Grant Agreement No: 101096307

Full Title: THz Industrial Mesh Networks in Smart Sensing and Propagation Environments

Start date: 01/01/2023

End date: 31/12/2025

Duration: 36 Months

Deliverable 7.2

Intermediate Report on Standardization, Dissemination and Exploitation Activities

Document Type	Deliverable
Title	D7.2 Intermediate Report on Standardization, Dissemination, and Exploitation Activities
Contractual due date	30/06/2024
Actual submission date	27/06/2024
Nature	R
Dissemination Level	SEN
Lead Beneficiary	BI-REX
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Revision history

Version	Issue Date	Changes	Contributor(s)
v0.1	22/05/2024	Initial document structure	Mate Boban (HWDU)
v0.2	07/06/2024	Contributions to Sections 2, 3, 4	Sara Lusini (BI-REX), Alberto Gualtieri (BI-REX), Mate Boban (HWDU), Thomas Kürner (TUBS), Per Hjalmar Lehne (TNOR)
V0.3	11/06/2024	Corrections on Sections 2, 3, 4, writing conclusions	Mate Boban (HWDU)
V0.4	17/06/2024	Further input to Section 2, editorial clean-up	Sara Lusini (BI-REX), Mate Boban (HWDU)
V0.5	17/06/2024	Further input to Section 3	Alberto Gualtieri (BI-REX)
V0.6	20/06/2024	Final editing before review	Mate Boban (HWDU)
V0.7	25/06/2024	Review of the deliverable	Varvara Elesina (TUBS), Dominik Wrana (USTUTT)
V0.8	26/06/2024	Addressing reviewer comments, finalizing deliverable	Mate Boban (HWDU)
V1.0	27/06/2024	Approved version	Danila Ferretti (CNIT), Luca Sanguinetti (CNIT)
V1.1	10/12/2024	Edits to address the mid-project review comments	Mate Boban (HWDU), Alberto Gualtieri (BI-REX), Sara Lusini (BI-REX)
V1.2	18/12/2024	Final editing	Flaminia Saratti (CNIT)
V2.0	18/12/2024	Approved version	Luca Sanguinetti (CNIT)

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List of Abbreviations

DCP	Dissemination and Communication Plan
IPR	Intellectual Property Rights
ISAC	Integrated Sensing and Communications
MIMO	Multiple-Input-Multiple-Output
RIS	Reconfigurable Intelligent Surface
SNS	Smart Networks and Services
SNS JU	Smart Networks and Services Joint Undertaking
THz	Terahertz
UE	User Equipment

Executive Summary

This deliverable summarizes the plan and provides mid-project progress for three important activities of SNS TIMES: i) dissemination and communication; ii) exploitation; and iii) standardization. In particular, dissemination and communication plan is summarized, along with the results achieved during the first half of the project are highlighted, including scientific and popular publications, organization of conferences, workshops, webinars, as well as outreach towards associations and scientific networks. Next, the exploitation plan and exploitation results achieved during the first half of the project are summarized. Finally, the standardization plan is outlined, along with the detailed description of the standardization contributions during the first half of the project, focused on ETSI and IEEE contributions related to THz use cases, spectrum regulation, as well as channel measurements and modeling.

Introduction

1.1 Scope

This deliverable summarizes the intermediate dissemination and exploitation outcomes of the project. Furthermore, it details the plan for (pre)standardization activities, including the contributions to different standardization bodies.

1.2 Audience

This report is intended for public use, in particular: researchers, engineers, policy makers and regulatory, professionals and operator, industries, 6G-IA and SNS Working groups, and general public.

1.3 Structure

The rest of the document is structured as follows:

- Section 2 provides a short overview of the dissemination and communication plan, along with the dissemination and communication results achieved during the first half of the project.
- Section 3 summarizes the exploitation plan and exploitation results achieved during the first half of the project.
- Section 4 summarizes the standardization plan and lists (pre)standardization contributions during the first half of the project.
- Section 5 concludes the deliverable.

Communication and Dissemination Activities

2.1 Summary of the Communication and Dissemination Plan

Work Package 7 (WP7) in TIMES project focuses on the dissemination and communication of the objectives and results to the external public, particularly targeting industrial stakeholders, public authorities, and the scientific community. WP7 is responsible for fostering technical discussions, facilitating collaboration with other projects, and engaging with external research forums.

TIMES dissemination and communication activities primary objectives are:
- Raise awareness on the topics addressed by the project.
- Pursue the notoriety of the project.
- Explain the main objectives of the project.
- Keep the public informed on developments and current/future activities.
- Provide a coordinated image to make all the actions easily recognizable and connected to TIMES.
- Promote both the intermediate and final outcomes of the project to industries and enterprises.
- Engage and connect with other SNS JU projects.

The TIMES communication strategy involves multiple communication channels (as seen in TIMES D7.1 Table 2.3a – TIMES Target Audience [TIMES2023-3]) and specific messages according to the target group (D7.1 Table 2.4b – TIMES messages [TIMES2023-3]), assuring the active involvement of stakeholders. TIMES project, with its ambitious goals and collaborative approach, stands as a testament to the European Union's commitment to fostering innovation and technological advancement in the digital, industry, and space sectors.

2.2 TIMES Publications

This section of the deliverable represents a comprehensive compilation of the scholarly articles, conference papers, and other academic materials produced over the course of the project. Each entry not only reflects the innovative research and collaborative efforts undertaken by our team, but also stands as a testament to the project's commitment to advancing knowledge in our field.

These works have been disseminated widely, contributing to the scientific community and ensuring that the insights and discoveries made are accessible to all stakeholders involved. This section serves as both a record of our achievements and a resource for future research endeavours. TIMES publications up to now are summarized in Table 1.

Table 1. List of TIMES publications.

Title	Author(s)	Venue	Date	DOI
LoS MIMO-Arrays vs. LoS MIMO-Surfaces	Marco Di Renzo, Davide Dardari, and Nicolo Decarli	17th European Conference on Antennas and Propagation (EuCAP 2023)	5/31/2023	10.23919/EuCAP57121.2023.10133498
Radio SLAM for 6G Systems at THz Frequencies: Design and Experimental Validation	M. Lotti, G. Pasolini, A. Guerra, F. Guidi, R. D'Errico, and D. Dardari	IEEE Journal of Selected Topics in Signal Processing	6/12/2023	10.1109/JSTSP.2023.3285101
Adapt and Aggregate: Adaptive OFDM Numerology and Carrier Aggregation for High Data Rate Terahertz Communications	Lutfi Samara, Tommaso Zugno, Mate Boban, Malte Schellmann , and Thomas Kürner	IEEE Journal of Selected Topics in Signal Processing (JSTSP)	6/13/2023	10.1109/JSTSP.2023.3285448

