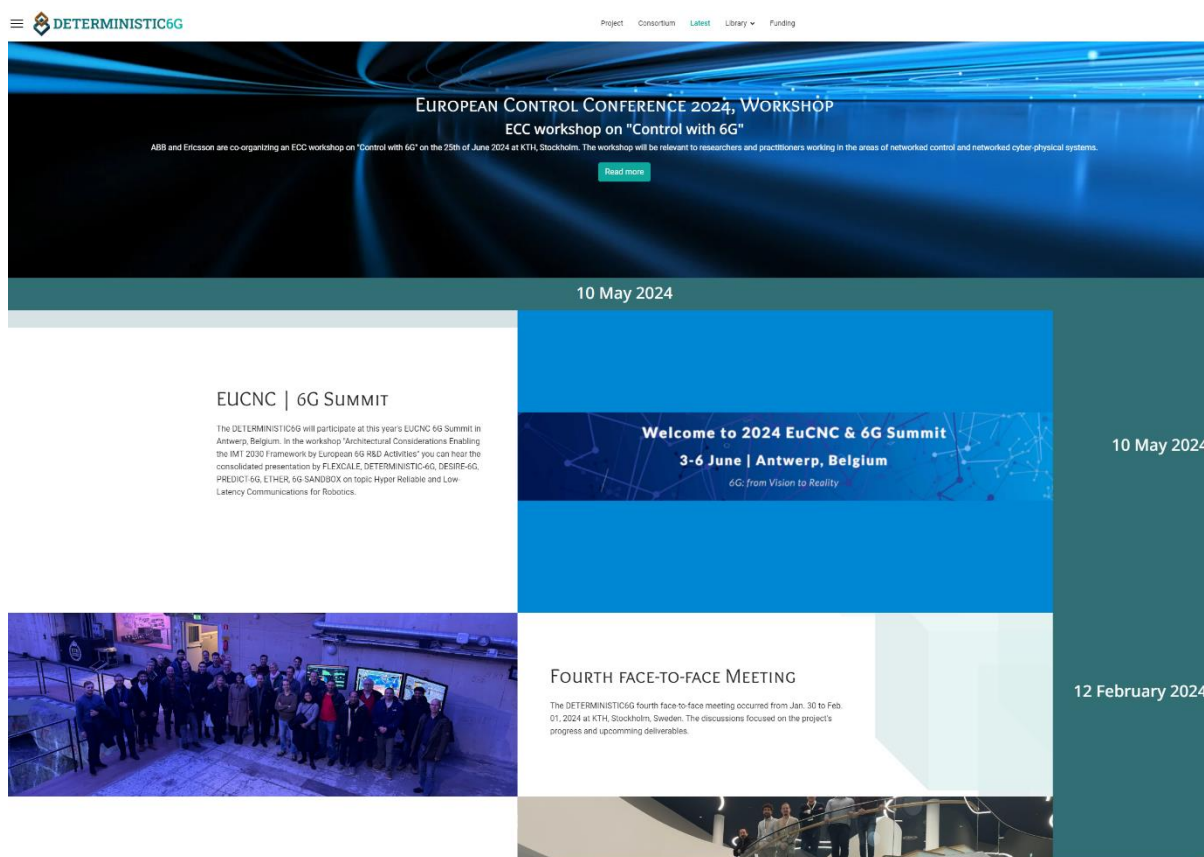


Figure 2: A screenshot of the DETERMINISTIC6G webpage

The project webpage is regularly being upgraded by the addition of new features and add-ons. To increase visibility and accessibility of the project's webpage, search engine optimizations have been performed. Separate pages with the titles "Releases" and "Newsletter" have been added under the "Library" tab. The "Library" tab contains different sections where tutorial presentations, deliverables, publications, software releases, and newsletters are available as open access. All open-source software frameworks developed under the project are available on the "Releases" page. In compliance with the European Commission open access policy, open access to all scientific publications created in the project will be ensured through the website, in compliance with the publisher's rules. All public project deliverables are also easily accessible openly via the project webpage.

After the completion of the project, the project webpages will be archived, and the website will be converted to static HTML. The archived copy will then be available on the web for at least 5 years. The website is GDPR compliant.

2.1.4 Social media

Social media and networking tools (LinkedIn, X) are being used to maximize exposure of the project. The social media platforms are being used to disseminate the project activities to a wide audience, and to build a community with similar interests. Social media accounts are interconnected with the project website to improve the search engine ranking. Moreover, further interaction with other SNS projects is planned, and it will also be disseminated through social media accounts. A YouTube channel has also been created to capture presentations from webinars, workshops, and online conferences. The YouTube channel can be accessed at <https://www.youtube.com/@DETERMINISTIC6G>.

The success of the social media presence of DETERMINISTIC6G is being regularly monitored and evaluated using both quantitative (e.g., by X Analytics) and qualitative measures (e.g., by evaluating comments). The chosen media and networking tools allow two-way interaction with the project and are, therefore, particularly interesting for DETERMINISTIC6G. Moreover, social media is considered of major relevance for the project to reach younger scientists who are in an early stage of their career.

The activity in DETERMINISTIC6G social media platforms as of June 2024 is summarized in Table 3. It also presents inputs, interactions, and impressions expressed in numbers. Inputs refer to the number of posts or tweets made until June 2024. Interactions measure the effectiveness of social media campaigns through likes and comments. Impressions suggest the number of times the content was displayed for at least 300 milliseconds to the social media platform user.

Table 3: Activity on DETERMINISTIC6G social media channels

| Platform | Inputs | Interactions | Impressions |
|----------|--------|--------------|-------------|
| LinkedIn | 32 | 224 | 10.3k |
| X | 30 | 200 | 4.6k |

LinkedIn

The LinkedIn account is being managed with the aim to disseminate official project information among a professional audience and the research community. LinkedIn channel is used as a key tool for communication. The channel can be accessed via <https://www.linkedin.com/company/deterministic6g>. Partners regularly contribute to disseminate project activities via LinkedIn posts to raise awareness of the project among their networks. Currently, the profile has 305 followers, which were 78 at the time when the deliverable [DET23-D51] was published. A high number of impressions have been generated, suggesting that the contents are mostly reaching relevant users. The goal for the remaining time of the project is to further boost these numbers by disseminating relevant content to the channel regularly. Figure 3 shows the current view of the LinkedIn profile.

