FIRST INTERMEDIATE PROJECT REPORT

Deliverable D9.2

Co-funded by the European Union

6GSNS

The TARGET-X project has received funding from the Smart Networks and Services Joint Undertaking (SNS JU) under the European Union's Horizon Europe research and innovation programme under Grant Agreement No: 101096614

FIRST INTERMEDIATE PROJECT REPORT

GRANT AGREEMENT	101096614
PROJECT TITLE	Trial Platform foR 5G EvoluTion – Cross-Industry On Large Scale
PROJECT ACRONYM	TARGET-X
PROJECT WEBSITE	www.target-x.eu
PROJECT IDENTIFIER	https://doi.org/10.3030/101096614
PROGRAMME	HORIZON-JU-SNS-2022-STREAM-D-01-01 — SNS Large Scale Trials and Pilots (LST&Ps) with Verticals
PROJECT START	01-01-2023
DURATION	30 Months
DELIVERABLE TYPE	Deliverable
CONTRIBUTING WORK PACKAGES	all
DISSEMINATION LEVEL	Public
DUE DATE	M12
ACTUAL SUBMISSION DATE	M12
RESPONSIBLE ORGANIZATION	Fraunhofer IPT
EDITOR(S)	Janina Knußmann
VERSION	1.0
STATUS:	final
SHORT ABSTRACT	This first intermediate project report provides an overview of the results and achievements accomplished during the first year of the TARGET-X project.
KEY WORDS	5G, 6G, trial sites, digital transformation
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Executive Summary

This first intermediate project report contains an overview of the results achieved in the TARGET-X project until the end of the first project year. It highlights the main achievements and provides references to the relevant documents and deliverables.

The achievements of the first project year span over the four application domains (verticals) Energy, Manufacturing, Automotive and Construction as well as the technology domain and already show synergies of the interdisciplinary collaboration.

Applications / use case of the 5G/6G technology are relevant for all end users of the beyond 5G technology and therefore, in all TARGET-X testbeds the use case identification and descriptions have been developed. A joint template for describing the use cases has been developed. The development of a methodological assessment framework already sparked a work item in the 5G-ACIA that is dedicated to the development of a calculation method of the business value of industrial 5G use cases. The TARGET-X testbeds are heavily collaborating with the technology partners to integrate the beyond 5G technology into their testbeds and prepare the large-scale pilots and use case implementations with e.g. architecture definitions. First connectivity tests and performance measurements have been conducted, and the testbeds will be fully operational by the end of the year, reaching the milestones.

TARGET-X will provide Financial Support for Third Parties with a budget of 6.000.000€. The budget will be distributed over two open calls each offering a set of different topics that describe challenges to be solved by the third parties. The topics for the 1st and the 2nd open call were defined in collaborative efforts by the TARGET-X consortium partners. The 1st open call was completed and received 132 proposals for 48 topics. From this, 27 projects are expected to start the project execution in 2024. The second open call will be open for applications from December until the end of February.

Finally, the project has implemented a communication and dissemination strategy, which has led to a website, LinkedIn channel, and the TARGET-X community. The project has actively contributed to conferences and industry fairs ensuring communication dissemination to technical as well as non-technical audiences across different verticals.

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List of Acronyms and Abbreviations

AAS	Asset Administration Shell
F2F	Face-to-face
FSTP	Financial Support for Third Parties
IT	Information Technology
JCAS	Joint Communication And Sensing
KPI	Key Performance Indicator
KVI	Key Value Indicator
OT	Operational Technology
PLL	Phase Locked Loop
PMU	Phasor Measurement Unit
PCB	Printed Circuit Board
RAN	Radio Access Network
RedCap	Reduced Capability
ROS 2	The Robot Operating System 2
SNS JU	Smart Networks and Services Joint Undertaking
TSN	Time-Sensitive Networking
WP	Work Package

1 Introduction

The TARGET-X project is one of the Smart Networks and Services Joint Undertaking (SNS JU) Phase 1 projects. There, it is allocated in Stream D ”Large-Scale SNS Trials and Pilots”. TARGET-X runs for 30 months and has started in January 2023. The project costs are more than 14 M€ of which 6 M€ are reserved for Financial Support for Third Parties (FSTP).

TARGET-X aims at accelerating the digital transformation in four verticals: Energy, Manufacturing / Robotics, Construction and Automotive. These key verticals jointly integrate beyond 5G technology in large-scale testbeds and evaluate the technology methodologically with Key Performance Indicators (KPIs) and Key Value Indicators (KVIs). The FSTP projects act as further innovation drivers.

This is reflected in the project’s structure which is shown in Figure 1-1:

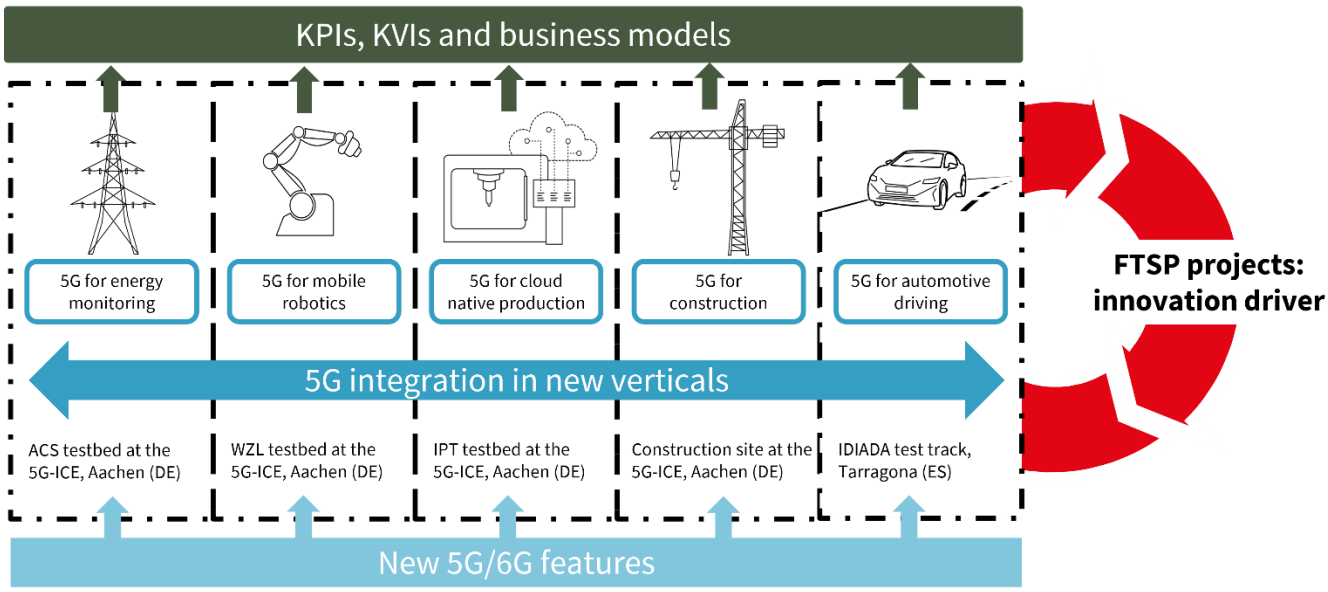

Figure 1-1: TARGET-X Structure

The TARGET-X Work Packages (WPs) can be mapped to the key elements of the TARGET-X structure: WP1 “Methodological Assessment Framework” focuses on use cases, business models and the methodological KPI /KVI assessment. The work packages 2-5 aim at the different verticals Manufacturing (WP2), Energy (WP3), Automotive (WP4) and Construction (WP5). The WP6 Technology Evolution Beyond 5G prepares and integrates new 5G/6G features into the testbeds. WP7 facilitates the FSTP projects while WP8 takes care of communication and dissemination. The project management is located in WP9.

Figure 1-1 gives an overview of the testbeds in TARGET-X. They aim at evaluating and validating the beyond 5G technology. The Energy testbed “5G for energy monitoring” is located at the 5G-Industry Campus Europe in Aachen, Germany and uses the RWTH-ACS main building EON Energy Research Center as a testbed for energy monitoring. The Robotics testbed “5G for mobile robotics” uses the RWTH-WZL Measurement Automation and Robotics Systems (MARS) Lab that is also part of the 5G-Industry Campus Europe in Aachen, Germany. The Cloud Native Production testbed “5G for cloud native production” is located at the machine hall of the Fraunhofer Institute for Production Technology IPT, the central coordinator of the 5G-Industry Campus Europe. Both, the robotics as well as the cloud native production testbed aim at the Manufacturing vertical. The Construction

testbed “5G for construction” implements a living lab on a reference construction site, that is also part of the 5G-Industry Campus Europe. The Automotive testbed “5G for automotive driving” is located at the Applus IDIADA test track in Tarragona, Spain, that covers 370 hectares and a mobile communication infrastructure.