NLOS Localization Exploiting Frequency-selective Metasurfaces	M. Lotti, G. Calesini, D. Dardari	IEEE International Conference on Communications (ICC 2024)	7/24/2023	10.1109/ICCWorkshops59551.2024.10615308
Reconfigurable Electromagnetic Environments: A Signal Processing Approach	Davide Dardari	International Conference on Electromagnetics in Advanced Applications (ICEAA 2023)	10/31/2023	10.1109/ICEAA57318.2023.10297738
Metaprism-aided NLOS Target Localization	Marina Lotti and Davide Dardari	31st European Signal Processing Conference (EUSIPCO 2023)	11/1/2023	10.23919/EUSIPCO58844.2023.10290002
Highly-Compact 20-mW, 270--320-GHz InGaAs mHEMT Power Amplifier MMIC	Laurenz John, Axel Tessmann, Sandrine Wagner, Arnulf Leuther	International Microwave Symposium (IEEE MTT-S 2024)	2/15/2024	10.1109/IMS40175.2024.10600274
Terahertz Communications for Industrial Manufacturing: a Use Case Analysis	Tommaso Zugno, Lutfi Samara, Mate Boban, Per Hjalmar Lehne, Thomas Kurner	IEEE Conference on Standards for Communications and Networking (CSCN 2023)	3/4/2024	10.1109/CSCN60443.2023.10453153
Characterization of Propagation in an Industrial Scenario from Sub-6 GHz to 300 GHz	Diego Dupleich; Alexander Ebert; Yanneck Völker-Schöneberg; Damir Sitdikov; Mate Boban; Lutfi Samara; Giovanni Del Galdo; Reiner Thomä	IEEE Global Communications Conference (GLOBECOM 2023)	3/21/2024	10.1109/GCWkshps58843.2023.10464485
Channel Measurements in an Industrial Environment for Access Point-to-Sensor Communication at 300 GHz	Carla E. Reinhardt, Varvara V. Elesina, Johannes M. Eckhardt, Tobias Doeker, Lucas C. Ribeiro, Thomas Kürner	German Microwave Conference (GeMIC 2024)	4/4/2024	10.23919/GeMiC59120.2024.10485341
Channel Measurements in Workspace with Robotic Manipulators at 300 GHz and Recent Results	Varvara V. Elesina, Carla E. Reinhardt, Thomas Kürner	18th European Conference on Antennas and Propagation (EuCAP 2024)	4/26/2024	10.23919/EuCAP60739.2024.10501210
Characterization of Propagation from Measurements at sub-THz for ISAC Applications in an Emulated Dynamic Industrial Scenario	Diego Dupleich , Alexander Ebert, Yanneck Völker-Schöneberg, Damir Sitdikov, Mate Boban, Giovanni Del Galdo, and Reiner Thomä	18th European Conference on Antennas and Propagation (EuCAP 2024)	4/26/2024	10.23919/EuCAP60739.2024.10501207
Direct Clustering and Multi-Path Component Identification on THz Channel Measurements in a Factory Environment	Mengfan Wu, Tommaso Zugno, Mate Boban, Falko Dressler	18th European Conference on Antennas and Propagation (EuCAP 2024)	4/26/2024	10.23919/EuCAP60739.2024.10501254
Ray Tracing and Measurement-Based Characterization of Inter/Intra-Machine THz Wireless Channels	Steffen Pahlke, Tommaso Zugno, Mate Boban, Diego Dupleich, Thomas Kürner	18th European Conference on Antennas and Propagation (EuCAP 2024)	4/26/2024	10.23919/EuCAP60739.2024.10501627

The integrated sensing and communication revolution for 6G: vision, technologies, and applications	Nuria Gonzalez-Prelcic, Musa Furkan Keskin, Ossi Kaltiokallio, Mikko Valkama, Davide Dardari, Xiao Shen, Yuan Shen, Murat Bayraktar, and Henk Wymeersch	Proc. of the IEEE	5/22/2024	10.1109/JPROC.2024.3397609
RIS-Empowered Near-Field Imaging in NLOS Scenarios	Giulia Torcolacci, Anna Guerra, Haiyang Zhang, Francesco Guidi, Qianyu Yang, Yonina C. Eldar, Davide Dardari	IEEE International Conference on Communications (ICC 2024)	5/29/2024	10.1109/ICCWorkshops59551.2024.10615296

2.3 Conference and Workshop Organizations

The strategic dissemination and communication plan for the TIMES project is set to engage a wide audience, encompassing both the general public and the scientific community. This initiative will leverage a variety of platforms, including external events, conferences, and sector-specific fairs, to ensure broad visibility and impact.

Integral to this effort is the collaborative involvement of all consortium members, who will contribute their expertise and insights. The WP7 Leaders, spearheaded by BI-REX, have undertaken a proactive approach by compiling a dynamic list of potential events that align with the project's objectives. This list, detailed in D7.1 Table 2.9a [TIMES2023-3], serves as a living document, reflecting the collective input of the partners and adapting to emerging opportunities for dissemination.

The comprehensive involvement of the consortium and the meticulous planning shown in are indicative of the project's commitment to effective communication and outreach.

Table 2. List of TIMES dissemination activities.

Dissemination Activity Name	Description	Date
IEEE P802.15 Working Group for Wireless Speciality Networks	The TIMES project showcased advancements in Terahertz technology for wireless communications at the Working Group for Wireless Specialty Networks (WSN), fostering collaboration and driving industry standards within the IEEE 802.15 community.	1/15/2023
ETSI Research Conference	This face-to-face event provided an exceptional opportunity for the research community to come together with industry representatives and standardization experts to discuss future technology research and links to standardization developments.	2/6/2023
Wireless World Research Forum Meeting 49 (WWRFM 49)	The TIMES project shared advancements developed within the project that fostered collaborations towards sustainable and automated communications at Wireless World Research Forum Meeting 49.	3/30/2023
6G Symposium Spring	The 6GSymposium Spring 2023 brought together the international community to build consensus on key issues and further the momentum towards 6G.	4/24/2023
European Conference on Networks and Communications (EUCNC 2023)	At EuCNC & 6G Summit, TIMES showcased the state of the art of research in communication networks and associated topics, participating in a video Interview for the Smart Networks and Services Joint Undertaking (SNS JU).	6/6/2023