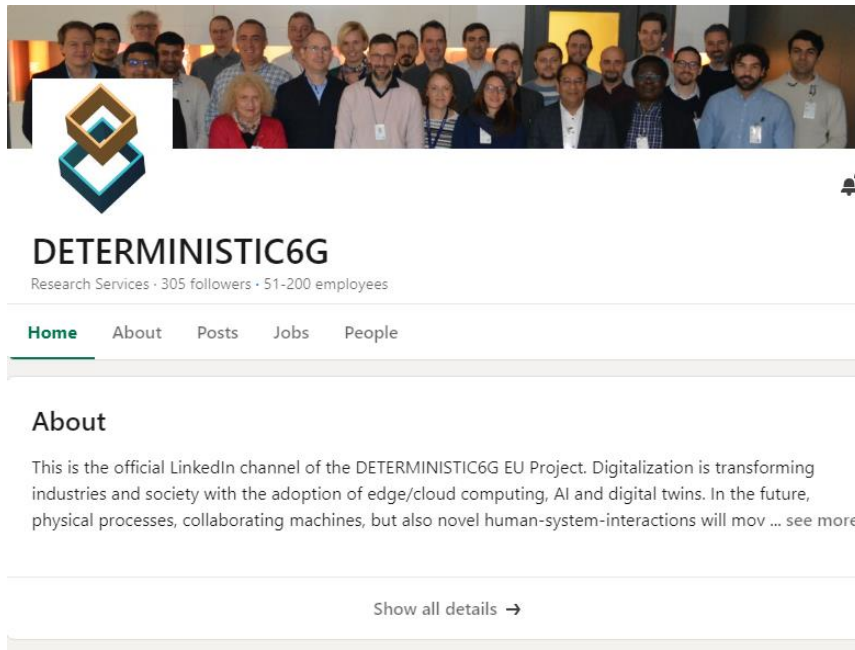


Figure 3: A screenshot of DETERMINISTIC6G LinkedIn page

X

X is also being used as a tool for the dissemination of DETERMINISTIC6G activities. The X account can be accessed at <https://x.com/DETERMINISTIC6G>. Similar to LinkedIn, X is used to disseminate DETERMINISTIC6G news, events, and relevant information on a regular basis targeting a professional audience. The engagement rate on X compared to LinkedIn is relatively low. Currently, DETERMINISTIC6G has 82 followers on the X platform. Therefore, the goal is to regularly post project activities to further increase the visibility of the project. Figure 4 shows the current view of the DETERMINISTIC6G X profile.



Figure 4: A screenshot of DETERMINISTIC6G X profile

2.2 Dissemination activities

In the following subsections, the status of the dissemination activities of the project up until June 2024 is presented.

DETERMINISTIC6G has defined a multi-fold dissemination, exploitation, and communications strategy to provide relevant information to all stakeholders and facilitate market adoption of the project's result. The dissemination plan is being constantly monitored, evaluated, and potentially adjusted.

The dissemination status shows good progress; however, more emphasis will be made towards scientific publication. Several publications are under preparation phase and are based on the project's technical deliverables. During the first half of the project, dissemination through keynotes, talks, and

panel discussions at various events was made. Moreover, workshops, a special session, and tutorial sessions have been organized. Contribution towards standardization activities has also been targeted.

Lectures and training activities to disseminate the project outcomes towards Bachelor’s and Master’s university courses have also been conducted. Both academic and industrial partners have contributed to these dissemination activities. Further dissemination and exploitation activities to achieve a broader impact of the project have also been planned.

Another aspect of the dissemination activities includes interacting with other SNS projects. Apart from organizing joint workshops, a joint webinar series titled “Architectural enhancements for 6G programmable and deterministic networks” took place on 14 June 2024. The online webinar series was organized by DETERMINISTIC6G, DESIRE6G, and PREDICT-6G projects. Further activities will also be organized to improve interactions and learning exchanges.

2.2.1 Accepted publications

The contribution of technical outcomes to scientific venues in the form of scientific publications is targeted during the project. Table 4 presents the list of accepted publications and the corresponding venues. Table 5 presents the venue and details of the publications under review. Further scientific publications are in the preparation phase while some are planned based on the upcoming deliverables of the project.

Table 4: List of accepted publications and venues

| Venue | Authors and title | Citations |
|----------------------------|---|-----------|
| IEEE Access | Gourav Prateek Sharma, Dhruvin Patel, Joachim Sachs, Marilet De Andrade, Janos Farkas, Janos Harmatos, Balazs Varga, Hans-Peter Bernhard, Raheeb Muzaffar, Mahin K. Atiq, Frank Duerr, Dietmar Bruckner, Edgardo Montes de Oca, Drissa Houatra, Hongwei Zhang and James Gross, "Towards Deterministic Communications in 6G Networks: State of the Art, Open Challenges and the Way Forward", in IEEE Access, vol. 11, pp. 106898-106923, 2023 | 9 |
| IEEE Globecom 2023 | Samie Mostafavi, Neelabhro Roy, Gyorgy Dan, James Gross, “Active Queue Management with Data-Driven Delay Violation Probability Predictors” | 0 |
| IEEE Globecom 2023 | Samie Mostafavi, Gourav Prateek Sharma, James Gross, “Data-Driven Latency Probability Prediction for Wireless Networks: Focusing on Tail Probabilities” | 3 |
| EuCNC special session 2023 | Gourav Prateek Sharma and James Gross, “Challenges and Directions for Deterministic Communication in 6G” | 0 |
| EuCNC special session 2023 | Mahin K. Atiq and Raheeb Muzaffar, “Time synchronization for deterministic communication” | 0 |
| INFOCOM CNERT 2024 | Samie Mostafavi, Marius Tillner, Gourav Prateek Sharma, James Gross, “EDAF: An End-to-End Delay Analytics Framework for 5G-and-Beyond Networks” | 1 |
| EuCNC 2024 | Amy Sokhna Sidibe’, Saimanoj Katta, Jose Costa Requena, "Performance Study of 5G Indoor Small Cells for Industrial MEC" | n/a |

| | | |
|--------------------------|---|-----|
| ARES 2024, STAM workshop | Huu Nghia Nguyen, Manh-Dung Nguyen and Edgardo Montes de Oca, "A Framework for In-network Inference using P4" | n/a |
|--------------------------|---|-----|

Table 5: Publications under review

| Venue | Authors and title |
|--|---|
| IEEE Communications Standards Magazine | Mahin Ahmed, Raheeb Muzaffar, Damir Hamidovic, Armin Hadziaganovic, Hans-Peter Bernhard, Oliver Höftberger, Franz Profelt, Emilio Trigili, Giulia Bigoni, Marilet De Andrade, and Janos Farkas, "Resilient Time Synchronization in 6G Networks: A Hot Standby Solution" |
| IEEE VTC | Damir Hamidovic, Armin Hadziaganovic, Mahin Ahmed, Raheeb Muzaffar, Marilet De Andrade, Joachim Sachs, Hans-Peter Bernhard, "6G Schedule and Application Traffic Alignment for Efficient Radio Resource Utilization" |

2.2.2 Panels, workshops, events, and fora

Table 6 presents a list of events where DETERMINISTIC6G was presented as part of the keynote, talk, poster, or panel discussion.