This document is the first intermediate project report of TARGET-X and gives an overview of the project’s achievements during its first year. It describes the relevant results and provides references to all deliverables, papers, and further output of the project. Some of these outputs can also be found on the TARGET-X website https://target-x.eu/ and in the project’s community on Zenodo https://zenodo.org/communities/targetx/ .

1.1 Objective of the document

The objective of this first intermediate project report is to summarize the achievements of the TARGET-X progress across the various work packages and verticals during the first year of the project. This includes the already achieved results and references to the relevant deliverables. For ongoing activities, the next steps and plans are described.

The objectives of the document align with the objectives of the TARGET-X project:

1. To demonstrate and validate industrial 5G/6G technologies and architectures in large-scale pilots in four different verticals.
2. Investigating 5G/6G and peripherical technologies across the whole value chain (devices, connectivity, service delivery) to identify, assess and propose new 5G/6G features targeting connected industries.
3. Enabling future use cases by self-adapting communication networks
4. Dynamic allocation of communication and computation resources across IT&OT
5. KPI and Key (Societal) Value Indicator (KVI) generation from real business cases validated on large scale trial sites
6. Enhance the 5G/6G ecosystem in the manufacturing & robotics, automotive, energy, and construction verticals
7. To disseminate and communicate the outcome of the TARGET-X project and contribute to standards, the scientific and industrial domains, and the subsequent SNS phases.

1.2 Structure of the document

The structure of this document orients at the overall structure of TARGET-X. This first chapter introduced the overall concept of TARGET-X. The following chapter 2 relates to WP1 “Methodological Assessment Framework” that targets use case descriptions and methodological assessment with KPIs and KVIs. In the next chapter, the TARGET-X testbeds that represent the WP2-5, describe their progress and work during the first year of the project and envisioned next steps. The following chapter 4 “Technology evolution beyond 5G” focuses on the technological developments and achievements during this first year. Then, the achievements related to the Financial Support of Third Parties is described. This is followed by a description of the communication and dissemination efforts. The chapter 7 concludes the document with a summary and gives an outlook for the second year of the project.

1.3 Relation to other activities

This deliverable is the first intermediate project report of the TARGET-X project. It is related to all the activities carried out in the project. In particular, it shows all the achievements of the work packages 1-8 during the first project year and points out the next steps. This way, it provides an overview of the current status of the project. A list of all related deliverables can be found in the References.

2 Use cases and methodological KPI/KVI assessment framework

The first work package is dedicated to the uniform and standardized description of the use cases that are to be implemented over the course of TARGET-X. Furthermore, Key Performance Indicators (KPI) and Key Value Indicators (KVI) are defined to build a methodological assessment framework enabling a uniform and holistic assessment of the implemented use cases.

2.1 Achievements during the first year

The assessment is primarily targeted at the evaluation of the benefits that are gained through implementation of the use cases in the different verticals. Since the use cases all come from different verticals, i.e. application domains, the challenge in this context is to create a use case description and subsequent evaluation based on standardized description and evaluation principles and criteria. For this reason, an Excel-based template for the use case description was developed and iteratively improved in exchange with the different verticals to enable a similar description for all use cases from each vertical. The KPI- and KVI-based assessment approach enables a multi-perspective evaluation of the implemented use cases. While KPI-based assessments focus on the technical and economic benefit that is gained through the use case implementation, an evaluation from a societal perspective is added through the definition and consideration of KVI. In this way, the evaluation of 5G-based use cases is not only driven by technical and economic performance but also by societal values. For the definition of the KVI, a stepwise approach developed by 6GIA was taken as a foundation [6GIA22]. The template created for the use case descriptions was submitted to the leads of the individual work packages and filled out by them. The use case description will be published in the first deliverable of work package 1 [TAR23-D11] at the end of the first year of TARGET-X.

To also integrate the methodological assessment framework into the open calls providing financial support for third parties (FSTP), an open call focusing on the contribution to the evolution of the assessment framework was published. Furthermore, a passage was created and added to all other open calls, enabling the assessment based on the methodological assessment framework of all open call projects. In this way, the developed approach can be applied to a multitude of different use cases and thereby continuously validated. First assessment results of the third-party results are expected in 2024.

As TARGET-X proceeds, the technical maturity of the implemented use cases will increase enabling the generation and measurement of data through execution of the use cases. Therefore, work package 1 also paid attention to the definition of confidentiality classes of data in the data management plan of TARGET-X [TAR23-D95]. Since the continuous evaluation of the implemented use cases will be based on product and process data, the aspects of handling different types of data play an important role in the KPI- and KVI-based assessment of the use cases.

As Fraunhofer IPT holds the co-chair of working group 05 (Industrial 5G in practice) of 5G Alliance for Connected Industries and Automation (5G-ACIA), work package 1 pitched the creation of a work item in working group 05 to broaden the scope of the KPI-based assessment of the TARGET-X use cases. The work item is dedicated to the development of a calculation method of the business value of industrial 5G use cases and enables the integration of a broader circle of expert opinions, especially from the IT & OT sector. Work on the work item started in July of 2023 and will continue until spring

2024. The expected results of the work item will directly contribute to the results of work package 1 of TARGET-X and additionally represent a dissemination activity of TARGET-X when published.

2.2 Next steps

The next steps to be taken in work package 1 focus on the refinement of the methodological assessment framework through application-based testing of the developed concept as well as further elaboration on the aspect of sustainability. For this purpose, resource (energy and materials) consumption of the 5G use cases will be taken into close consideration. The framework will be continuously adapted according to new insights gained through application of the framework. Furthermore, the aspect of cyber security will be taken into account by development of a classification method for entities integrated into a 5G/6G network which is then used for the assignment of permissions to each device that are necessary for executing the use cases. In this way, a tailor-made permission profile for important devices of a use cases is developed.

3 TARGET-X Testbeds

3.1 Energy testbed

The Energy testbed within the TARGET-X project aims to further integrate 5G technology into the energy domain. This can either be for grid monitoring or increased energy awareness. These two use cases have different requirements. The grid monitoring use case depends on high sampling rates and high time tagging accuracy, whereas the energy awareness case requires a high energy metering accuracy. The testbeds for both types of use cases are located at the 5G-Industry Campus Europe at RWTH Campus Melaten in Aachen. Both use cases focus on a 5G enabled synchronized measurement devices that can be used for local grid monitoring as well as for the other verticals to measure the consumption of, for example, machines at a construction site.

Grid Monitoring

The grid monitoring case is carried out at the RWTH-ACS institute building and will focus on the voltage behaviour of the local low voltage grid. In that building, different laboratories and workshops will be monitored for voltage and current. Further energy monitoring will be carried out at the construction testbed. The measurement data from both testbeds will be sent to an edge cloud like infrastructure that can visualize the data and handle short- and long-term storage. A more detailed description of the energy testbed is given in deliverable D3.1 [TAR23-D31].

Energy Awareness

The energy awareness use case is utilizing the construction testbed. In the construction testbed different processes on a construction site will be evaluated from an energy perspective. To achieve that, energy as well as current and voltage measurements are needed. This is accomplished by utilizing the edgePMU and extending it with a weatherproof box for inline measurements. Further information about the construction site can be found in Section 3.5.

3.1.1 Achievements during the first year

The work done during the first year covers multiple deliverables and a milestone, as well as technical work for the two use cases.

A first overview of the trail sites, time planning, and a set of planned tests are described in D3.1 [TAR23-D31], which was submitted in May 2023. The first draft of the architecture including technical information of the development was submitted end of December 2023 in deliverable D3.2 [TAR23-D32].

With the setup of a storage server for measurements and device managmenent, the integration of a private 5G network and the submission of D3.2 the Milstone 6 was reached in December 2023.

The energy vertical proposed 6 topics for the first open call and received 24 proposals. After the evaluation process 6 were selected for funding.

The technical work can be separated into general hardware work concerning both use cases and work that is specific for one use case. For the 5G edgePMU components for the fast data acquisition device were further developed. This includes an isolated modular input stage (see Figure 3-1) and a PLL-based time synchronization.