Smart Networks and Services Joint Undertaking Steering Board Meeting (SNS JU SB meeting)	The meeting brought together several EU-funded projects to establish interactions and facilitate collaboration among them. During the event, project coordinators were able to share their experiences and collaborate on ways to advance the SNS JU.	9/5/2023
IEEE Conference on Standards for Communications and Networking (IEEE CSCN 2023)	The IEEE CSCN 2023 delivered a rich technical program discussing the future of mobile communications systems, offering distinguished Keynotes, Panels, Tutorials and Technical Sessions. Together with two other SNS projects (6G-SHINE and TERRAMETA), SNS TIMES organized a Special Session on "Key challenges for enabling high-performance short-range communications in extreme propagation environments" (https://cscn2023.ieee-cscn.org/program/special-session).	11/6/2023
Hexa-X-II workshop	TIMES participated in a Hexa-X-II workshop, diving into Enablers for 6G system blueprint with a presentation on Wireless Communication Technologies and Signal Processing.	1/26/2024
Joint SNS Workshop TIMES, 6G-SHINE, TERRAMETA, in synergy with RESTART-IN	TIMES organized and presented in a joint Workshop with 6G-SHINE, TERRAMETA, and RESTART-IN in February 2024. This collaboration marked an important step in our journey towards exploring Smart Propagation Environments, Signal Processing Enhancements, 6G-Oriented Networking and Localisation.	2/6/2024
Presentation at University of Bologna (UniBO)	We hosted a lecture at University of Bologna to inspire innovation and share insights on 6G's potential in industry.	2/23/2024
IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP 2024)	Stemming from its WP3 work on channel modelling, SNS TIMES was invited to give a keynote on Radio Maps at Workshop on Radio Maps and Their Applications (RMA), held as part of IEEE ICASSP 2024.	4/22/2024
Hannover Messe 2024	The TIMES project aimed to engage with industry leaders, showcase research, and explore Industry 4.0 solutions at Hannover Messe in a panel with 6G-SHINE.	5/3/2024
Stem Day	TIMES organized and hosted a visit from high school students from Serbia and Croatia in the BI-REX's Pilot Plant. The objective was to inspire innovation among students by demonstrating the transformative potential of 6G technology in industry.	6/3/2024
European Conference on Networks and Communications (EUCNC 2024)	The project participated at the EuCNC & 6G Summit in a joint booth with Terrameta, Converge and Superiot and gave a presentation at the Hexa-XX II 6G Series Workshop titled "TIMES: Channel Characterisation in Industrial Environments at 300 GHz".	6/9/2024
IEEE International Conference on Communications (ICC 2024)	TIMES project showcased advancements, fostered collaborations, and engaged with global experts at IEEE ICC 2024 by co-organizing the industrial panel "Key challenges for high-performance 6G communications in smart environments" in collaboration with 6G-SHINE, 6GTandem and TERRAMETA.	6/10/2024
Green and Sustainable Wireless Networks Webinar	The Green and Sustainable Wireless Networks Webinar is a forward-thinking event that addresses the pressing need for eco-friendly and energy-efficient wireless communication systems. It brings together experts and industry	7/3/2024

	leaders (Huawei and Telecom Italia) to discuss innovative strategies and technologies that can reduce the carbon footprint of wireless networks.	
SSIE – IEEE Italy Section PhD Summer School	Based on WP3 work on channel modelling, SNS TIMES was invited to give a talk "Learning the radio environment: building radio maps with learning-based methods" at the SSIE – IEEE Italy Section PhD Summer School https://ssie.dei.unipd.it/technical-program-ssie-2024-track-1/	7/10/2024
European Microwave Week 2024	TIMES' participation in the European Microwave Week highlights the organization's commitment to advancing microwave technology and fostering industry collaboration. The project aims to disseminate research findings in a workshop with 6G-SHINE.	9/22/2024
IEEE Conference on Standards for Communications and Networking (IEEE CSCN 2024)	Together with two other SNS projects (6G-SHINE and TERRAMETA), SNS TIMES organized a Special Session on "Key enablers for integrated sensing and communications in industrial environments" (https://cscn2024.ieee-cscn.org/special-sessions-0#SS3).	11/25/2024

2.4 Dissemination Activities towards Scientific Associations and Networks

The dissemination of research findings to scientific associations and networks is a pivotal component of any European project. It ensures that the knowledge generated reaches the widest possible audience, facilitating the exchange of ideas and fostering collaborative opportunities.

By effectively disseminating our findings, we aim to contribute to the scientific community's collective knowledge and encourage the practical application of our research outcomes.

2.4.1 COST INTERACT

The COST CA20120 Action, known as COST INTERACT (https://interactca20120.org/), is dedicated to advancing radio network intelligence. This initiative strives to surpass existing network capabilities by integrating intelligence directly into the radio network infrastructure. Through comprehensive research in antenna technology, signal processing, localization, and network protocols, COST INTERACT is committed to developing innovative solutions for intelligent radio communications. It also focuses on gathering empirical data for the broader research community. Working Group 1 (WG1) within COST INTERACT concentrates on understanding radio channels both theoretically and experimentally, creating models that aid in the design and planning of future wireless systems. WG1 tackles a spectrum of challenges, from sub-GHz to THz frequencies, exploring massive antenna arrays and intelligent surface technologies, crucial for the SNS TIMES project. Notably, WG1's sub-group on mmWave and THz is pioneering in THz channel sounder design and metrology. The outcomes of COST actions, such as standardized channel models referenced in publications like [Liu2012], are significant contributions to the field. COST INTERACT also produces white papers, collaborative research papers, and project proposals, culminating in a comprehensive book that encapsulates the action's major discoveries.

2.4.1.1 Contributions by SNS TIMES to COST INTERACT

Since its inception, SNS TIMES has been a pivotal participant in the COST INTERACT project, engaging from the outset and offering substantial technical expertise during the COST INTERACT assemblies. The consortium, comprising esteemed members such as CNIT and HWDU, has not only contributed to the project's leadership but has also been instrumental in steering the direction of the action.

The collaborative efforts of SNS TIMES, including key institutions like TUBS, HWDU, and CNIT, have yielded over ten technical contributions in the form of Temporary Documents (TDs), which serve as a standard modality for contributions within COST actions. These contributions have primarily centered on the intricate aspects of channel measurements and modeling within the THz frequency bands, emanating from the TIMES WP3 initiative. Although COST TDs are not publicly accessible, a significant portion of the insights garnered from the TIMES contributions has been assimilated into the widely available COST INTERACT WG1 White Paper. This document, titled "Radio Channel Modeling and Prediction to Support Future Environment-aware Wireless Communication Systems," and cited as [Bob2023], has been enriched by the substantial input from SNS TIMES members, particularly in the technical discourse of Sections 3, 6, and 7, as well as their editorial acumen.

Looking ahead, SNS TIMES is committed to sustaining its influential role within COST INTERACT by persistently delivering technical insights, especially pertaining to channel measurements and modeling in THz bands for industrial settings, as delineated in WP3. Additionally, the consortium is poised to play a significant part in synthesizing the final compendium of COST INTERACT – a comprehensive volume encapsulating the paramount discoveries of the action. This endeavour will not only reflect the culmination of the project's achievements but also serve as a testament to the collaborative spirit and intellectual rigor that SNS TIMES has consistently brought to the table.

2.4.2 one6G

one6G (https://one6g.org/) is an independent, non-profit association dedicated to the evolution, testing, and promotion of pioneering cellular and wireless solutions. Its primary mission is to expedite the adoption of 6G technology and enhance its market presence by fostering research and standardization initiatives. The organization is composed of specialized working groups that unite industry professionals, academics, and government representatives. Collaborating with multiple partners from the SNS TIMES consortium, such as CNIT, TUBS, HWDU, and TNOR, one6G serves as a vital conduit for the dissemination and demonstration of project milestones to a broader expert community. Notably, Working Group 2 is delving into the technological underpinnings of 6G, addressing several areas also covered by the SNS TIMES project, including terahertz communication, integrated sensing and communication, and advancements in 6G radio technology. For instance, TUBS and HWDU are making significant contributions to a project on terahertz communication, while CNIT is actively involved in a project focused on integrated sensing and communication. These efforts are encapsulated in the "6G Technology Overview" white paper, published by one6G [one6G2023]. Moving forward, SNS TIMES is committed to ongoing contributions to pertinent one6G projects and to the promotion of the results achieved within the framework of the association.