Table 6: DETERMINISTIC6G presentations and talks

| Date | Event | Presenter and Title |
|-----------------------|---|---|
| 06-08 Feb. 2023 | ETSI research conference 2023, Sophia Antipolis, France | Dhruvin Patel, DETERMINISTIC6G poster presentation https://www.etsi.org/events/2130-etsi-research-conference#pane-6/ |
| 09–10 May 2023 | IEEE 6G Summit Dresden, Dresden, Germany | Joachim Sachs, "With 6G towards a Digitalized, Programmable and Intelligent World" http://5gsummit.org/dresden/ |
| 11-12 May 2023 | Aachen Machine Tool Colloquium AWK'23, Aachen, Germany | Joachim Sachs, "Towards 6G - A Cyber-Physical Continuum for Industry 5.0" https://www.awk-aachen.com/?lang=en |
| 22 Jun. 2023 | O-RAN for Vertical Industry Workshop, Osaka, Japan | Joachim Sachs, "Connecting the cyber-physical world with 6G" https://www.o-ran.org/blog/o-ran-for-vertical-industry-workshop-osaka-june-2023 |
| 04-07 Sep 2023 | NetSys, Potsdam, Germany | Joachim Sachs, Keynote on "Creating a digitalized, programmable and intelligent world" https://www.kuvs.de/netsys/2023/program/ |
| 04-07 September, 2023 | NetSys, Potsdam, Germany | James Gross, "Dependable Performance Guarantees for 6G Networks: Model-driven vs Data-driven?", in Future of Networking expert symposium https://www.kuvs.de/netsys/2023/program/zdn/ |

| | | |
|-----------------|--|--|
| 14-15 Sep. 2023 | Fuseco Forum, Berlin, Germany | Hans-Peter Bernhard, "Deterministic Communication in 6G, Where We Are and Where To Go", https://fokus-fraunhofer.lineupr.com/fuseco-forum-2023/ |
| 27-28 Sep. 2023 | TSN/A Conference, Stuttgart, Germany | Joachim Sachs, Frank Dürr, "Towards Wireless End-to-end Deterministic Communication" https://events.weka-fachmedien.de/tsna-conference/home/ |
| 19-23 Feb. 2024 | Lecture at the EU Marie-Curie Doctoral Network TOAST | Joachim Sachs, "Fundamentals of 5G Wireless Communications" https://sites.google.com/unisi.it/toastts/home-page |
| 24-25 Feb. 2024 | Pre-MWC GTI workshop, Barcelona, Spain | Joachim Sachs, "Deterministic Communication - Technology evolution and typical scenarios", invited talk, https://www.gtigroup.org/work_detail/20519.html |
| 18 Mar. 2024 | 5G-TSN workshop, Berlin, Germany | Joachim Sachs, "5G and TSN – status and way forward" |
| 18 Mar. 2024 | IETF 119, Brisbane, Australia /Online participation | Balázs Varga, Joachim Sachs, Frank Dürr, Samie Mostafavi, "Latency Analysis of Mobile Transmission", https://datatracker.ietf.org/meeting/119/materials/slides-119-detnet-sessb-04-latency-analysis-of-mobile-transmission-00.pdf |
| 21 Mar. 2024 | IETF 119, Brisbane, Australia/Online participation | János Farkas, "Updates in draft-ietf-raw-architecture-17" https://datatracker.ietf.org/doc/slides-119-detnet-sessb-02-raw-architecture/ |

2.2.3 Organization of events

Several joint workshops, a special session, and tutorial sessions have been organized under the DETERMINISTIC6G project. Tables 7 - 9 present the list of these events.

Table 7: DETERMINISTIC6G organized workshops

| Date | Event | Title | Status |
|-----------------|--------------------------------|--|-----------|
| 06-09 Jun. 2023 | EuCNC 2023, Gothenburg, Sweden | Joint workshop on "Future deterministic programmable networks for 6G" organized by PREDICT-6G, DESIRE6G, and DETERMINISTIC6G https://www.eucnc.eu/programme/workshops/workshop-10/ | Completed |
| 05-08 Sep. 2023 | PIMRC 2023, Toronto, Canada | Joint workshop on "Vision and challenges on Sustainable and Intelligent Future IoT" organized by DETERMINISTIC6G and COST INTERACT https://pimrc2023.ieee-pimrc.org/program/workshops/vision-and- | Completed |

| | | | |
|------------------------|----------------------------------|--|----------|
| | | challenges-of-wireless-communication-for-future-industrial-iot/ | |
| 25-28 Jun. 2024 | ECC 2024, Stockholm, Sweden | European Control Conference workshop on "Control with 6G" https://www.ericsson.com/en/events/ecc-ws-control-6g | Accepted |
| 30 – Jul. 02 Aug. 2024 | ARES 2024, Vienna, Austria | Joint workshop on "Safety and security testing and monitoring (STAM)" organised by several EU projects including DETERMINISTIC 6G. https://www.ares-conference.eu/stam | Accepted |
| 07 Oct. 2024 | VTC Fall 2024, Washington DC, US | Joint workshop on "Dependable wireless 6G communication" organized by DETERMINISTIC6G and COST INTERACT https://events.vtsociety.org/vtc2024-fall/conference-sessions/call-for-workshops/w6-dependable-wireless-6g-communication/ | Accepted |
| 18 Nov. 2024 | MobiCom 2024, Washington DC, US | Joint workshop on "6G programmable deterministic networking with AI (6GPDN)" organized by DETERMINISTIC6G, DESIRE6G, and PREDICT-6G https://6g-pdn2.netcom.it.uc3m.es/ | Accepted |

Table 8: DETERMINISTIC6G organized special session

| Date | Event | Title | Status |
|-----------------|--------------------------------|---|-----------|
| 06-09 Jun. 2023 | EuCNC 2023, Gothenburg, Sweden | Dependable wireless communication systems and deterministic 6G communication https://www.eucnc.eu/programme/special-sessions/special-session-3/ | Completed |

Table 9: DETERMINISTIC6G organized tutorial sessions

| Date | Event | Title | Status |
|-----------------|-------------------------------------|---|-----------|
| 02-04 Oct. 2023 | European Wireless 2023, Rome, Italy | An overview of time-bounded and deterministic communication https://ew2023.european-wireless.org/ | Completed |
| 10 Jul. 2023 | IEEE 802 Plenary, Berlin, Germany | IETF Reliable available wireless (RAW) https://www.ieee802.org/1/files/public/docs2023/tutorial-bernardos-farkas-RAW-0723-v02.pdf | Completed |

2.2.4 Standard contributions

Table 10 presents the contributions towards standardization activities. The current contributions are mainly focused on 3GPP. During the second half of the project, it is planned to target IEEE and IETF standardization bodies for dissemination of project results.