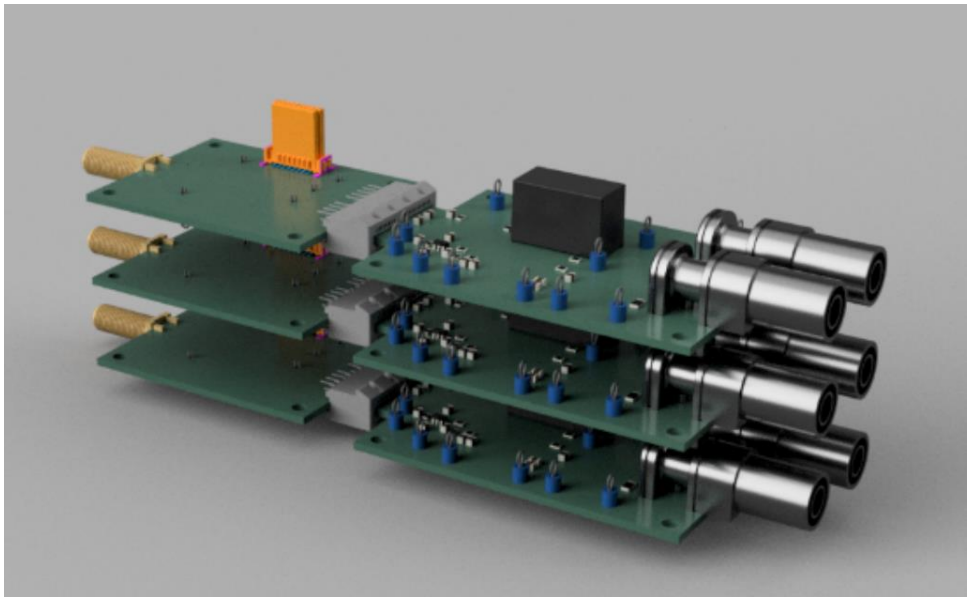

Figure 3-1: Modular isolated analog input stage, for isolating the low voltage grid from the measurement device for voltage and current.

On the software and edge cloud side, the architecture for the storage and management platform was developed. This platform enables the control and configuration of the field devices and provides a storage endpoint for the measurements. In the last year, a data storage server was procured, and set up. For the software auto-deployment infrastructure and data handling, first software prototypes were developed. This includes, for example, an HTTPS based Ansible deployment, the evaluation of different storage formats and authentication methods. Further information is given in D3.2.

Grid Monitoring

For the grid monitoring, first meetings were held with the electrical workshop to identify suitable locations for the monitoring device. It was decided to place them in the electrical cabinets for the mechanical and electrical workshop, as well as for two laboratory rooms. Further information can be found in D3.1.

Energy Awareness

During the first year, the energy test bed started synchronizing with other verticals, to identify the requirements for a synchronized monitoring device for energy, power, voltage and current. During this phase, meetings at the Construction testbed were held. The result is a first mock-up of an outdoor-capable measurement box that can be easily connected in line with a load. Such a load could be a crane or other construction tools. The mock-up is shown in Figure 3-2. A key component of the measurement box is an energy metering device, which will run in parallel to a high-frequency sampling device that acquires voltage and current. The goal is to allow for long term metering as well as high-time-resolution process monitoring.

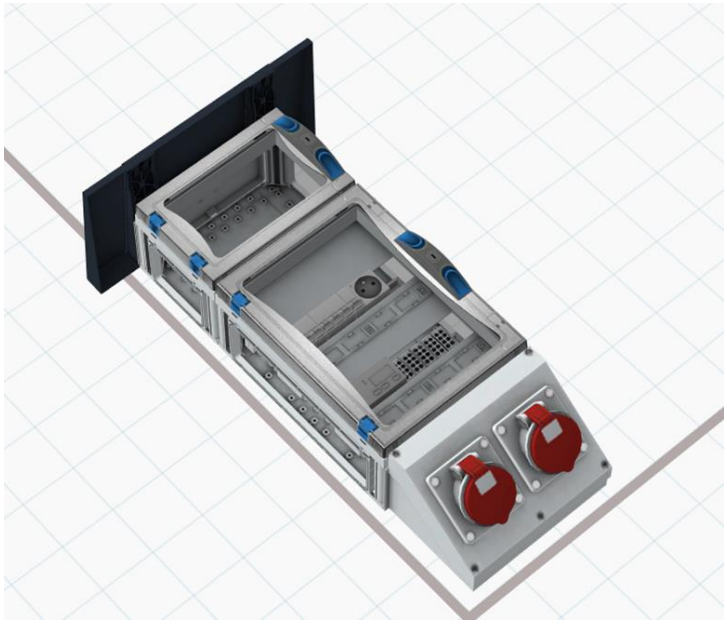

Figure 3-2: Mockup of measurement box with the connection plugs on the bottom, for connecting the device in line with the device under test.

To select the most suitable metering device, two different devices were ordered and compared in a laboratory setup to select the one with the highest accuracy. The comparison is described in D3.2 [TAR23-D32].

3.1.2 Next steps

The next steps within the energy testbeds will mainly focus on the development of the above-mentioned hardware and software stack. From a hardware perspective, the different PCBs will be designed and tested. This includes a carrier and adapter board for a M2 based 5G modem, an analog acquisition board, and a synchronization board. All these components are part of the updated fast acquisition device. Furthermore, the second revision of the modular isolated analog input stage will be developed. The work will lead to the above-mentioned acquisition box. In parallel to the hardware development, the work on the edge cloud platform will be continued. This includes the evaluation of different types of brokers, the integration of visualization, and an access concept for the data. Finally, the storage concept needs to be finalized and integrated with the VILLASframework.

For the deployment of the measurement box within the energy awareness use case, further coordination with the different trial sites will be needed. After that, the deployment at the different testbeds and verticals will be done.

For the deployment of the 5G edgePMU within the grid monitoring use case futher coordination with the electrical workshop is needed. Then the next step is to palce the device in the electrical cabinetts and start with data aquistition.

6 FSTP projects for energy vertical from 1st open call will start in Q1, 2024. While for the 2nd open call of FSTP, 7 topics are proposed as challenges in energy vertical which will be published in December 2023.

3.2 Cloud native production testbed

The implementation and validation of the cloud native production use cases in TARGET-X will take place in Aachen, at the Fraunhofer Institute for Production Technology IPT. The trial site at IPT is used to evaluate the potential of 5G/6G for machining in industrial production.

3.2.1 Achievements during the first year

During the conceptual phase of the project, we were able to achieve success by forming focused groups among project partners. This allowed for collaborative ideation, which led to the creation of a comprehensive list of possible use cases for “Inline Quality Assurance for Machining”, “Track and Tracing of Workpieces” and “Environmental Condition Monitoring” [TAR23-D21].

For the use cases “Environmental Condition Monitoring” and “Track and Tracing of Workpieces” the development of an overall architecture for the use case, Figure 3-3, dividing responsibilities between field and cloud-level systems, has been a key focus. Following the architecture, a first draft for a hardware architecture for the needed sensor platforms has been designed, with specific sensors identified for each sub-use case, developed by Marposs. Discussions and decisions regarding the 5G devices and interfaces for the sensor platform, involving Fivecomm, have taken place. An initial draft of the cloud architecture has been outlined, and requirements for wireless communications have been defined. These developments signify advancements in establishing a functional framework for environmental monitoring and trace and tracking systems. A more detailed description of the use case is given in [TAR23-D21].

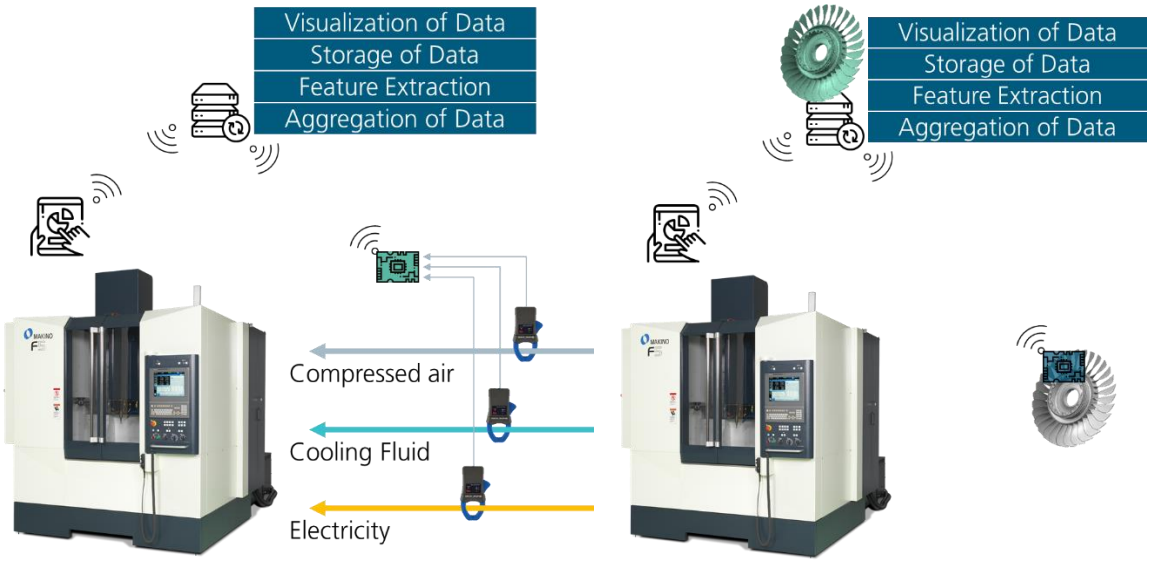

Figure 3-3: In the left: use case for environmental condition monitoring. In the right: use case for track and tracing of the workpieces using 5G wireless sensor platform [TAR23-D21].