2.4.2.1 Contributions by SNS TIMES to one6G

The members of SNS TIMES, specifically TUBS, HWDU, and CNIT, have made significant contributions to the one6G initiative, focusing on the development of terahertz communications and integrated sensing and communications. Their work has been recognized and incorporated into the influential white paper titled "6G Technology Overview," [one6G2023], particularly in sections 1 and 4, which detail the advancements in these cutting-edge technologies. This acknowledgment highlights the collaborative effort and expertise within the SNS TIMES community, contributing to the evolution of 6G technology.

SNS TIMES members TUBS, HWDU, and CNIT have contributed to one6G work items on terahertz Promotion of SNS TIMES standardization activities within 6G-IA

SNS TIMES actively contributed to the advancement of standardization within the 6GIA framework by

delivering a key presentation on February 21st within the 6GIA pre-standardization working group (https://6g-ia.eu/6g-ia-working-groups/#pre-standardization). This presentation highlighted the project's commitment to shaping the future of 6G technology through collaborative pre-standardization efforts. By engaging with the 6GIA pre-standardization working group, SNS TIMES is at the forefront of defining the next generation of communication standards, ensuring that their innovative approaches are integral to the global 6G landscape.

Exploitation Activities

3.1 Exploitation Plan

The ultimate objective of TIMES is to strengthen the European capability on 6G (and beyond) technology, providing solutions for highly efficient and productive value chains encompassing the whole range of activities. In order to reach TIMES expected impacts, the Consortium is setting up an exploitation strategy of the project's fundamental results. In this context, TIMES partners are in a favourable position in capitalising the outcomes of the project activities, dissemination, and demonstration.

TIMES exploitation strategy is based on the following two main pillars:

- IPR Management, which addresses the ownership of the IPR, and the management of the access rights to such IPR by the project partners.
- The Exploitation Plan, which presents the methodology and approach for the exploitation of the results generated during the project and provides outlines of the individual exploitation plans for the expected results.

These pillars will be described in this document. At the end of the project, the final exploitation plan will elaborate the real exploitation strategy based on actual achieved results. This final deliverable will also incorporate and refine the preliminary strategy designed to exploit at best the results achieved, with respect to the partners' practices.

Given that, mainly through patents and publications, most partners intend to produce some form of IP during this project, IPR management is fundamental to a successful collaboration and subsequent exploitation of results obtained in this project. With the advancement of the project, the emerging result will be subject of IPR analysis with the objective to assess the existing IPR and the possible potential management of the generated IPR.

The purpose of the preliminary exploitation plan is collecting and gathering the contributions of all TIMES partners engaged in exploitation activities, to create a business and exploitation plan that will explore the potential for the development and exploitation of the expected results during and beyond the life of the TIMES project. Exploitation focuses on the mid- and long-term use of the project's results in further research and in the development, creation, and marketing of new products and processes. The TIMES project is expected to deliver its exploitable results by the year 2026 the latest. Therefore, this document provides a preliminary description of the approach to the exploitation, expected results, and required activities for creating impact (Table 3 – Exploitation strategy).

More specifically, the objectives of this document are:

- Outline the approach towards intellectual property rights and protection.
- Identify the project's exploitable results, suitable for further use in research and industrial exploitation.
- Outline a possible approach for effective, future exploitation of the project results.
- Align project activities related to the exploitation.

This document does not make any decision on how the TIMES project results must be implemented but

aims to offer various alternatives for consideration. In the course of the project, this preliminary plan for exploitation and impact creation will be updated and finalized in the deliverable D7.3 “Final Report on Standardization, Dissemination and Exploitation Activities”.

Table 3. Exploitation strategy

Partner	Exploitation strategy
TUBS	TUBS will exploit the results from the TIMES project in order to enhance current lecture and research topics. The involved Ph.D. students will benefit from the results of TIMES as basis for their Ph.D. thesis. The results will be exploited by papers and talks at international conferences and high-quality journals. The in-house developed Simulator for Mobile Networks (SiMoNe) will be enhanced by expanding its functionality and integrating outcomes from the TIMES project. This will improve current research activities as well as lectures and collaboration with industry partners where SiMoNe is involved.
CNRS	As an academic partner and member of local and national valorisation clusters, CNRS will first exploit the TIMES results in terms of publications in scientific journals, international conferences, and young researcher training and experience. A second set of guidelines for exploitation can be highlighted: as the infrastructure will be used/adapted for TIMES, the development of the THz communication cluster established in CNRS would be a clear exploitation plan as an outcome of the TIMES project. As a follow-up of new use-cases to be developed, potentially new patents could be considered, as the project addresses new usages and scenarios for THz communications that are beyond the actual scope at CNRS and/or THz communications in general.
USTUTT	USTUTT will benefit from TIMES through intensification of its research activities in the field of mmW and sub-mmW circuit design. The project contributes to USTUTT and its international visibility through publications and presentations at internationally renowned conferences and scientific journals. The involvement of undergraduate students in the project e.g., through B.Sc. and M.Sc. theses improves the quality of education for the university’s students, enabling them to participate in a cutting-edge research topic. As a non-profit organization, USTUTT does not seek a direct commercial exploitation of the project results but uses them to apply for follow-up projects on the national and international level. Furthermore, TIMES will enable USTUTT to offer advanced research and development services to Europe’s key industry.
CNIT	CNIT will exploit the results of participation to TIMES in several directions: 1) Offering enhanced competence to industry partners in the field of automation and mechatronics. 2) Offering enhanced competence to telecom operators in Italy. 3) Offering enhanced competence to SMEs in the field of electronics for telecommunications, for those investing in THz communications. 4) Using the competence acquired in the context of IoT Academies. 5) Using the knowledge and methodology developed in the project within the academic courses taught at the University of Bologna and Pisa, at M.Sc. and PhD level.