Table 10: DETERMINISTIC6G contribution towards standardization

| Date | ID | Body | Title | Status |
|-----------------|----------------------------|------|--|--------|
| 05 Jan. 2023 | S2-2300205 | 3GPP | Support of integration with IETF Deterministic Networking (TS 23.501) | Public |
| 05 Jan. 2023 | S2-2300207 | 3GPP | Support of integration with IETF Deterministic Networking (TS 23.502) | Public |
| 05 Jan. 2023 | S2-2300208 | 3GPP | Support of integration with IETF Deterministic Networking (TS 23.503) | Public |
| 04 Jan. 2023 | S2-2300316 | 3GPP | Reporting timing synchronization status | Public |
| 10 Feb. 2023 | S2-2302394 | 3GPP | Support of integration with IETF Deterministic Networking (TS 23.501) | Public |
| 10 Feb. 2023 | S2-2302395 | 3GPP | Support of integration with IETF Deterministic Networking (TS 23.502) | Public |
| 10 Feb. 2023 | S2-2302396 | 3GPP | Support of integration with IETF Deterministic Networking (TS 23.503) | Public |
| 10 Feb. 2023 | S2-2302397 | 3GPP | Support of integration with IETF Deterministic Networking (TS 23.503 on YANG models) | Public |
| 06 Apr. 2023 | S2-2304125 | 3GPP | Time synchronization status reporting | Public |
| 07 Apr. 2023 | S2-2304126 | 3GPP | Resolve editor's note on indication of TEID and QFI to the TN CNC | Public |
| 05 Apr. 2023 | S2-2304127 | 3GPP | Updates to 5GS DetNet integration | Public |
| 13-17 Sep. 2023 | S2-2312467 | 3GPP | On Event ID in the SIB9 | Public |
| 22-26 May 2023 | S2-2306440 | 3GPP | Study on DetNet Phase 2 | Public |
| 11-15 Dec. 2023 | SP-231630 | 3GPP | Downscoping of "Study on enhancement of Timing Resiliency, TSC&URLLC, and LAN" | Public |
| 11-15 Dec. 2023 | SP-231507 | 3GPP | Study on user plane redundancy (revision/downscope TSC&URLLC and LAN SI) | Public |
| 18 May 2023 | - | IEEE | FRER extensions to support cloudification | Public |
| 29 Feb. 2024 | - | IETF | Latency analysis of mobile transmission | Public |
| 16 Mar. 2024 | - | IETF | RAW Architecture | Public |

2.2.5 Open-source framework and datasets

The open-source contributions for the software packages and datasets around the evaluation framework are publicly available and promoted through the project webpage. A GitHub repository has

been created where these evaluation frameworks are available. The DETERMINISTIC6G GitHub can be accessed via <https://github.com/DETERMINISTIC6G>.

Moreover, open-source software packages are also available on the Zenodo platform. Table 11 presents the software packages developed as part of the DETERMINISTIC6G project and corresponding open-access links at the GitHub and Zenodo platform.

Table 11: DETERMINISTIC6G software packages available at Github and Zenodo platform

| Software package | GitHub | Zenodo |
|--|---|--|
| Simulation framework for validating the concepts for a wireless-friendly design for end-to-end deterministic communication | https://github.com/DETERMINISTIC6G/deterministic6g | https://zenodo.org/records/10401977 |
| Implementation of a high-precision monitoring system using InBand network telemetry and P4 | https://github.com/DETERMINISTIC6G/deterministic6g_security-solutions/ | https://zenodo.org/records/10401698 |
| Network Latency measurement tool | https://github.com/DETERMINISTIC6G/nlmt.git | https://zenodo.org/records/10829153 |
| Latency Measurement Framework | https://github.com/DETERMINISTIC6G/edaf.git | https://zenodo.org/records/10829210 |
| Sample COTS 5G measurements | | https://zenodo.org/records/10390211 |
| Security Solution for Deterministic Applications on 6G Networks | https://github.com/DETERMINISTIC6G/deterministic6g_security-solutions/ | https://zenodo.org/communities/deterministic6g (https://zenodo.org/records/10401698) |

2.2.6 Dissemination through university courses

Topics and available results from the DETERMINISTIC6G project were also integrated into different academic courses and final theses. Table 12 presents a list of Bachelor’s and Master’s courses along with the corresponding topics that were conducted or that are planned to be conducted with inputs from the DETERMINISTIC6G project.

Table 12: List of academic courses with inputs from DETERMINISTIC6G project

| Date / Semester | Course Title | Topics from project | Partner |
|-----------------------|---|--|---------|
| Winter term 2022/2023 | Lecture (Master): Real-Time Concepts for Embedded Systems + Exercises | Concepts and technologies for deterministic real-time communication including Time-Sensitive Networking (overview of TSN standards, time-triggered scheduling with Time-aware shaper (TAS), end-to-end packet scheduling with TAS), analysis of deterministic bounds of IntServ Guaranteed Services, field | USTUTT |

| | | | |
|-----------------------|---|---|--------|
| | | buses (CAN). Scheduling algorithms for deterministic real-time tasks. | |
| Winter term 2022/2023 | Lab-course (Master): Software-Defined and Time-Sensitive Networking | Practical introduction to technologies for deterministic real-time communication including TSN and Software-Defined Networking (SDN), e.g., TSN scheduling with TAPRIO on Linux, SDN controllers and protocols (OpenFlow), Network emulation with Mininet | USTUTT |
| Summer term 2023 | Lab-course (Master): Software-Defined and Time-Sensitive Networking | Topics see lab-course SDN/TSN in winter term 2022/2023 above. | USTUTT |
| Winter term 2023/2024 | Lecture (Master): Real-Time Concepts for Embedded Systems + Exercises | Topics see lecture Real-time Concepts for Embedded Systems in winter term 2022/2023 above. | USTUTT |
| Summer term 2024 | Lab-course (Master): Software-Defined and Time-Sensitive Networking | Additional topics compared to lab-courses SDN/TSN above: network simulation of deterministic networks with OMNeT++/INET including DETERMINISTIC6G simulator extensions | USTUTT |

Table 13 presents a list of Bachelor’s and Master’s theses that have been written in the scope of the DETERMINISTIC6G project.