Whereas, for the “Inline Quality Assurance for Machining” use case, the focus has been on defining the relevance of this use case within manufacturing and identifying the specific 5G/6G features requiring validation. A key accomplishment is the development of a structured architecture, encompassing both field-level real-time capable closed loop architecture and the integration of the Factory Cloud system. Decisions have been made regarding hardware devices and design options, prioritizing commercially available systems for industrial production. Additionally, requirements for wireless communication have been clearly defined, establishing a solid framework for the practical

implementation and validation of this technology in the domain of condition monitoring. The use case is described in further detail in [TAR23-D21].

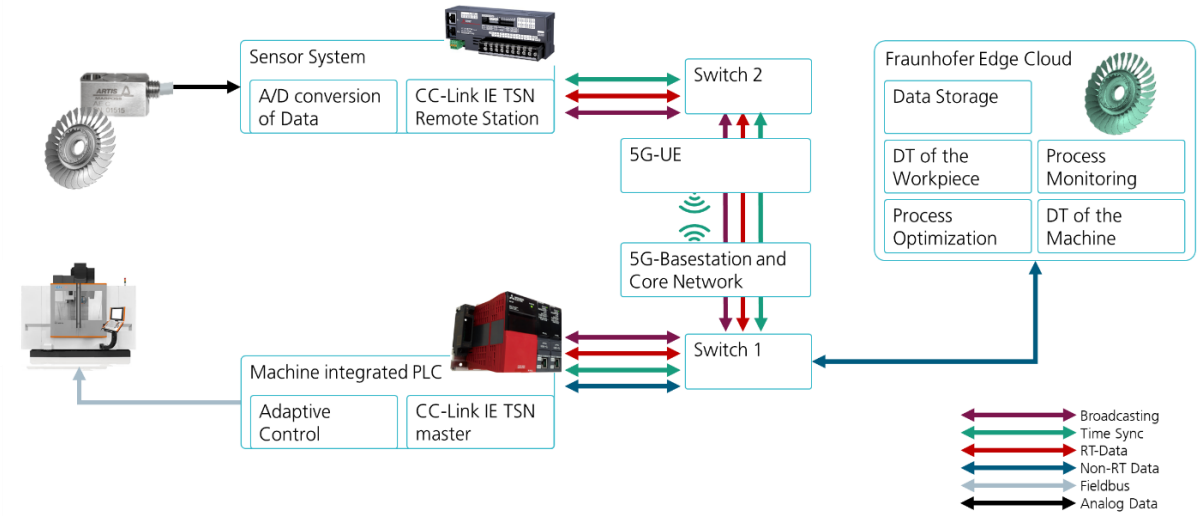

Figure 3-4: Architecture for Inline Quality Assurance for Machining use case [TAR23-D21].

The Fraunhofer Institute for Production Technology (IPT) has established together with the partner Mitsubishi Electric and Ericsson a Time-Sensitive Networking (TSN) testbed for integrating 5G systems. The testbed includes interfaces for integrating 5G midband, mmWave, and URLLC testbeds. Additionally, a connection to the Factory Cloud has been successfully implemented, enhancing the overall capabilities of the 5G systems for efficient data exchange and real-time communication.

3.2.2 Next steps

The next steps for the Manufacturing testbed, for each use case scenario, are:

- Smart Sensors for Track and Tracing of Workpieces and Environmental Condition Monitoring:
  1. Finalization of hardware prototypes, developed by Marposs.
  2. Design and development of software for the sensor platforms.
  3. Testing RedCap devices in IPT 5G network.
  4. Drafting test scenario and KPIs to be evaluated.
  5. Testing the performance of the overall architecture.
  6. Mentoring of the related FSTP project.

- Inline Quality Assurance for Machining:
  1. Integration of the commercially available industrial devices in the TSN-testbed.
  2. Connecting the testbed to the URLLC-testbed at IPT.
  3. Testing the performance of the overall architecture.
  4. Validating the results and define 5G/6G features that need to be added to the pipeline to be tested in the midband and mmWave system.
  5. Mentoring of the related FSTP project.

3.3 Robotics testbed

For the development of the use case involving edge robotics in WP2, different system designs and implementation strategies are being studied, specifically focusing on the Line-less Mobile Assembly Systems (LMAS) and their integration with 5G/6G connectivity at the *Werkzeugmaschinenlabor* (German) or Laboratory for Machine Tools and Production Engineering (WZL) | RWTH Aachen University. The main goal is to assess the practicality and efficiency of utilizing 5G/6G technologies in mobile manipulation and automation. The testbed at WZL is used to evaluate the potential of 5G/6G, analyzing a specific use case involving edge-controlled automation with mobile manipulation.

3.3.1 Achievements during the first year

In the initial year of our project, achievements have been realized by establishing focused groups among project partners during the conceptual phase, facilitating collaborative idealization and resulting in potential use cases for the scenario of edge controlled robotic assembly. Following a series of workshops and meetings of the Robotics Stream within WP2, a specific use case, "Edge-Controlled Automation with Mobile Manipulation," was finalized and documented in [TAR23-D22].

The description achieved so far is the following: the use case utilizes advanced technologies like machine vision, transfer learning, mobile manipulators, and 5G communication to automate bin-picking in industrial tasks. The use case highlights real-time decision-making, improved motion control, and efficient communication with Beyond 5G technologies. Evaluation of middleware setups and communication layer performance will ensure optimal system efficiency for bin-picking. As showed Figure 3-5, the automated tasks involve a mobile manipulator localizing itself, approaching assembly stations, scanning objects, detecting, and picking them, transporting safely, and navigating between assembly stations. A more detailed description of the use case is given in [TAR23-D22].

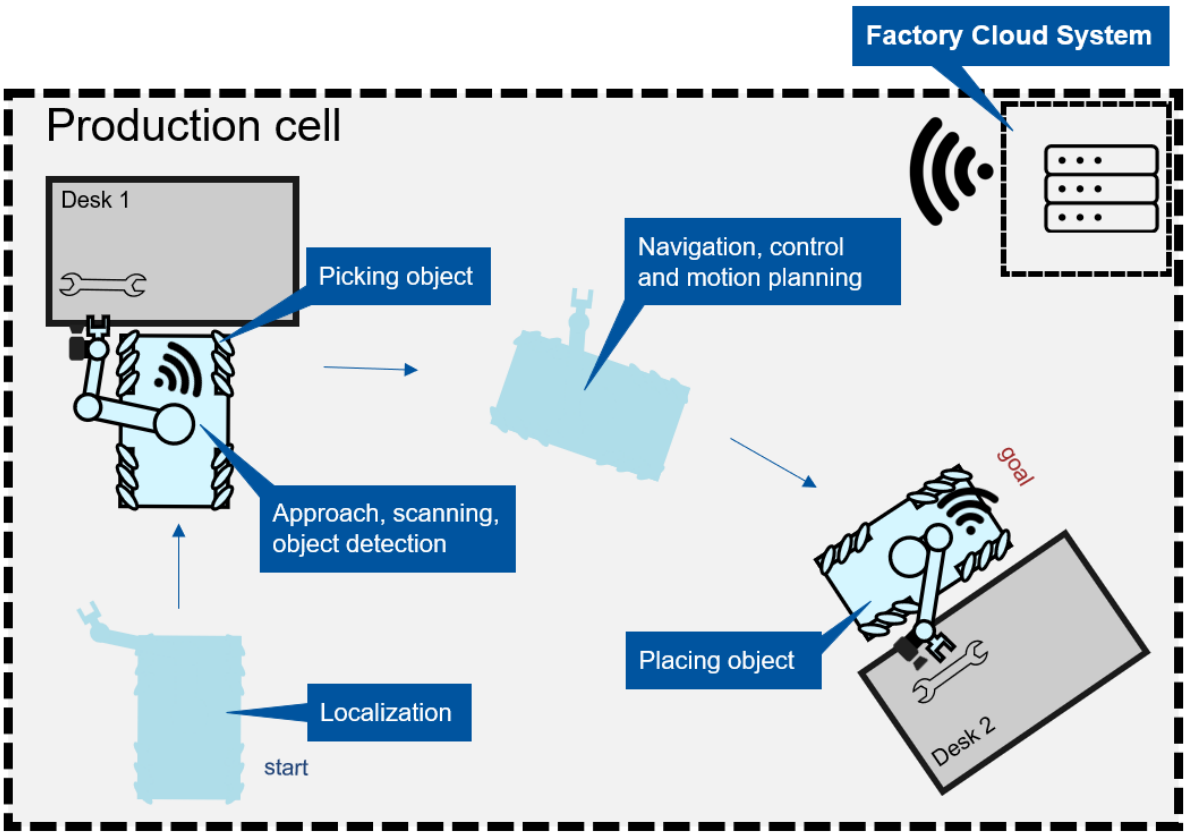

Figure 3-5: Robotics testbed and use case description [TAR23-D22].