	6) Increasing the number of publications in scientific journals and conferences. All these activities will make CNIT a reference point in the National Community for Industrial IoT applications; moreover, it will reinforce its position in the international scientific community. Finally, and more importantly, this exploitation plan will support the economic growth of Italy, which is driven by the manufacturing industry sector, in particular in the field of automation and mechatronics.
FRAUNHOFER	The results of TIMES, including the development of novel low-cost THz front-end integration technologies for higher volume manufacturing, will be key products to attract industry partners and SMEs. In addition, publications and hardware demos on exhibitions are used to strengthen FRAUNHOFER's reputation in the field of high-frequency technologies and applications.
BI-REX	The results will be used to offer consultancy and test before investing services to companies, in particular small and medium enterprises. The companies can visualize the application of scientific knowledge and perform test in BI-REX pilot plant.
HWDU	The results will be exploited by a) generating intellectual property to protect key technological outcomes of the project; b) for local talent development and industrial PhD training; and c) subsequent cooperation with academic and industrial partners in Europe.
TNOR	The results will be used to develop business plans for Industrial IoT (IIoT) and other vertical based services. Also, the technical outcomes are important to determine the challenges with high frequency communications both with respect to limited coverage, but also to ensure sustainable operations.
ANT	Anteral will exploit the results of the TIMES project to publish research articles in journals and conferences, showcasing its capabilities and knowledge to the community, in order to increase the trust of future clients and demonstrate new capabilities in the design of high-performance high-frequency devices. Likewise, the results will serve to expand the company's standard product portfolio and design and consulting services offered, which will directly impact new and increased sales and a more solid business model.
AETNA	AETNA is owner of TECHLAB in Italy and also of three other TECHLABs in Spain, Germany, and USA (Atlanta). During the TIMES project, the final results achieved in the Italy TECHLAB will be presented to the others with the idea to extend the results to all TECHLABs. AETNA Group has 15 commercial subsidiaries and 7 production sites (AETNA Partners) around the world. AETNA will organize informative meetings with AETNA Partners to present the TIMES results and demonstration. The objective is to expand the market of future wireless networks to the industrial partners. The results will be used to offer a better product in automatic packaging machine market, using high frequency communication to provide a better internal machine architecture and sensing.

3.2 Exploitation Activities

In order to collect information from the partners and to monitor the progress of the results achieved during the implementation phase of the project, specific survey tools (questionnaires) focused on the definition of Key Exploitable Results have been prepared and submitted to all the partners. The first result of the survey

will be discussed during the F2F meeting (26-27 June 2024), the inter-partner discussion aims to cluster the results based on similarities and define mixed partner working group.

The survey activity will be repeated during the duration of the project and finalized in the deliverable D7.3, Final Report on Standardization, Dissemination and Exploitation Activities (M36).

As the results are made available, an analysis of the market potential will be carried out.

An attempt to quantify the market and business opportunities for each type of product and technology developed within the project will be made. Potential markets, both in economic and geographical size, will be analyzed and mapped through the available platform, using the following methods:

- Analysis of the patent portfolio of international companies holding patents on technologies similar to those adopted in the project. The platform will be queried using targeted keywords.
- Analysis of the sectors of economic activity (number of companies, turnover trend, economic trend of the value of the patent portfolio) with the aim of identifying the main competitors.
- Identification of companies with patents and/or innovation systems similar to the technologies adopted by the project partners.
- Identification and analysis of sector reports in the context of wireless telecommunication and/or selected manufacturing industry at the level of individual countries and international scenario.

3.3 Exploitation Channels and Strategies

The exploitation of the expected/achieved results, mapped through the tools presented in the previous section, will be supported by several specific actions, including workshops, training courses and dissemination actions, ad hoc communication, availability of results and knowledge acquired in open source format. As far as exploitation channels are concerned, different modalities will be used, as summarised in Table 4.

Table 4. List of exploitation channels

Exploitation channel	Description
Use by the Creator	"Use by the creator" means that the IP gets used in: • Further R&D • The integration into existing product/processes/services • The production/marketing as a new offer The integration into existing business means that the IP gets used to create a competitive advantage, either in the form of a cost-cutting mechanism (for example in the case of a process innovation or a new material) or by product differentiation (which should result in an improved customer perception and higher value of the solution.
Licensing	A licence agreement is a contract that grants a third party (licensee) the right to use the IP of the IP holder for a defined purpose, within the limits set by the provisions of the contract. In general licensing will provide the IP holder with certain financial provisions. Various types of licensing are known, including exclusive, non-exclusive and sole.

Joint ventures/ strategic alliances	Joint ventures are a type of collaborative commercialisation. It is a situation where two or more parties jointly commit resources and research efforts to projects. Joint venture may range from short-term projects to long-lasting strategic partnerships with multiple members and stakeholders. More specifically, the parties to the joint venture share risks and contribute with their intellectual capital to technology research and development, production, marketing and further commercialisation.
Sale of technology	Outright sale of technology through the transfer of the ownership of IP form one party to another party, where the latter becomes the new owner of the IPR
Collaborative research	Commercialization of research results through collaboration of academia with one or more industrial partners. Issues involving the ownership of IP are facilitated through contracts, covering ownership scenarios, exploitation of results and licensing rights issues.
Start-up / Spin-off company	A spin-off refers to a separate company usually established to bring IP onto the market. It is deemed to be a valuable channel to transform the generated results into product and service, as well as to license out technology. Most importantly, spin-offs are considered as a fundamental mediator between the research environment and industries as they are a powerful means of technology transfer between these two sectors

Finally, for each technological result with commercial potential developed in the project, an economical and scientific exploitation analysis will be prepared. The analysis will highlight the market scenario, the main target segments and business forecasts.

3.4 Preliminary Key Exploitable Results

The TIMES Project aims to produce several results with high scientific and industrial impact, which could be considered for further exploitation.

With this objective, an initial analysis of the key exploitable results to be achieved, their potential means for exploitation, markets to be addressed and eventual IPR protection measures foreseen, has been carried out, shortlisting in Table 5 those which are expected to have a higher potential for market uptake.

Table 5. Overview of most significant results expected throughout the TIMES project

Code	Partner	Result Title	Commercialization strategy	Potential partnership	Available IPR management strategy	Market potential
R1	CNIT, HWDU	LoS-MIMO capacity evaluations in RIS-enhanced factory environments	Create simulation software or tools that can be licensed to factory automation companies and network designers.	Partner with smart factory solution providers to embed the technology into their systems.	Publish key findings on capacity evaluation in RIS-enhanced factory environments.	As Industry 4.0 continues to evolve, the market for smart factory solutions is expected to grow substantially, offering vast opportunities for advanced communication technologies.
R2	HWDU	Waveform design for THz ISAC	Develop software libraries or firmware updates that can be sold to manufacturers of sensing and communication devices.	Work with manufacturers of IoT and smart sensing devices to integrate the waveform design into their products.	Patent the developed waveform and partner for commercialization.	The integration of sensing and communication is crucial for smart cities and IoT applications, providing a large and expanding market for this technology.
R3	HWDU	Impact of RF impairments on RIS-based networks	Offer consultancy services to companies looking to optimize their RIS-based networks or develop custom solutions.	Engage with telecom operators to test and implement the findings.	Publish key findings to inform the telecom actors of the relevance of impairments; patent any mitigation techniques developed.	The adoption of RIS in telecommunications can significantly enhance network performance, with a potential market size in the hundreds of millions as 5G and beyond technologies mature.