Table 13: List of Bachelor and Master theses in scope of DETERMINISTIC6G project

| Thesis title | Bachelor / Master | Partner |
|---|-------------------|---------|
| Adaptive Robust Scheduling in Wireless TSN | Master | USTUTT |
| Design and Implementation of a an Extensible Centralized Network Controller (CNC) for TSN | Bachelor | USTUTT |
| Scheduling with Uncertainty for TSN Using Robust Optimization Techniques and Integer Linear Programming | Master | USTUTT |
| Design and Implementation of a Network Emulator with Stochastic Network Delay Support | Bachelor | USTUTT |

| | | |
|---|----------|--------|
| Simulation and Evaluation of the Performance of Clock Synchronization with PTP under Variable Network Delay | Bachelor | USTUTT |
| Algorithms for Calculating Robust Schedules for TSN | Master | USTUTT |
| Design and Implementation of a Web-Based CNC for TSN | Bachelor | USTUTT |
| Implementation and Evaluation of Robust Schedules for IEEE TSN | Bachelor | USTUTT |
| Roaming with Deterministic Real-Time Guarantees in Wireless TSN | Master | USTUTT |

2.2.7 6GIA events

Regular participation and contribution to 6GIA organized events and meetings are ensured by the members of the DETERMINISTIC6G projects. These meetings correspond to joint efforts on different working group activities, exchange of ideas and activities from technical managers of different SNS projects, and information exchange on communication and dissemination activities. As a result, a joint workshop (Table 14), was organized at EuCNC for several SNS projects where DETERMINISTIC6G participated and contributed to the event. Additionally, DETERMINISTIC6G project is involved in the 6GIA Architecture working group, and continuously contributes to the ongoing white papers preparation activities.

Table 14: Event organized under 6GIA

| Date | Event | Title | Status |
|--------------|----------------------------|--|----------|
| 03 Jun. 2024 | EuCNC Workshop on IMT 2030 | Hyper Reliable and Low-Latency Communications for Robotics | Accepted |

2.2.8 DETERMINISTIC6G deliverables

Table 15 presents a list of deliverables that have been published until May 2024, in chronological order. As mentioned, all project deliverables are openly available and accessible on the project webpage.

Table 15: List of DETERMINISTIC6G deliverables

| Number | Title |
|--------|---|
| D6.1 | Management Handbook and Project Website |
| D5.1 | Impact, exploitation and dissemination plan for academic research, awareness of potential benefits to industry, standardization synergies |
| D6.2 | Data management plan |
| D1.1 | DETERMINISTIC6G use cases and architecture principles |
| D2.1 | First report on 6G centric enabler |
| D2.2 | First Report on the time synchronization for E2E time awareness |

| | |
|------|---|
| D3.1 | Report on 6G convergence enablers towards deterministic communication standards |
| D3.2 | Report on the Security solutions |
| D4.1 | DETERMINISTIC6G DetCom simulator framework release 1 |
| D6.3 | First Intermediate Project Report |
| D4.2 | Latency measurement framework |
| D1.2 | First report on DETERMINISTIC6G architecture |

2.2.9 Other events, press articles, and publications

DETERMINISTIC6G has also contributed through other miscellaneous activities to disseminate the objectives and outcomes of the project. Table 16 presents a list of such activities carried out until June 2024.

Table 16: Dissemination through miscellaneous activities

| Date | Event | Title | Status |
|-----------------|---|---|--|
| 06 Feb. 2023 | Press release | | Published |
| Jun. 2023 | SNS Journal 2023 | Deterministic6G contributions in 6G IA Journal https://smart-networks.europa.eu/wp-content/uploads/2023/05/sns-journal-2023-web-1.pdf | Published |
| 06-09 Jun. 2023 | Recorded during EuCNC 2023 | Video 6G SNS JU Phase 1 project overview https://www.youtube.com/watch?v=jSxGtAb59JI | Available on YouTube and Deterministic6G LinkedIn page |
| 02 Nov. 2023 | Interview for Italian online science newspaper (INNLIFES) | Il 6G scalda i motori per rivoluzionare la teleoperazione ("6G is gearing up to revolutionize teleoperation"): https://www.innlifes.com/med-tech/6g-teleoperazione-trigili/ | Available online |
| 31 May 2024 | SNS Journal 2024 | Deterministic6G contributions in 6G IA Journal 2024 | Published |
| 05 Jun. 2024 | Newsletter | DETERMINISTIC6G first newsletter | Published |
| 20 Jun. 2024 | Joint webinar Series # 1 | 6G-Programmable deterministic webinar on "Architectural enhancements for 6G programmable and deterministic networks" | Available on DETERMINISTIC6G YouTube channel |

| | | | |
|--|--|--|--|
| | | organized by PREDICT-6G, DETERMINISTIC6G, and DESIRE6G https://www.youtube.com/watch?v=OVLAIbUZOY | |
|--|--|--|--|

2.3 Summary of KPIs to achieve impact

Considerable progress towards communication and dissemination of the project results has been made so far. To have a clear goal, these dissemination activities have been evaluated by means of KPIs, their target values, and their current status, which are listed in Table 17.

Table 17: Summary of proposed targets and status

| Category | KPI | Targets | Status |
|-----------------------------------|--|--|--|
| Standard contributions | Standards and impact to standards groups | 3GPP (SA1, SA2, RAN1, RAN2) Future revision of IEC/IEEE 60802 Intended new amendment to IEEE 802.1Q OPC UA FX framework | More effort towards 3GPP and IEEE/IETF and OPC/UA |
| | Number of contributions | 30 | 18 |
| Industry and scientific community | Keynotes and panels in major conferences | at least 6 keynotes and at least 2 panels | 11 keynotes and talks 3 panel discussion (EuCNC, O-RAN, 6G summit Dresden) |
| | Number of publications (journals, conferences) | 30 | 8 (accepted) 2 (under review) Some are under preparation |
| | Workshops in major conferences | at least 2 | 2 (organized) 4 (accepted) |
| | 5GPPP/6GIA activities | Contribution to steering board, technology board, pre-standardization, architecture, vision, and societal challenges | 6GIA webinar, SNS journals, SNS video, Contribution to SNS 6GIA workshop at EuCNC, involvement in the 6GIA Architecture WG |
| | Tutorials | | Half-day tutorial at European Wireless'23 |

| | | | |
|--|--------------------------------------|----------------------------|--|
| | | | IEEE 802 Plenary, Berlin, Germany |
| | Special session | | Special session at EuCNC 2023 |
| | Webinar series | | 1 (conducted) Joint webinar with sister SNS projects |
| Influence towards academia | Training activities (summer schools) | 2 | Planned for project year 2 and 3 |
| | Graduate, PhD courses | 3 | 5 Master courses Further planned for project year 2 and 3 |
| Communication towards the general public | Website visits outside consortium | 1000+ | 1649 (unique hits) |
| | Press release, research blog | 10+ | 2 (published) |
| | Social media channel used | Twitter, LinkedIn, YouTube | Active |

Compared to the dissemination goals presented in Table 2, the status in Table 17 reflects categories where the dissemination activities exceeded the planned targets. Specifically, the dissemination goals towards industry and scientific community, and influence towards academia was more focused. The dissemination activities conducted in these aforementioned categories resulted in gaining an increased project impact and created an understanding towards the relevant stakeholders on the requirements and importance of the project’s targeted technologies. The number of attendees at these events, i.e., workshops, special session, tutorials, webinar, and talks varied between 40 and 70. These activities successfully provided platforms for knowledge exchange and contributed towards disseminating DETERMINISTIC6G technical developments to a broader community. While the intention is to continue in a similar fashion with these dissemination activities and further promote the project outcomes, other dissemination categories will also be targeted to build on the momentum gained so far. In particular, the focus is to contribute towards DetNet and IEEE standardizations, peer-reviewed scientific publications based on project deliverables and software packages, training activities, and communication towards a wider audience. We aim to ensure that our dissemination efforts are more effective, inclusive, and impactful during and after the completion of the project.