For the implementation phase, four design options are currently being explored, considering hardware and software aspects, addressing components like motion planning, object detection, communication layer performance, and evolving 5G network requirements. The design options are described in detail in [TAR23-D22].

Additionally, strategic attention was given to defining the connectivity requirements of the intended use case in collaboration with WP1 and WP6. This involved a detailed conceptualization of design options, layout, and network architecture.

The development and implementation of the 5G/6G factory cloud system infrastructure (a local server system located near the assembly stations with cloud capabilities, detail definition in [TAR23-D22]) at edge robotics testbed was also improved during the year. This infrastructure intends to enable low-latency communication between the edge server (factory cloud system) and mobile manipulators interfaces, fostering seamless data flow within the manufacturing environment.

Collaboration with Ericsson / WP6 led to measurements on the testbed, evaluating the performance of the factory cloud system in the context of 5G/6G networks. The focus of these initiatives was to redefine and study requirements for 5G/6G networks in manufacturing environments. Challenges were identified in the middleware framework (ROS 2), prompting a focused approach to address and optimize middleware integration.

Regarding the 1° Open Call for FSTP, the robotic stream contributed with four topics as challenges for receiving proposals. After the evaluation of the proposals, three proposals were accepted to be funded and will receive mentoring from RWTH-WZL.

3.3.2 Next steps

The next steps for the Robotics testbed are:

1. New measurements and network requirements definitions to be carried out in the upcoming months.
2. The four design implementation options presented in [TAR23-D22] will be further studied; one implementation option will be chosen in the implementation phase of the project.
3. The integration of the Qualcomm Robotics RB5 Development Kit at the end-effector of the mobile manipulators is being studied and tests will be run to decide integration for the use case.
4. The evaluation of the communication layer will take place during the implementation phase.
5. Mentoring of three FSTP projects related to edge robotics sector will start in Q1, 2024.

3.4 Automotive testbed

In the automotive testbed, the focus is on deploying tools and mechanisms that facilitate cooperative perception, enable the creation of automotive digital twins, and increase safety in tele-operated driving by integrating Quality of Service (QoS) prediction. The main objective is to evaluate the performance of these automotive use cases using 5G networks in IDIADA Connected Vehicle Hub (CVH) or IDIADA testbed (Figure 3-6). The testbed includes a 5G NSA network (it also includes 2G/3G/4G networks), an edge computing facility, a hyperscaler public cloud, and connected vehicles.

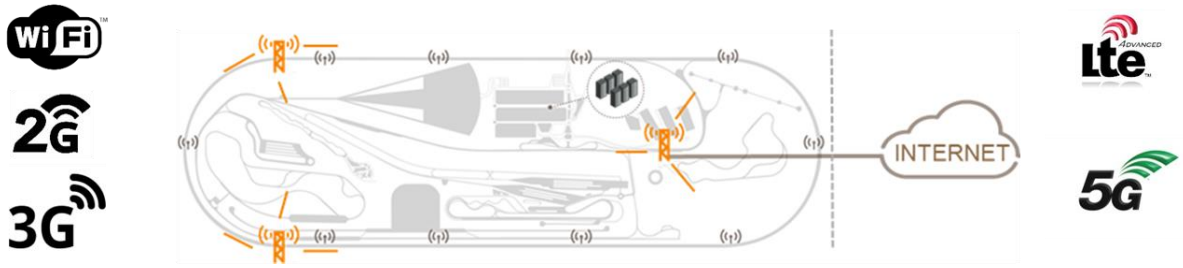

Figure 3-6: IDIADA Connected Vehicle Hub - Technologies.

3.4.1 Achievements during the first year

In the first year of the project, the aim was to identify the use cases to be deployed in the CVH. To do so, weekly and bi-weekly meetings, in addition to a workshop in Barcelona were held, and several use cases were proposed and analysed. At the end, three use cases were selected: cooperative perception, automotive digital twin, predictive QoS for tele-operated vehicles. These use cases were described together with their requirements in Deliverable D4.1 [TAR23-D41], which was submitted in September 2023.

In the cooperative perception use case, vehicles' perception of the environment will be enabled through the exchange of sensor information between vehicles and infrastructure, and among vehicles. In the automotive digital twin use case, the objective is to create virtual replicas of the vehicles, road environment, and/or network used to connect the vehicles. This will be used to evaluate the performance of cooperative perception techniques using simulation before performing real life tests. In the predictive QoS for tele-operated vehicles use case, we aim at developing an architecture and a set of tools that allow the network to detect changes in the provided QoS and send early notification to affected vehicles. This will give the human/machine tele-operating the vehicle a sufficient window of time to take the necessary actions that mitigate the impact of these changes.

During the WP4 workshop held in Barcelona, the 5G network deployed in the CVH was evaluated in terms of basic KPIs (i.e., round trip latency and throughput) using 5G-enabled Quectel modems and smartphones. The test of connectivity was very satisfactory and straightforward. Furthermore, we identified several solutions for the integration of an Edge server in the CVH. The aim of the integration process is to 1) allow 5G-enabled equipment (from TARGET-X WP4 and third parties) to communicate with the edge, 2) provide the edge with internet connection for software update, and 3) enable remote access to the edge using SSH for configuration and management. After several meetings, WP4 partners agreed on a specific architecture and the integration of the edge server is ongoing.

Finally, the automotive vertical proposed 14 topics as challenges the first FSTP open call. After the evaluation of the proposals, seven projects were accepted to be funded in the automotive vertical.

3.4.2 Next steps

The ongoing work is being focused now on designing the functional architectures of the three use cases and the tools needed to deploy these architectures.

The challenges for the second round of FSTP will be published in December. For the automotive vertical there will be some challenges from the first round that will be eliminated as they have already applicants and other will be revised. In addition, the focus on WP7 will be on coordinating and mentoring the accepted FSTP projects accepted in the first round.

3.5 Construction testbed

The Reference Construction Site of the Center Construction Robotics serves as testbed for research and development in the construction vertical of the TARGET-X project. The site is located at the Campus Melaten in Aachen and is connected to the 5G-Industry Campus Europe. Through the establishment of an extensive 5G testbed of this kind, setup demands, network efficiency and feasibility can be assessed and the advantages of an integration of 5G into construction sites can be showcased. Examining 5G performance on the Reference Construction Site offers crucial insights into the network's capabilities, limitations, and potential areas for improvement. This process empowers network operators, engineers, and involved parties to make well-informed choices, fostering the successful implementation and function of resilient and effective 5G networks. Furthermore, it opens up opportunities for exploring 5G's potential in circular construction.

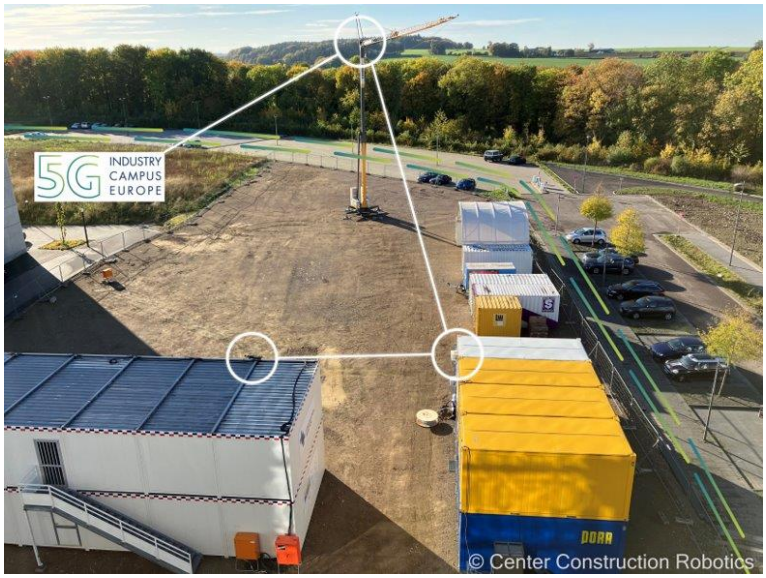

Figure 3-7: Reference Construction Site on the Aachen Campus Melaten as testbed for 5G in construction.