R4	HWDU	Method for cooperative and distributed blockage prediction	Develop a software tool or module that can be integrated into existing network management systems.	Collaborate with network equipment manufacturers and service providers to incorporate the prediction method into their products.	Implement the prediction algorithms into future products to improve performance.	With increasing deployment of dense networks and reliance on high-frequency bands, the market for advanced blockage prediction tools is expected to see significant growth.
R5	ANT	New devices at sub-THz frequencies	Expand the product catalog and market the new devices directly to customers in high-frequency communication sectors.	Partner with telecommunications companies and research institutions to further test and improve the devices.	Patent the new devices and consider forming strategic alliances for global distribution and application.	The demand for high-frequency devices is growing rapidly with the advent of 5G and beyond, making this a lucrative market with potential in various high-tech sectors.
R6	ANT	Beamsteering Antenna (Non-Static)	Develop prototypes and seek collaborations with manufacturing industries and other industries to demonstrate its effectiveness.	Partner with telecommunications companies and research institutions to further test and improve the devices. Collaborate with Industrial partner to validate the market	File patents for the antenna design and negotiate licensing agreement.	The potential for expansion into aerospace suggests significant advancements in communication systems for aviation and space exploration.
R7	ANT	Intelligent Reflecting Surface	Develop and market IRS technology to improve signal strength and coverage.	Collaborate with telecom operators and network infrastructure companies to test and deploy the technology.	Patent the IRS technology and seek licensing agreements for broad application.	This innovative technology is poised to revolutionize signal transmission, presenting a key area for future development and market growth.
R8	FRAUNHOFER	Chip-to-Waveguide transitions	Develop THz components with these components as key building block, not available as stand-alone component	Partner with industrial partners to develop high-frequency components	Only internal IP, not shared with partners/customers	The RF front-end component market is rapidly expanding, where these components are required as key building blocks

R9	FRAUNHOFER	Low-Cost Packaging Technology	Develop prototype modules to attract new partners/customers from industry.	Collaborate with communication equipment manufacturers and users to develop novel front-end solutions	Secure patents where possible and publish research results	The need for low-cost packaging solutions is key for a commercial usage.
R10	FRAUNHOFER	Integrated Signal Generation	Develop PLL prototypes which will be used as key building block of novel RF front ends	Collaborate with communication equipment manufacturers and users to develop novel front-end solutions	Secure patents where possible and publish research results	An integrated, low-cost, signal generation block will significantly improve the value/functionality of front-end modules which significantly increased the market potential of the front ends
R11	FRAUNHOFER	300-GHz Power Amplifiers	Produce and sell high-power amplifiers directly or through licensing agreements with major electronics manufacturers.	Collaborate with companies in wireless communications and other sectors needing high-frequency amplification.	File patents for the amplifier designs and explore co-development or joint venture opportunities for large-scale production.	The high-frequency power amplifier market is critical for future wireless communication systems, offering a market potential in the high hundreds of millions, especially with 6G development.
R12	CNRS	Testbed for the measurement of the new reflective surface technology	Develop prototypes and run extensive tests to validate the technology.	Partner with research institutions and industrial stakeholders to ensure technology viability.	Secure patents for the testbed design and explore strategic partnerships for commercialization.	The successful validation of this technology could lead to significant improvements in signal processing and transmission, opening new market opportunities.
R13	CNRS, ANT	Knowledge and Dataset based on the validation of the new device	Utilize the generated data to enhance current and future projects.	Collaborate with academic and industrial partners to disseminate findings and leverage the data for innovation.	Disseminate intellectual property through publications to establish thought leadership.	This endeavour will enrich the knowledge base, providing a foundation for future technological advancements and collaborations.
R14	CNRS	Master level learning module based on the test results of the new antenna	Develop and integrate the learning module into educational programs.	Partner with educational institutions to implement the module in relevant courses.	Disseminate the educational content through publications.	This initiative will enhance the educational curriculum, fostering the next generation of experts in antenna technology and related fields.

R15	AETNA	Industrial POC application results	Develop a robust wireless solution for industrial environments and market it as a flexible alternative to wired connections.	Engage with industrial automation companies and OEMs to pilot and adopt the wireless solution in their operations.	Consider patents for the wireless connectivity solutions and partnerships with industries for implementation.	As industries move towards greater automation and flexibility, the market for industrial wireless solutions is expected to expand significantly, offering opportunities worth hundreds of millions.
R16	USTUTT, FRAUNHOFER, ANTERAL, CNRS	Highly integrated RF front-ends and antennas with beam steering capabilities	Develop and produce advanced RF front-ends and antennas and market them to telecom and manufacturing industries.	Partner with leading telecom equipment manufacturers to integrate beam-steering capabilities into their products.	Patent the RF front-end designs and beam steering technology, and establish licensing agreements.	The RF front-end market is rapidly expanding, driven by the need for advanced communication systems. The market potential is significant, especially with the growing demand for high-frequency and beam-steering technologies in manufacturing and telecommunication sectors.
R17	CNIT	Development of AI-based routing algorithms for multi-hop THz networks	Develop and validate routing algorithms that can be implemented in future THz chipsets.	Device manufacturing companies, smart factory solution providers, telecom operators.	Publish the key findings validated through network simulations, highlighting their robustness and applicability. Additionally, the routing scheme might show potential for patentability.	To support highly demanding industrial applications, such as digital twins or real-time remote control, current wireless technologies are insufficient. The vast bandwidths offered by THz frequencies can serve as key enablers for these applications. However, at these frequencies, coverage becomes a significant challenge, necessitating the deployment of multi-hop strategies in a simple yet efficient manner.

Standardization

4.1 Contribution Plan to (Pre-)Standardization Activities

Due to events external to the project that occurred after the project proposal writing, such as the establishment of ETSI Industry Specification Group on THz communications (ETSI ISG THz: https://www.etsi.org/committee/2124-thz), establishment of a sub-working group on mmWave and THz sounding within COST INTERACT (https://interactca20120.org/wgs/radio-channels/) as well as contributions to the IEEE 802.15 Standing Committee THz (SC THz), input to pre-standardization and standardization associations from SNS TIMES has started well ahead of the planned schedule, which was in M16. As a result, SNS TIMES has provided significant contributions to these associations during the first 18 months of the project execution. In particular:

- The output of the work on use cases and KPIs in WP2 and channel modelling and spectrum work in WP3 has been contributed to ETSI ISG THz;
- A general project description and the work on channel characterisation has been contributed to IEEE 802.15 SC THz.
- The activities on channel measurements and modelling in THz bands has been provided as input to COST INTERACT.

Details of the specific contributions and the results can be found in Section 4.2. In addition to standardization contributions, standardization and pre-standardization efforts have also been promoted within relevant bodies, such as the 6GIA Pre-standardization working group (https://6g-ia.eu/6g-ia-working-groups/).

In this section, we detail the ongoing standardization engagement plan with key associations as carried out by the project. Depending on whether related activities arise, SNS TIMES might engage with pre-standardization and standardization associations other than those listed below. Some further relevant associations include 5G-ACIA, NGMN, 3GPP, etc.

4.1.1 ETSI Industry Specification Group (ISG) on THz Communications

ETSI ISG THz aims to establish the technical foundation for the development and standardization of THz communications (0.1-10 THz) in the future. In particular, it has performed the work in the following directions:

- Definition and selection of relevant use cases for THz communications, including mapping of selected use cases to relevant channel measurement scenarios. This work was carried out as part of Work Item “Identification of use cases for THz communication systems”, which generated a group report on use cases [ETSITHz001]
- Definition of frequency bands of interest. This work was carried out as part of Work Item “Identification of frequency bands of interests for THz communication systems”, which generated a group report THz spectrum [ETSITHz002]
- Analysis of existing work in the area of THz channel measurements and modeling and performing of radio channel measurements and modeling. This work is ongoing and is being carried out as part of Work Item “Channel measurements and modeling in THz bands”.
- Modeling of RF hardware components for THz communications systems. This work is ongoing and is being carried out as part of Work Item “RF Hardware Modeling”.