2.4 Synergies and dissemination comparison with sister SNS projects

In this section we draw synergies with DESIRE6G, PREDICT-6G, TARGET-X, and ADROIT6G sister SNS projects to design and organize further joint collaborative activities.

The goal of the DESIRE6G project is to design, develop, and demonstrate a new wireless communication system that will provide near real-time autonomic networking and support extreme URLLC application requirements. DESIRE6G employs a combination of innovative technologies such as terahertz communication, artificial intelligence (AI), and machine learning.

These technologies will allow the design and testing of new hardware and software components that will form the basis of the new wireless communication system.

Synergy: DETERMINISTIC6G focuses on architectural aspects and algorithms for scalable and converged future network infrastructures to enable dependable end-to-end (E2E) time-critical communication across wired and 6G wireless domains. DESIRE6G and DETERMINISTIC6G projects have overlapping interests in developing AI/ML based techniques to support low-latency communication. Both projects are closely collaborating to jointly disseminate the project developments.

PREDICT-6G aims to create a secure, modular, interoperable, and extensible deterministic network and management framework that automates the definition, provisioning, monitoring, fulfillment, and life-cycle management of end-to-end deterministic services over multiple network domains. This will hide the complexity of continuously balancing and re-configuring the constituent domain-specific enablers to maintain a consistent end-to-end determinism.

Synergy: DETERMINISTIC6G is developing features for deterministic wireless transmission and wireless-friendly enhancements for TSN and DetNet. The development of technology enablers for E2E deterministic communication is an overlapping interest to both projects. PREDICT-6G and DETERMINISTIC6G are collaborating closely in organizing webinars and joint workshops for dissemination of project results and knowledge exchange.

The TARGET-X project envisions accelerating the digital transformation of key verticals such as energy, construction, automotive, and manufacturing using large-scale trials in multiple testbeds. By demonstrating, validating, and evaluating the potential of 5G/6G in real environments, technologies such as real-time communication, localization, self-description, digital twinning, and sensor-network data fusion can be tested and evaluated.

Synergy: The DETERMINISTIC6G developments on TSN to support dependable wireless transmission and TARGET-X vision to validate real-time communication create synergies between the two projects. Dissemination collaboration in terms of organizing a joint special session are currently underway.

ADROIT6G's overall goal is to evolve the existing service-based architectures of 5G mobile networks, and design, implement and validate a fundamentally new approach for a futureproof, cognitive, next-generation 6G architecture by adopting a fully distributed AI-driven dynamic paradigm, with functional elements automatically deployed on-demand as virtual functions in cloud native environments, across the far-edge, edge and cloud domains, operated by different stakeholders.

Synergy: The development of 6G time synchronization solution to ensure end-to-end time awareness and new concepts for deterministic edge cloud solution for integration in the 6G system in the DETERMINISTIC6G project brings synergies with ADROIT6G. Collaboration on dissemination activities can be coordinated with ADROIT6G based on mutual topics of interest.

While DETERMINISTIC6G is collaborating with sister SNS project to jointly disseminate project results and is organizing events for knowledge exchange, it is also worth to examine how well DETERMINISTIC6G dissemination efforts are compared to the aforementioned sister SNS projects. The comparison is based on the activities listed on the respective project webpages and social media platforms and may not reflect true values. The intension of this comparison is to steer DETERMINISTIC6G dissemination efforts to focused categories so that a wider project dissemination and exploitation impact can be realized.

In terms of organized workshops, around one or two events have been organized by the sister projects. DETERMINISTIC6G has gained well in this category as is presented in Table 17. Moreover, no information on tutorials or organization of special sessions by sister SNS projects is found. In terms of invited talks and keynotes, a maximum of five presentations are made by the sister projects. DETERMINISTIC6G also performed well in this category. Contribution towards standardization is an area that is highly encouraged since it brings a major impact towards realization of the technical developments. Information on contribution towards standardization was not found on any of the project's webpages. However, DETERMINISTIC6G is making its efforts to achieve the targeted values. During the second half of the project, the intension is to contribute more towards DetNet and IEEE standards. Lastly, in terms of peer-reviewed publications, it is observed that on average seventeen contributions are made by the sister SNS project.

By comparing the dissemination activities conducted by the DETERMINISTIC6G project with other projects, it can be stated that DETERMINISTIC6G is performing well in all dissemination categories but is lacking in terms of peer-reviewed publications. This will now be a focus of the project's dissemination activities. However, dissemination activities for all other categories will be maintained to achieve larger project impacts.

3 Exploitation Plan

The DETERMINISTIC6G exploitation strategy pertains to an overall exploitation plan of the project as well as individual partner exploitation plans. The project results allow partners to explore new market areas and enable the definition of a roadmap for future products and solutions. Different types of exploitable results are identified. Industrial partners lead future standardization work in the direction of dependable communication. Academic partners contribute towards research outcomes in the form of publications and demonstration through simulation framework in the direction of future wireless networks. SMEs will be able to offer new techniques and functions allowing them to maintain their innovative and competitive value. The direct and indirect value and impact for different stakeholders will be considered to boost the actions of interested partners in their exploitation strategy. The exploitation plans both on consortium level as well as individual partner level have been described in D5.1 and remain valid. In this section, contributions so far by individual partners and further plans on exploitation activities are added.

3.1 Strategy on exploitation

The DETERMINISTIC6G project has mainly focused on establishing technical cornerstones and directions resulting in high-quality research output towards project deliverables and development of the first release of the simulation framework. The strategy for the remainder of the project is to further focus on standardization activities targeting IETF (DetNet) and IEEE (TSN) SDOs. We are progressively closing this phase to shift our focus to publications of new results (which will be described in the upcoming deliverable). The intention is to continuously publish new results, including concept evaluations and verifications by leveraging the capabilities of the first release of the "DetCom simulator framework".

Although the activities and outcomes of the project are currently being disseminated through various channels including talks at industrial and academic conferences, organization of workshops, and dissemination through customer meetings, a joint webinar series has been initiated together with DESIRE6G and PREDICT-6G to further boost dissemination and exploitation of the project results. The first webinar took place on 14 June 2024, while two more webinar sessions are planned for the year. The intention is to provide technical presentations of specific topics from the projects, followed by a

panel discussion. These webinars will be recorded and uploaded to the YouTube channel. Dissemination of the event started using social media channels, project webpage, and the newsletter.