3.5.1 Achievements during the first year

For the construction vertical, the first project year set off with the kick-off meeting in Aachen in January 2023. All consortium partners were present and shared their research ideas for the TARGET-X project in plenary as well as individual vertical sessions. Furthermore, all partners could visit the Aachen test beds. Taking away the impressions and feedback from the kick-off meeting, the planning of the use cases started under the lead of CCR, in the following weeks. In the proposal, the real-time aggregation of on-site information for the purpose of controlled deconstruction and enhanced circularity had been set as the main goal.

Under this scope three subject areas were defined for which 5G will be tested. Firstly, the automation of a controlled deconstruction process will be the focus of one use case. The second use case will be centered around the potentials of mixed reality for deconstruction planning. The last use case will address a safety assistant for construction robots. In June, deliverable D5.1 was presented as an interim report on the status of the use case planning in the form of a roadmap [TAR23-D51]. A more elaborate description of the use cases including network requirements and KPIs as well as KVIs can be found in deliverable D1.1 [TAR23-D11].

Other than that, the energy vertical under the lead of RWTH-ACS and the construction vertical have started a closer collaboration on the monitoring of energy consumptions on the construction testbed. For this purpose, RWTH-ACS presented an outdoor-proof design of the edge PMU since the original design was not suitable for an outdoor deployment on the construction testbed. More details on the design and capabilities of the edge PMU devices were presented in deliverables D3.1 and D3.2 [TAR23-D31, TAR23-D32].

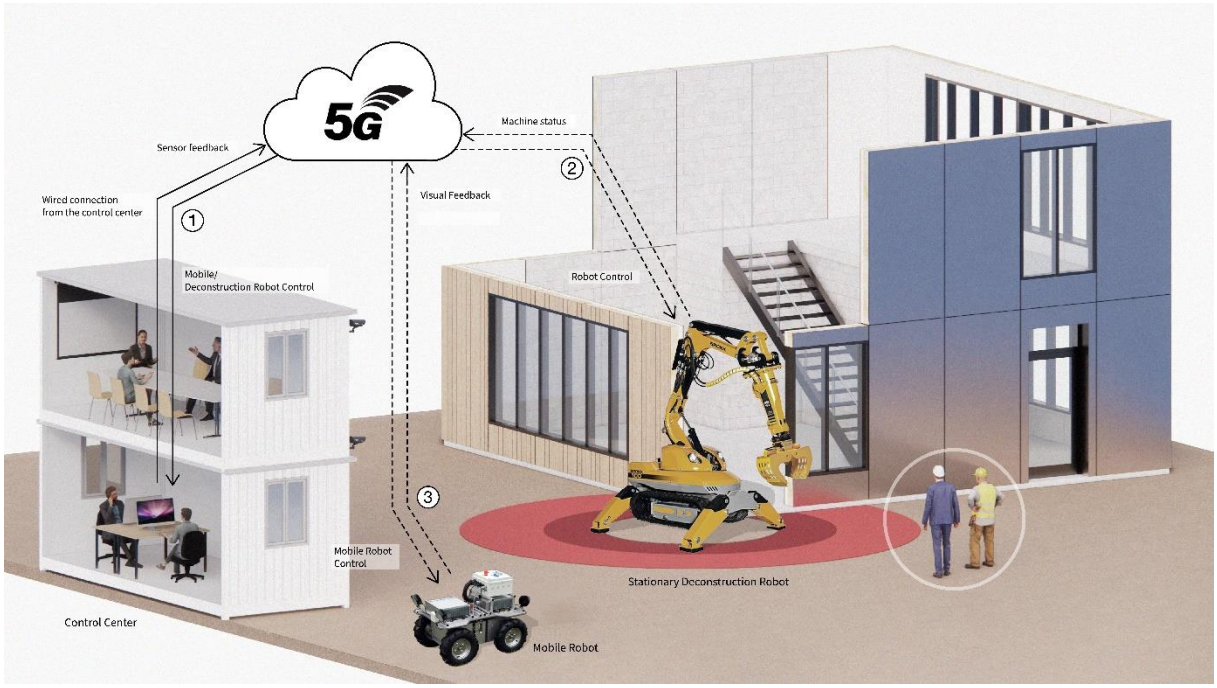

Figure 3-8 Planned setup for the Integration of 5G in the construction vertical for controlled deconstruction and enhanced circularity.

Beyond that, the construction vertical contributed seven topics to the challenges that were published in the first open call. The evaluation of the proposals received for this open call demonstrated that the potential benefits of 5G for the construction industry are not yet in the focus of most companies. Another reason for the limited resonance could be the economic downturn the construction industry faces these days. From the 21 received applications five have been preselected for the first funding period. However, in collaboration with work packages “Open Calls & FSTP” and “Communication and Dissemination” more specific advertisements for the second open call are being planned. The challenges for the second round will be finalized by the end of November. For the construction vertical there will be some new challenges as well as a relaunch of challenges from the first open call.

In view of the upcoming milestone at the end of this year, the Reference Construction is being prepared as testbed for TARGET-X. In a previous project the connection to the 5G-Industry Campus Europe has been established and a tower crane has been equipped with a 5G antenna to provide the Reference Construction Site with its own network cell [5GN22].

However, several challenges had to be overcome to provide the testbed with a robust 5G network. In the beginning, no stable connection could be established due to a reset of the connection that took place periodically. This matter could be solved, by a reconfiguration of the used routers. Object of current investigations is the limitation of the uplink which turned out to be considerably lower than expected. Possible solutions are being researched, implemented, and validated. Solving the matter is not only essential for the progress of the research in construction vertical but also for any FSTP project results that are to be validated on the testbed.

3.5.2 Next steps

The upcoming year will be dominated by two major activity branches. The first branch will have the focus on the development, implementation, and deployment for the planned use cases under the scientific lead of RWTH-IP. The second branch will be concerned with the coordination and mentoring of the FSTP projects. In December 2024, the second project year will end with the submission of deliverable D5.2.

4 Technology evolution beyond 5G

The work package “Technology evolution beyond 5G” provides a technology platform to the test beds of the verticals in TARGET-X. The test beds on the trial sites consume this state-of-the-art 5G technology, and with introduction of use cases of the various verticals, this technology platform will be extended with a set of elements that reach beyond today’s 5G network solutions and capabilities.

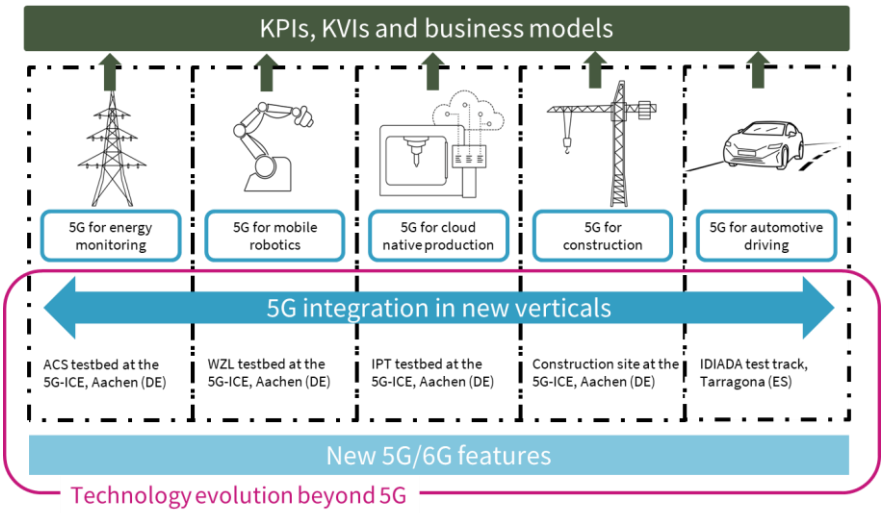

Figure 4-1: Highlighted technology evolution focus areas

Next to the introduction of these beyond 5G technology elements, focus is also given to measure and quantify the benefits of introduced features, both on a functional as well as on a socio-economical level. This goal will be accomplished by executing measurements before and after the introduction of defined elements, as well as by evaluating the features against KVIs in the framework, defined in one of the other work packages of this project.