ETSI ISG THz is currently focused on producing informative documents such as Group Reports (GR) and white papers, which contain a systematic output on use cases, frequency bands of interest, channel models, system parameters, RF models and evaluation assumptions for the future evaluation of THz communication systems.

From its inception, SNS TIMES has cooperated closely with ETSI ISG THz. TIMES consortium members (TUBS, HWDU, TNOR) are founding members of ETSI ISG THz and are actively participating in the leadership of the ISG THz (as chair, vice-chair, and rapporteurs). The activities of TIMES in WP2 on use cases and KPIs for industrial THz systems, and of WP3 on THz frequency bands of interest, channel measurements and modeling are directly related to the past and ongoing work of ETSI ISG THz. In addition to already provided contributions to ISG THz (detailed in Section 4.2), TIMES plans to provide further output from TIMES WP3 to the channel measurements and modeling work item WI3 (https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=67530) in ETSI ISG THz in the forms of technical contributions provided by one or more of SNS TIMES consortium members that are also members of ETSI ISG THz.

4.1.2 IEEE 802.15.3 SC THz

The IEEE 802.15 Standing Committee Terahertz (IEEE 802.15 SC THz) is chartered to explore the feasibility of Terahertz for wireless communications. A spin-off of this group in 2017 IEEE std. 802 has published IEEE Std 802.15.3d-2017 [IEEE802153d] as the first wireless standard for 300 GHz for fixed point-point links and published a revision in IEEE Std 802.15.3-2023. IEEE 802.15. SC THz is observing the advances in THz Communications research, which may trigger further concrete standardisation projects leading to a further amendment of IEEE Std 803.15.3-2023 or a completely new standard. Apart from there are important regulatory aspects to be considered. For example, the allocation of THz spectrum for passive services, amongst others, are topics of the THz standing committee, which are dealt with via liaison statements with ITU-R or ETSI, for example.

4.2 Contributions to Standardization and Pre-Standardization Bodies

Based on the above plan, in this section we list the contributions that SNS TIMES has already provided to standardization-related bodies during the first 18 months of the project execution.

4.2.1 ETSI ISG THz

We summarize the contributions from SNS TIMES towards ETSI ISG THz in Table 6. The table briefly describes the contribution, which activity/WP in SNS TIMES it came from, and where within ETSI ISG THz the contribution was included. We note that contributions below were contributed from TIMES consortium members HWDU, TNOR, and TUBS, often jointly.

Table 6. List of SNS TIMES contributions to ETSI ISG THz.

Contribution Title	Description	Output from SNS TIMES activity	Input to
THz(23)000170 Use case on Virtual Commissioning of Industrial Plants	Commissioning of industrial plants or production chains is a fundamental step to ensure that all system components are working properly and fulfill the operational requirements. Virtual commissioning makes it possible to carry out the commissioning process in a virtual replica of the real system, i.e., the digital twin, by mimicking the physical behaviour of the production process through software simulations. Real-time co-simulation or Hardware in the Loop (HiL) validation, requires tight synchronisation between the real system and its digital twin. Hence, THz communications can be exploited to enable fast and reliable communications and achieve fast feedback exchange between the production system and the simulation platform. Moreover, peculiar sensing capabilities of THz signals can aid the twinning process.	[TIMES2023-3]	[ETSITHz001]
THz(23)000172 Use case on Predictive Maintenance and Diagnostics	Proper maintenance and fault diagnostics are crucial operations to avoid unplanned interruptions and ensure seamless functioning of industrial machines and manufacturing systems. This contribution proposes THz communications to realise the data connection between the industrial machine and the edge computer.		
THz(23)000168 Use case on Real-time industrial control	Industrial machines are equipped with one or multiple industrial computers (e.g., Programmable Logic Controllers) for the control of the manufacturing process. Computers communicate with sensors and actuators installed on the machine to monitor the status of the process and trigger actions. Similarly, sensors and actuators within a machine or across multiple machines can communicate directly with each other to exchange information relevant for decision-making. Current solutions use wired fieldbus connections (e.g., Profinet, EtherCAT, Powerlink, Sercos, etc.) between sensors/actuators and industrial computers. Such wired connections can be replaced with wireless communications at THz frequencies. This solution has the potential to provide the communication performance required by industrial real-time applications without the need for cabling.		

	Moreover, sensing capabilities of THz signals can be exploited to aid the monitoring of the industrial process and to supervise machine operations.		
THz(23)000159 Use case on cooperative mobile robots	The combination of very high data rates, reliability, and low latency is needed to guarantee the safe operation and driving of mobile robots, such as AGVs. In the case of distributed processing, some decisions may be taken autonomously in the robot, while others need support or commands from a network-side application server, creating a need for data exchange in both directions as well as between robots. Due to the availability of very wide bandwidths, the THz spectrum may lay the foundation to address such stringent requirements. Cooperative mobile robots also require high-accuracy sensing and localization, which can be provided in the THz spectrum. The mobile robots not only need to sense and localize themselves in a static environment, but also in relation to other mobile robots, humans, and moving objects.		
THz(23)000020 Regulatory Situation of Spectrum between 252 and 450 GHz	Radio regulations. Edition 2020, Activities towards WRC-23, summary of regulatory situation between 252 and 450 GHz, channel plan for IEEE Std 802.15.3d-2017	WP2 and WP3	[ETSITHz002]
THz(23)000028 Frequencies of interest for THz communications	Frequency range to study and criteria for 'being of interest'		
THz(23)000050 Overview of spectrum bands for WI 002	Spectrum band overview 0.1-3 THz, recommended band definitions		
THz(23)000102 Transmittance Window for THz Communications	Proposal of an alternative visualization of the THz spectrum through the concept of transmittance.		
THz(23)000122 European regulations above 100 GHz – Input to chapter 4 of GR 002	Text proposals for European regulations from CEPT/ECC		
THz(23)000179 Input to Section 3.2 of GR002	This document contains proposed text for section 3.1 and Annex A on Transmission Windows		
THz(23)000296 Text Proposal on Mapping the discussed frequency bands and physical environments to relevant channel	In order to support the development of channel models for the frequency bands defined in the clauses above table 2 below summarizes each of the physical environments, classifies them into frequency bands and indicates related THz channel measurement studies available in the existing literature for that particular environment		