In addition to the webinars, it is also planned to utilize YouTube to disseminate information related to the open-source software frameworks of the project through short demo videos. All these activities will be announced using the project's webpage and social media platforms.

Furthermore, newsletter editions every 4 months are planned to provide a comprehensive overview of the results and progress of the project.

Similarly, as per the dissemination targets, lectures as part of summer school courses are also being organized. Further information on this will be disseminated in due time.

3.2 Strategy on open-source practices

The DETERMINISTIC6G project outcomes are aimed to be available as open access (whenever possible) so that the academic, industrial, as well as a broader community can benefit from various results of the project. However, all internal communication, reports, and discussions within the consortium leading to the project results will not be made public. Similarly, restricted data due to contractual reasons will not be shared openly.

All project-related outcomes including the project deliverables, publications, tutorial presentations, software packages, and information on dissemination activities are available on the project webpage. The project webpage and social media accounts are maintained to disseminate project updates and to make a wider community aware about the availability of the project outcomes.

As planned, open-source contributions for the software packages around the evaluation framework, corresponding to publicly available software repositories are established and promoted through the project webpage.

3.3 Individual partner exploitation contribution and plans

In addition to the overall exploitation strategy, individual partners have been contributing towards exploitation of the project. A summary of individual contributions and further plans for the second half of the project are summarized below. A final version of the exploitation contributions and future exploitation activities will be reported in the final impact and dissemination report.

3.3.1 Ericsson

EAB

EAB has contributed to the following dissemination activities: a journal paper (Access Journal), three talks between May and June 2023 (see list in 2.2.2), six 3GPP papers related to TSC/URLLC and time synchronization, and a tutorial (see 2.2.3). EAB has been contributing to 5G-ACIA activities related to DETERMINISTIC6G project.

EAB is currently contributing to a journal paper and two conference papers that are currently under review. EAB is also contributing to a conference paper that is under preparation for submission.

More publications as expected based on implementation and results that will be obtained from the validation framework (WP4) for activities mainly related to WP2.

EAB is currently preparing for a 3GPP SA2 Rel-20 WI, with the plan to submit it around Q2 2025. Most of the material of WP2 (which EAB is leading) is the fundament to motivate such standardization work. Ericsson is committed to carrying on the standardization work beyond the end of the project duration.

EDD

EDD has contributed to the following dissemination activities: a journal paper (Access journal), and one conference paper that is currently under review. More publications are planned based on the contributions made to the project deliverables, in particular in WP1, WP2 and WP3.

EDD has given or contributed to 8 invited talks, made 1 keynote presentation and made one lecture. EDD has also co-organized 5 scientific workshops, 1 special session at a conference. EDD contributed also to one project webinar. EDD also participated in 3 panels at conferences. EDD made one standardization contribution. EDD also provided two data sets for latency measurements obtained from trial network performance analysis.

EDD is committed to disseminating project results also in future and also beyond the lifetime of the project. This includes contributions to future related standardization activities.

ETH

ETH has contributed to the Access Journal paper titled 'Towards Deterministic Communications in 6G Networks: State of the Art, Open Challenges and the Way Forward'.

ETH has prepared nine 3GPP contributions related to DetNet and one IEEE contribution related to TSN FRER extensions to support cloudification. Furthermore, ETH led the preparation of two IETF contributions (for details, see section 2.2.5).

ETH was also involved in the tutorial on time-bounded and deterministic communication at European Wireless (for details, see section 2.2.4). Additionally, ETH participated in a tutorial on 'IETF Reliable Available Wireless' at the July 2023 IEEE 802 Plenary.

ETH has submitted two presentations for the TSN/A 2024 conference with the topics of Ethernet OAM and edge cloud – TSN integration.

Until the end of the project, ETH's objective is to focus on standardization, by strengthening the efforts to disseminate the project's results towards IETF and IEEE. For IETF, several follow-up contributions are planned to the upcoming meetings during the lifetime of the project. For IEEE, the intention is to start preparing contributions from Q3 2024.

Peer-reviewed journal and conference publications are also planned, based on the description of concepts developed in WP2 and WP3, where ETH has been contributing, and their validation using the simulation framework developed in WP4.

ETH also intends to contribute to the dissemination activities (e.g., preparation of white papers, workshop presentations) of the 6G-IA working groups, where the project is involved.

Additionally, ETH is contributing to the preparation of a 3GPP SA2 Rel-20 WI related to deterministic communication.

3.3.2 MONTIMAGE (MI)

Montimage has contributed to the ARES conference STAM workshop with one paper describing the techniques developed for high precision monitoring, and the project's IEEE Access paper. It has also added the software developed to Github and Zenodo.

Montimage is developing a monitoring solution and anomaly detection techniques to assess the performance and security of networks requiring deterministic behavior. It plans to industrialize the results, which include in-band network telemetry and AI-based behavioral analysis. It will present the results at forums and other events to generate interest among industrial stakeholders (i.e., operators, equipment manufacturers, Industry 4.0). It will exploit the results as open source with advanced commercial services (e.g., integration, deployments, training, maintenance, customizations) and

industrial-grade releases. It will also participate in future Industry 4.0-related projects and tenders, proposing strategies for end-to-end high-precision telemetry and automated response to detected anomalies to achieve reliable, robust networks.

3.3.3 SILICON AUSTRIA LABS (SAL)

SAL is leading the impact and dissemination work package and maintaining the project webpage and social media platforms. SAL organized joint workshops at EuCNC and PIMRC. Again, this year joint workshops are being organized at VTC fall 2024 and MobiCom 2024. Moreover, SAL has been contributing towards project deliverables, publications, and dissemination of the project at events such as 6G Summit in Dresden, Fuseco forum, SAL symposium on 6G, ESBS-Austria Conference, etc.

SAL is actively involved in research activities on HotStandby 6G integration architectures, RAN scheduling and optimization, and situational awareness through digital twinning.

SAL will further exploit the research work carried out under the DETERMINISTIC6G project to attract industry and academic partners and to create awareness on activities performed to maximize the impact of the project. Moreover, the project results will be exploited on a European and international level in the form of peer-reviewed journals and conference publications.

3.3.4 CUMUCORE (CMC)

CMC has contributed to EUCNC 2024 with a conference paper including the results of MEC platform. CMC is working to extend the results and publish new paper with additional results including network slicing to deliver optimized data flows with lower delay jitter.