4.1 Achievements during the first year

The first year of execution in TARGET-X in technology evolution has been focused on understanding and assessing the status-quo with regards to technology availability on the trial sites. The technology assessment was combined with the initial understanding of use cases that the verticals plan to introduce. The findings from this assessment activity were documented in the TARGET-X deliverable D6.1 [TAR23-D61] and initial deployment intent and priority for the technology elements across the different test beds was created.

Table 4-1: Deployment intent with high (1) and lower (2) priority [TAR23-D61]

	ENERGY	MOBILE ROBOTICS	CLOUD-NATIVE PRODUCTION	CONSTRUCTION	AUTOMOTIVE
Service differentiation	2	1	1	2	1
mmWave spectrum			1		2
Asset Admin. Shell			1		
Positioning		1	2	2	1
Real-time ecosystem		1	1		2

The assessment was followed by the introduction of first technology elements that we considered of relevance beyond 5G. The effects of the hardware installation and/or the software updates were verified by executing initial measurements.

4.1.1 Service differentiation

The density and variation of services in 5G and beyond networks will increase as more and more use cases from industry verticals are transferred to wireless networks. By classifying services in different classes, we introduce logical differentiation of services, on the same bearers. Several mechanisms exist to provide different service levels to different classes. These mechanisms will be further studied, and their effectiveness will be validated by introducing selected mechanisms to use cases in construction, energy, and automotive verticals.

4.1.2 mmWave spectrum

The need for more bandwidth in mobile networks increases constantly. More connected devices with ever increasing payloads drive the need for bandwidth, both from device to the network, as well as from the network to the devices. The introduction of mmWave spectrum in 5G is a first step towards more bandwidth availability in future.

The mmWave tests and introduction into use cases of TARGET-X are planned to be executed in the cloud-native production testbed. A mmWave antenna was mounted on the shopfloor and the needed RAN configuration was performed. After the installation activities, a few available devices were attached to the deployed mmWave to perform first connectivity and propagation tests.

4.1.3 Asset Administration Shell

The activities for Asset Administration Shell have started with an introduction of the concepts of the Asset Administration Shell(s) to the TARGET-X consortium. This internal competence build-up session took place shortly after the project kick-off, to secure that all partners have a common understanding of AAS when elaborating their use cases scenarios.

The planning regarding the introduction of an AAS is documented in a separate deliverable D6.3 [TAR23-D63].

4.1.4 5G Indoor positioning

Indoor positioning with 5G is seen by industries as a key differentiator as it enables communication and positioning via the same platform, and thus rendering the need for 2 different, and possibly disconnected platforms, obsolete. Positioning with 5G can be seen as a step in the evolution towards JCAS in 6G [Eri21]. JCAS or Joint Communication and Sensing builds on the concept that the radio waves, used for communication purposes, can also be used to sense the coverage field for objects. The information that is gathered in this way, can be used to optimize the network, or provide positional information of the detected objects.

A part of the TARGET-X robotics trial site was chosen for the initial introduction of a prototypic indoor positioning setup. At this site, 2 areas were identified that offer interesting conditions for experiments with 5G indoor positioning.

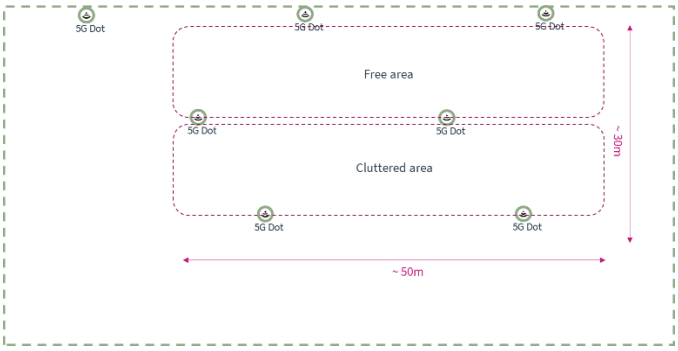

Figure 4-2: Sketch 5G indoor positioning setup

4.1.5 Real-time ecosystem

The need for reliable, deterministic, and low latency communication remains unchanged in industrial communication. TARGET-X introduces several use cases where the need for reliable, deterministic, and low latency communication is key. In the first year of execution, TARGET-X focused on the execution of measurements, both with state-of-the-art 5G networks, as well as with prototype implementations. The measurements, combined with the requirement definition with the consortium members, gave additional insights on the communication needs for the use cases.

4.2 Next steps

The next steps for the technology evolution scope of TARGET-X can be split in 3 parts:

1. Introduction and study of the remaining technology elements, using similar methods and strategies as before. In addition, we intend to study option of introducing RedCap as an additional technology element, which will require analysis and configuration efforts.
2. Support the implementation of the use cases and the introduction of beyond 5G technology in the use cases.
3. Onboard FSTP projects onto the various test beds and provide mentoring during the implementation of their proposed solutions to challenges posted by the TARGET-X consortium.

5 Financial support for third parties in TARGET-X

TARGET-X will provide the financial support for the third parties (FSTP). The beneficiaries (up to 100 entities) will be selected during the two Open Calls.

The objectives of Work Package 7 (Open Calls & FSTP) are to define the topics for the Open Call through a collaborative process, reach out a critical mass of applicants;, to manage the full process of open calls following EC standards, to ensure a smooth management of the Financial Support to Third Parties based on a lump sum scheme certified against deliverables, to provide a full range of support services to the selected third party projects.

5.1 Achievements during the first year

The topics for the 1st and the 2nd Open Calls were established by the TARGET-X Consortium Partners through collaborative efforts.

Below, we present the number of topics and selected projects per vertical.

Table 5-1: Topics and selected projects per vertical

TITLE	TOPICS IN 1st OPEN CALL	PROJECTS SELECTED IN THE 1st OPEN CALL	TOPICS IN 2nd OPEN CALL	PROJECTS SELECTED IN THE 2nd OPEN CALL
METHODOLOGICAL ASSESSMENT FRAMEWORK	2	0	2	to be selected in 2024
MANUFACTURING	10	8	12	to be selected in 2024
ENERGY	6	6	7	to be selected in 2024
AUTOMOTIVE	14	7	3	to be selected in 2024
CONSTRUCTION	7	5	13	to be selected in 2024
TECHNOLOGY EVOLUTION BEYOND 5G	9	1	7	to be selected in 2024
	48	27	44	-

To help the applicants understand the TARGET-X requirements, application and evaluation process, TARGET-X Consortium Partners prepared 'Package of Open Call Documents' (Guide for Applicants with annexes, Frequently Asked Questions, Open Call Announcement, Application Form and Guide for Evaluators).

Figure 5-1: Annex 1 Topic description from the package of open call documents

The TARGET-X Consortium Partners wanted to present the easy and clear application process, that is why we created the microsite, on which application form, documents, information about the online events organized for applicants, and a direct link to the TARGET-X social media were uploaded in one place.

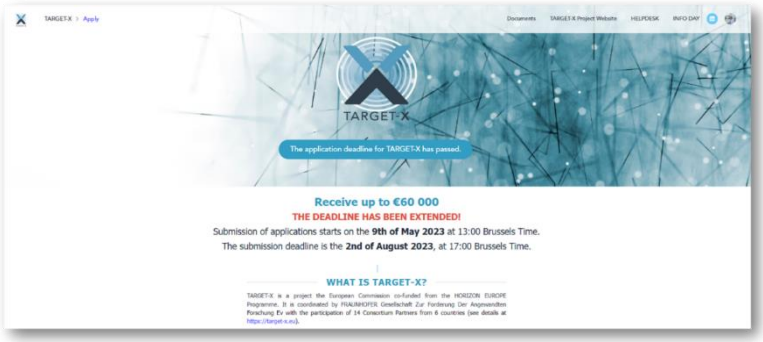

Figure 5-2: TARGET-X microsite

Applicants were supported in their application journey, FundingBox created the helpdesk, where the applicants had the opportunity to ask direct questions to the Consortium Partners and we organized two online events – InfoDay and Q&A session. FundingBox prepared the 'Dissemination Toolkit' to help TARGET-X Consortium Partners disseminate information about the project.

FundingBox presented the draft of SubGrant Agreement (which will be signed with the TARGET-X Beneficiaries) to provide applicants with an overall overview of the Support Programme.

For the TARGET-X 1st Open Call, 132 proposals were submitted. After closing the Open Call, the evaluation process started.