measurements scenarios			
THz(24)000021 Ray Tracing and Measurement-Based Characterization of Inter/Intra-Machine THz Wireless Channels	Comparison between measurements and ray tracing in industrial environment is shown, where measurements and ray tracing results were compared and were found to have good agreement.	[TIMES2023-2]	ETSI group report Terahertz 003 (ETSI GR THz 003): https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=67530
THz(23)000193 Simultaneous multiband (6.75 GHz, 74.25 GHz, and 305.27 GHz) channel measurements and modelling in an industrial scenario	This contribution presented simultaneous ultra-wideband (5 GHz bandwidth) dual-polarized multiband measurements (centre frequency 6.75 GHz, 74.25 GHz, and 305.27 GHz) for characterization of short-range propagation in an industrial environment in line of sight (LOS) and non-LOS (NLOS) scenarios.		
THz(24)000035 Dual-polarized double directional ISAC channel measurements at 190 GHz in an industrial setting	In this contribution, the results of dual-polarized double-directional measurements at 190 GHz in an industrial setting with integrated sensing and communication applications are presented. The set-up consists of a bi-static configuration emulating two access points with beam-steering capabilities in a machine room. One access point serves a machine with a wireless link, while the other access point senses the environment to detect moving objects. The objective is to study the detectable scattering characteristics of a forklift truck to detect possible obstructions that could interrupt the communication link or cause accidents on the production line.		
ETSI_ISG_THz(24)000020_Channel_measurements_in_workspace_with_robotic_manipulators	This contribution presents an initial characterization of radio channel with robotic manipulators at low terahertz frequencies. The measurement scenarios include both time-invariant and time-variant settings, reconstructing channels between two robotic arms and between an access point and a sensor node on the manipulator. The evaluation results include path gain, power delay profile and delay spread for time-invariant setups. For the time-variant setups, the evaluation results include 3D power delay profile and path gain versus time for a fixed delay value. The findings presented here demonstrate the feasibility of wireless communication in workspaces containing robotic arms and lay the foundation for further channel measurements and models development for industrial environments.		
ETSI_ISG_THz(24)000023_Channel Measurements in an Industrial Environment for	This contribution presents channel measurements for a machine to access point communication scenario at low THz frequencies. The measurements included time-invariant scenarios where an access point communicated with two static sensors as well		

Access Point-to-Sensor Communication at 300 GHz	as a time-variant scenario in which a static access point communicated with a moving sensor node. Recent evaluation results are provided, comprising power delay profiles that simultaneously demonstrate the potential for THz communication in these scenarios and highlight emerging challenges that warrant further research.		

4.2.2 IEEE

We summarize the contributions from SNS TIMES towards IEEE 802.15 SC THz in Table 7. The table briefly describes the contribution, which activity/WP in SNS TIMES it came from, and where within IEEE 802.15 SC THz the contribution was included. We note that contributions below were contributed from TIMES consortium member TUBS.

Table 7. List of SNS TIMES contributions to IEEE 802.15 SC THz.

Contribution Title	Description	Output from SNS TIMES activity	Input to
Overview on the Horizon Europe 6G-SNS-Project TIMES; doc: 15-23-0133-00-0thz https://mentor.ieee.org/802.15/dcn/23/15-23-0133-00-0thz-overview-on-the-horizon-europe-6g-sns-project-times.pdf	This document provides information on the Horizon Europe 6G SNS Project TIMES (THz Industrial Mesh Networks in Smart Sensing and Propagation Environments)	WP 7 (Project Description)	Information of IEEE 802.15 SC THz on ongoing activities
Channel Measurements in Workspace with Robotic Manipulators at 300 GHz and Recent Results; doc: 15-24-0243-00-0thz https://mentor.ieee.org/802.15/dcn/24/15-24-0243-00-0thz-channel-measurements-in-workspace-with-robotic-manipulators-at-300-ghz-and-recent-results.pdf	This contribution reports on time-variant channel measurements at 300 GHz in a robotic environment, which have been carried out in the framework of the European 6G-SNS-JU TIMES project.	[TIMES2023-2]	Information of IEEE 802.15 SC THz on ongoing activities

Conclusions

In its first 18 months, SNS TIMES has made great strides in terms of communication, dissemination, and exploitation activities. In particular, SNS TIMES has generated more than 20 scientific papers in top relevant conferences and journals (e.g., IEEE Journal of Selected Topics in Signal Processing, IEEE Communications Magazine, IEEE International Conference on Communications, etc.). SNS TIMES has also presented its results in relevant scientific and industrial events, such as conferences (e.g., IEEE ICC 2024, EuCNC 2024, EuCAP 2023 and 2024), relevant industry fairs (e.g., Hannover Messe 2024), and research forums (e.g., Wireless World Research Forum). It also organized (or co-organized with other SNS projects) conferences, workshops, and special sessions in the area of THz communications (e.g., special sessions at IEEE CSCN 2023 and IEEE ICC 2024). Furthermore, ten initial key exploitable results have been generated in the first 18 months, relating to highly integrated THz RF front-ends, antennas with beam steering capabilities, intelligent reflecting surface, new channel models for THz communications, and new PHY- and MAC-layer schemes aided by smart propagation environments. In addition, due to favourable standardization landscape, including the establishment of ETSI ISG THz as well as ongoing activity of the IEEE 802.15 Standing Committee THz (SC THz), standardization contributions from SNS TIMES are well ahead of the planned schedule, with more than 15 contributions provided to ETSI ISG THz and IEEE 802.15. Some of these contributions have already found their way into the published standardization documents, in particular into ETSI group reports on THz use cases and on THz spectrum. In the second phase of the project, SNS TIMES consortium will further engage with industry – through dissemination and standardization activities – with the goal of increasing the industrial traction of sub-THz and THz wireless communications and sensing systems.

References

[one6G2023] 6G Technology Overview Whitepaper, one6G Association, Oct. 2023.

[Bob2023] Boban, Mate, and Vittorio Degli-Esposti (editors) "White Paper on Radio Channel Modeling and Prediction to Support Future Environment-aware Wireless Communication Systems." arXiv preprint arXiv:2309.17088 (2023).

[ETSITHz001] ETSI Industry Specification Group, group report on use cases (ETSI GR THz GR001): https://www.etsi.org/deliver/etsi_gr/THz/001_099/001/01.01.01_60/gr_THz001v010101p.pdf

[ETSITHz002] ETSI Industry Specification Group, group report on THz spectrum (ETSI GR THz GR002): https://www.etsi.org/deliver/etsi_gr/THz/001_099/002/01.01.01_60/gr_THz002v010101p.pdf

[IEEE802153d] 802.15.3d-2017 - IEEE Standard for High Data Rate Wireless Multi-Media Networks--Amendment 2: 100 Gb/s Wireless Switched Point-to-Point Physical Layer.

[Liu2012] Liu, Lingfeng, et al. "The COST 2100 MIMO channel model." IEEE Wireless Communications 19.6 (2012): 92-99.

[TIMES2023] SNS TIMES Deliverable D4.1 - intermediate report on PHY layer enhancements for THz links supporting sensing and communication functionalities, 2023.

[TIMES2023-2] SNS TIMES Deliverable D3.1 - Initial channel measurements in industrial environments at sub-THz frequencies, 2023.

[TIMES2023-3] SNS TIMES Deliverable D2.1 - Definition of use cases, KPIs, and scenarios for channel measurements, 2023.