3.3.5 KUNGLIGA TEKNISKA HOEGSKOLAN (KTH)

KTH contributed to a number of dissemination activities including both talks and scientific publications. The work carried out with respect to data-driven latency predictions led to two conference publications in IEEE Globecom 2023. Further, KTH led the preparation of the manuscript titled "Toward Deterministic Communications in 6G Networks: State of the Art, Open Challenges and the Way Forward", which has been published in IEEE Access. Furthermore, KTH worked on developing an open-source framework for latency measurement in 5G. The results of this work have been presented in the CNERT workshop at IEEE INFOCOM. The sample measurements collected using this framework have been published at the Zenodo platform.

A conference paper is under preparation on the analysis of overhead in different learning architectures in 5G. Furthermore, a mathematical framework is being developed to quantify predictability of a given system. This work is expected to be submitted as a manuscript for journal publication.

3.3.6 UNIVERSITY OF STUTTGART (USTUTT)

USTUTT has participated in the following dissemination activities: a joint journal publication published in the IEEE Access journal on the state of the art and open challenges for deterministic communication in 6G networks; a talk at the TSN/A 2023 conference including as a topic the impact and challenges of end-to-end scheduling for dependable communication in 6G networks. Besides the participation in scientific publications and talks, USTUTT leads the development of the open-source simulation platform and is the main contributor to its code base. In this context, USTUTT has set up and maintains the code at the public project GitHub and via the Zenodo platform for making the source code and software artifacts openly available to the community. Moreover, technologies and early results of the project have been included into Bachelor and Master courses at USTUTT, and students have been involved in the research activities of the project through various Bachelor and Master theses.

In the future, USTUTT will further intensify its efforts to publish and present results at international conferences, workshops, and in renowned journals to further strengthen their scientific reputation

and expertise in the area of computer networks and distributed systems, specifically TSN and SDN. The efforts in developing an open-source simulation platform will continue with the goal to establish the DETERMINISTIC6G simulator as a prominent tool for the community to evaluate concepts in TSN and 6G systems. To further increase the visibility of the simulator, it will be presented at summer schools and through tutorials and posters. Also, the goal of involving students in the project at an early stage through university courses and final theses will be continued.

3.3.7 B&R Industrial Automation (B&R)

B&R Industrial Automation GmbH took part in the European Wireless Conference, presenting the challenges of industrial communication in the future and providing an outlook on use-cases that outline the benefits of deterministic wireless communication in combination with TSN-enabled wired networks in the context of adaptive manufacturing.

During this project, B&R Industrial Automation GmbH will further aim to disseminate results of the project into various OPC Foundation working groups, in particular, the OPC UA FX Networking and Base Facet Working Group.

3.3.8 ORANGE (OR)

As a 5G-ACIA member, Orange is involved in the activities of a 5G-ACIA related to DETERMINISTIC6G. Orange will take the opportunity to promote its contribution to the project and the overall project results in the future, if such an opportunity is presented and if time permits, especially in one of the SNS JU working groups.

Orange remains interested in promoting the development of 6G and industrial network standards with deterministic communications, using the results of DETERMINISTIC6G. Orange may also use DETERMINISTIC6G results and findings to generate ownership and profitability in the operation of 6G networks and the provision of 6G connectivity to IT services. Orange expects the results of DETERMINISTIC6G to play an important role in industrial automation and the digital transformation of industries, in enabling new classes of IT and network services and in developing new markets within the industrial services domain by extension of the existing business-to-business market sector.

3.3.9 IUVO

IUVO contributed to the following dissemination activities: i) material preparation for a presentation about DETERMINISTIC6G project, held at the SNS Stream B/D Projects Workshop on KPIs and KVIs (16 May 2024, <https://smart-networks.europa.eu/event/sns-stream-b-d-projects-webinar>); ii) contribution to a journal paper submitted to IEEE Communications Standards Magazine. At least another scientific contribution (journal or conference paper) is expected to present the simulation environment for the exoskeleton use case scenario (WP4).

3.3.10 SCUOLA SUPERIORE DI STUDI UNIVERSITARI E DI PERFEZIONAMENTO SANT'ANNA (SSSA)

SSSA contributed to the following dissemination activities: online interview for an Italian science newspaper; material preparation in collaboration with IUVO for the presentation about KPIs and KVIs of DETERMINISTIC6G project held at the SNS Stream B/D Projects Workshop; contribution to a journal paper submitted to IEEE Communications Standards Magazine. At least another scientific contribution (journal or conference paper) is expected to present the simulation environment for the exoskeleton use case scenario (WP4). SSSA plans to raise awareness about the outcomes of DETERMINISTIC6G in the scientific community and industrial partners on national and international level via established networks.

3.3.11 ABB

As a 5G-ACIA member, ABB participated in 5G-ACIA activities related to DETERMINISTIC6G project.

4 Conclusions and Outlook

In this document, DETERMINISTIC6G dissemination and exploitation activities implemented during the first 18 months of the project were presented. A detailed description of the available communication channels and material prepared for dissemination of the project was also provided. The document has been created with inputs from consortium partners and includes initiatives related to projects dissemination and exploitation strategy. DETERMINISTIC6G communication, dissemination, and exploitation plans have been described in the deliverable D5.1.

As per the dissemination activities, the project is contributing by publishing scientific papers, contributions to standards, keynotes and talks, panel discussion, university courses, organization of workshops, and several other miscellaneous activities. The aim is to create synergies with the operational technology players, and to communicate with the scientific community as well as with the regulators and standardization bodies in order to raise awareness of the project results.

An exploitation plan both for the project as a whole and individual consortium partners was provided. It is planned that the dissemination activities will be followed extensively also during the second half of the project to be at the forefront on the topics, concepts, and architectures developed under the project.

References

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List of abbreviations

Table 18: List of abbreviations

| | |
|-----------------|---|
| 3GPP | 3rd Generation Partnership Project |
| 5G | Fifth Generation Cellular Network Technology |
| 5G-ACIA | 5G Alliance for Connected Industries and Automation |
| 6G | Sixth Generation Cellular Network Technology |
| 6G-IA | 6G Smart Networks and Services Industry Association |
| AI | Artificial Intelligence |
| CNC | Centralized Network Controller |
| DETERMINISTIC6G | Deterministic End-to-end Communication with 6G |
| DetNet | Deterministic Networking |
| E2E | End-to-end |
| ETSI | European Telecommunications Standards Institute |
| EU | European Union |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronics Engineers |
| IETF | Internet Engineering Task Force |
| IoT | Internet of Things |
| PLC | Programmable Logic Controller |
| RAW | Reliable Available Wireless |
| SDN | Software-Defined Networking |
| SDO | Standards Development Organization |
| SME | Small and Medium-sized Enterprise |
| SNS | Smart Networks and Services |
| TAS | Time-Aware Shaper |
| TSN | Time Sensitive Networking |
| URLLC | Ultra-Reliable Low-Latency Communication |
| WI | Work Item |