Each phase of evaluation process which was carried out by the TARGET-X Consortium Partners and External Evaluators with the respect of the EC principles of equal treatment, transparency, confidentiality and non-conflict of interest.
Below, we present the timeline of the evaluation process:

Table 5-2: Timeline of the evaluation process of the first open call

PHASE	TIME	RESPONSIBLE	NUMBER OF PROPOSALS
THE ADMISSIBILITY AND ELIGIBILITY CHECK	2/08/ 2023	FUNDINGBOX	130 proposals
IN/OUT SCOPE SCREENING	3/08 – 29/08/2023	THE SELECTION COMMITTEE	87 proposals
INDEPENDENT INDIVIDUAL EVALUATION	14/09 – 26/09/2023	THE EXTERNAL EVALUATORS	-
EVALUATION CONSENSUS GROUP	29/09/2023	THE EXTERNAL EVALUATORS	62 proposals
CONSENSUS MEETING	16/10/2023	THE SELECTION COMMITTEE, TWO EXTERNAL EVALUATORS AND ETHICS EXPERTS	27 proposals
ETHICS REVIEW	-	FOUR EXTERNAL ETHICS EXPERTS	-
FORMAL CHECK	20/10– 12/2023.	FUNDINGBOX	

The evaluation process for the 1st Open Call was completed and 27 projects were selected. FBA manage the Formal Check and the process of signing the SubGrant Agreement is planned for Q1, 2024.

Preparations have begun for the TARGET-X Support Programme (start: Q1, 2024). FundingBox prepared the drafts of the deliverables which will be submitted (and approved by the Selection Committee) at each Milestone Review:

- 1st Milestone Review: Individual Mentoring Plan;
- 2nd Milestone Review: Interim progress review;
- 3rd Milestone Review: Final review.

The TARGET-X Consortium Partners organized the online meeting with the selected beneficiaries to provide general information about the Support Programme, information about the Mentor, detailed information about the documents which each beneficiary must provide, payment arrangements, answers to all the questions and doubts the beneficiaries had.

In December 2023, the TARGET-X 2nd Open Call was launched. TARGET-X Consortium Partners updated the 'Package of the Open Call Documents' and created a new microsite for the TARGET-X 2nd Open Call. Documents, information about the online events organized for applicants, and direct links to the TARGET- X social media were uploaded on the new microsite.

FundingBox organized the online event – Info Day for the applicants, where the objectives detailed about the 2nd Open Call were presented. The next online event - Q&A session in the planning stage. All online events are organized via the ZOOM Platform.

The preparation of the evaluation process for the TARGET-X 2nd Open Call is ongoing.

5.2 Next steps

The Support Programme for the TARGET-X 1st Open Call will start in Q1, 2024. TARGET-X Consortium Partners will be Mentors for the applicants for the whole duration of the Support Programme.

In February 2024 the 2nd Open Call will be closed and the evaluation process of the TARGET-X 2nd Open Call will start.

The Support Programme 2nd Open Call will start in Q3, 2024 depending on the holiday period.

6 Dissemination and impact

TARGET-X employs a dedicated work package for communication and dissemination to coordinate the contribution of all project partners working on relating activities and to enable a joint strategy for communication and dissemination to reach a maximum impact of the activities. The objectives of work package 8 are:

1. to maximize the external impact of the project by means of a multi-fold dissemination strategy to provide relevant information to all stakeholders and facilitate market adoption of the project's results.
2. to coordinate the industry-related, strategic dissemination activities of the project towards regulation, standardization, and other forums.

6.1 Achievements during the first year

TARGET-X implemented a coordinated impact and dissemination plan that foresees presentation and promotion of project results at scientific conferences, journals, workshops, consumer expos, industry groups and forums, cross-project consortia, among a dedicated IoT community, as well as promotion of the open calls.

In the first year of the project, the focus has been on stimulating the international research community, increasing the visibility of the project, promoting the exchange of knowledge regarding 5G/6G in the four verticals, and promoting the open calls, thus accelerating the expected impact.

Deliverable D9.1 [TAR23-D91] describes the project's website (https://target-x.eu). Deliverable D8.4 explains the TARGET-X community, as a vibrant and participatory web-based platform for stakeholders in the Internet of Things (IoT) area.

The communication activities aim at interacting with both technical and non-technical audiences with the overall aim of spreading awareness of 5G /6G technology in the targeted verticals. Dissemination activities included showcasing the use of 5G/ 6G in a number of conferences as well as contributions to international fairs and workshops. The impact and dissemination plan includes the following major activities:

1. Contribution to journal papers, white papers and international conferences
2. Contribution to standardization meetings and regulatory bodies
3. Deliver keynote speeches and contribute to panels
4. Participation in 5G/6G events for addressed verticals in the project
5. Conduct training activities
6. Performing 5G/6G demos and validation events

In the first year of the project, TARGET-X has already come a long way, from the development of a complete corporate design to a website and publication media.

Figure 6-1: Flyer TARGET-X

In terms of the plan, TARGET-X has identified a number of activities for disseminating and communicating news and results and the project has a track record, of conferences, workshops to trade fairs.

However, it has to be noted that the year was characterized by setting up a communication strategy and building visibility alongside the huge efforts on promotion the open call for third party projects.

The web and social media presence is an important asset of TARGET-X communication strategy. The project's website, the LinkedIn focus page posts register measurable traffic. These channels are used to publish the results produced by the project, the project's presence at various events, upcoming events, as well as other news about the project.

LinkedIn [https://www.linkedin.com/showcase/target-x/]

Organic KPI [01.01.2023 – 30.11.2023]

- 310 Follower [30.11.2023]
- 8626 Impressions across all posts [01 – 11. 2023]

Website: [https://target-x.eu/]

- Stats [01.01.2023 – 17.11.2023]
- Website views in total: 32.7224
- Unique visitor: 6.025

Publications from the project are distributed through the website (https://target-x.eu/publications/) as well as through a scientific community Zenodo (https://zenodo.org/communities/targetx/).

Table 6-1 contains the dissemination and communication activities linked to the project during its first year, from Jan 2023 to Nov 2023.

Table 6-1: Dissemination activities linked to TARGET-X from January - November 2023

DISSEMINATION ACTIVITIES	NUMBER OF ACTIVITIES
CONTRIBUTION TO JOURNAL PAPERS, WHITE PAPERS AND INTERNATIONAL CONFERENCES	1
CONTRIBUTION TO STANDARDIZATION MEETINGS AND REGULATORY BODIES	1
DELIVER KEYNOTE SPEECHES AND CONTRIBUTE TO PANELS	2
PARTICIPATION IN 5G/6G EVENTS FOR ADDRESSED VERTICALS IN THE PROJECT	7
CONDUCT TRAINING ACTIVITIES	2
COMMUNICATION ACTIVITIES (PRESS RELEASES, NEWSLETTERS ETC.)	5

6.2 Next steps

In the following year, the intention is to continue to pursue the objectives with regard to the number of papers, participation in conferences etc. in line with the plan. Here, even greater efforts must be made to bring the project and its results closer to the academic community. Regarding the communication activities, emphasis will be put on the results from the cooperation with the FSTP projects. The 2nd Open Call will be also promoted at onsite events and fairs.

Continuous communication work on social networks and on the web in general will continue as before, as well TARGET-X participation in international events.

7 Conclusion and impact

In the intermediate project report, the main accomplishments of TARGET-X during the initial year of the project are emphasized. The report includes references to the project deliverables and demonstrates significant progress made by TARGET-X in its first year of execution.

The identification and description of the use cases has happened across all the vertical's work packages. Also, initial architecture definitions are in place and prepare the testbeds for the upcoming implementations. The testbed preparations have been supported by the technology evolution work package, where the 5G/6G features have been identified and are ready for setting up the large-scale pilots in the five testbeds. The completion of the several milestones shows that the testbeds are already operational.

The basis of the methodological assessment framework has been laid out and the KPI/KVI evaluation across the four verticals Energy, Manufacturing, Automotive and Construction has already started to create synergies between the industrial users with the joint use case description. This will also facilitate the joint evaluation of the beyond 5G features.

The first open call for FSTP was executed and led to a high number of proposals. The identified community and projects already enhanced the 5G/6G ecosystem in the manufacturing & robotics, automotive, energy, and construction verticals.

In conclusion, the first intermediate project report of TARGET-X demonstrates significant progress and achievements in various application domains, successful collaboration of end users and technology partners, and the initiation of financial support for third parties. The project's communication and dissemination efforts have also been effective in reaching a wide range of audiences.

In the upcoming year, the use case implementations and the application testing will be a crucial part of the activities. Therefore, further software and hardware implementations will take place as well as design, implementation and deployment of the use cases in the five testbeds. This will allow for refining the methodological assessment framework and set a stronger focus on performance testing. Integrated with the project, the FSTP projects will enter their execution phase with the start of 2024. For the first open call, this will be seven months at the beginning of the year, and the second open call project execution start will follow directly afterwards.

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