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IoT-NGIN

D1.1
Definition analysis of use cases and GDPR Compliance

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List of Acronyms and Abbreviations

AR	Augmented Reality
AGLV	Automated Guided Land Vehicle
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
DR	Demand Response
DSO	Distribution system operator
GA	Grant Agreement
GDPR	General Data Protection Regulation
GUI	Graphical User Interface
HVAC	Heating, Ventilation and Air Conditioning
IN	Industry 4.0
IoT	Internet of Things
LL	Living Lab
ML	Machine Learning
MaaS	Mobility as a Service
PMU	Phasor Measurement Unit
SA	Smart Agriculture
SC	Smart Cities
SCADA	Supervisory control and data acquisition
SE	Smart Energy
UC	Use Case
UML	Unified Modeling Language
WP	Work Package

Executive Summary

This document aims to provide a list of the IoT-NGIN requirements by giving precise and elaborate analyses of the 10 use case scenarios. Further to the requirements, each analysis identifies business objectives, actors and user needs, lists the target KPIs and identified risks, challenges and/or assumptions. The document will structure and list the IoT-NGIN requirements stemming from needs identified by the LL owners and industrial partners, as well as user needs. Additionally, this document gives a detailed description of the GDPR compliance and a general monitoring methodology on ensuring compliance not only for the purposes of this deliverable but for the lifetime of the project.

Within this deliverable a common set of needs and requirements can be drawn from what was provided by the LL Owners and end-users for the majority of the UCs. Combining the lists of requirements individually addressed per UC in the chapters below, one can draw conclusions on common patterns. Keeping in mind the individuality of each UC application and the unique innovative suggested elements, the requirements can loosely be group into ones concerned with issues on accuracy, maintaining security, low latencies and human safety. On the needs, gathered by end-users in each domain, there is a common preference towards the use of ML for predictions and general use of AI.

For verification and validation of the project's approach, we consider industry-specific use cases from four vertical sectors: Smart Cities, Smart Agriculture, Industry 4.0 and Smart Energy- each presented in Chapters 3-6. Within the document, a specification of functional and non-functional requirements, that were gathered by the LL owners (FVH, SYN, OPT, BOSCH, ABB, ASM, EMOT) as well as contributions from all the task participating partners and users, is listed.

In the final chapter, conclusions about the use cases' requirements are drawn. Additionally,emphasis is given on the interrelations between the project's workpackages with specific mention to WP7: "IoT-NGIN Living Labs Validation & 3rd Party Support" during which, validation of the UCs will take place.

1 Introduction

This deliverable responds to task T1.1 on the use case refinement, analysis and the target KPIs definition, as well as task 1.3 on the GDPR compliance component. The methodology of the project is presented below to respond to the IoT-NGIN's GA commitments and the mapping to this deliverable' outputs to other project workpackages, tasks and deliverables. Given emphasis on the dependencies with other WPs and of course the need to continuously test and redesign parameters to achieve results.

The objectives of this deliverable are essential to give detailed definitions of appropriate post-exploitable use cases linked to specific target technological KPIs and provide an analysis of the challenges and requirements definitions that will later be used for the design of the architecture of the IoT-NGIN platform.

1.1 Deliverable Overview:

Chapter 2- describes the methodology used in assessing the use case requirements and user needs to be documented in this report.

Chapters 3-6 set out the groups of use cases including the use case scenarios alongside use case requirements, end-user needs and target KPIs and provide the partner key roles in the formation of the use cases. Target KPIs are mentioned in this report as documented in the project's GA, however, they will be revisited and finalised in future deliverables within WP7.

Chapter 3 – details the framework on the Smart Cities domain provided by FVH and AALTO.

Chapter 4 – details the framework on the Smart Agriculture domain provided by Synelixis.

Chapter 5 – details the framework on the Industry 4.0 domain provided by BOSCH and ABB.

Chapter 6 – details the framework on the Smart Energy domain by ASM and EMOT.

Chapter 7 – provides the overall plan and methodology for the GDPR/privacy compliance by PRI.

Chapter 8 - concludes with the findings of the report.

2 Methodology

This deliverable report responds to the work laid out in Task 1.1 "Requirements' analysis, use case refinement and target KPIs" and work laid out in Task 1.3 "Verification framework and GDPR Compliance". Collaboration between the author and the rest of the partners involved in the two tasks as well as communication with the Living Lab owners responsible for testing and validation was key to meet high qualitative EC standards for this report. The IoT-NGIN project will bring about operational efficiencies on various levels and these will be measurable under specific parameters as presented in the GA in the form of KPIs. Each use case has a dedicated section within this deliverable report where target KPIs are presented.

2.1 UC Scenario

The scenario for each UC, is described in 5 distinct parts as listed below:

1. The use case objectives
2. The involved actors
3. The background information
4. The scenario narrative
5. Risks, challenges or assumptions deriving from the scenario

2.2 UC Requirements

To capture the requirements, eBOS requested input from all partners involved in Task 1.1 requesting information on functional and non-functional requirements, pre-conditions, post-conditions and ways of measuring the target KPIs as mentioned in the GA, per use case. Three iterations of the created templated tables ran and the final sets of functional and non-functional requirements were assessed and re-defined by the LL owners. A sample of each of the three iterations is presented in Annexes 1 and 2.

Although the requirements have been collected by project partners only, project partners are industry experts with direct contact with their end users. Project partners have transferred the requirements from their customers/collaborators to the deliverable through the questionnaires. The consortium is confident that project partners are very much aware of the requirements for their specific use case and they can sufficiently cover the external stakeholder's point-of-view.

2.3 Key Performance Indicators

For the purposes of this deliverable report, target key performance indicators are defined in responding sections of this deliverable, per UC. The KPIs presented in this deliverable may either be business performing indicators or technological ones. Additionally, the KPIs may easily be divided into qualitative and quantitative indicators, the former exhibiting targets as per the LLs accepted levels of quality while the latter provides a numerical target that measures quantity. It is essential to stress again that these indicators will be revisited and re-evaluated as necessary when measurements are clearer within the validation stage in WP7.

Additionally, the input on requirements was elicited by questionnaire responses provided to each domain's identified end-users: Smart Cities, Smart Agriculture, Smart Energy and Industry 4.0. The requirement for documenting the needs of end-users for each of the four domains are clearly stated in the description of Task1.1 "Requirements' analysis, use case refinement and target KPIs" reported in this deliverable. In achieving the capture of user needs, the partners involved within Task1.1 contributed to three iterations of questions for the creation of the user questionnaire, tailored to respond to the four project domains.

The questionnaires were divided into three parts, with the first and second being common in all four of the domains;

(i) general information of the user and
(ii) information on the data and technological capabilities
(iii) The third part of each questionnaire responded to questions specific to each of the four domains. Specific responses on each of the domains are presented in Tables within the rest of the deliverable under their responding domain. Because of the travelling restrictions and many cancellations of planned conferences and exhibitions, reaching sufficient numbers of end-users was difficult, therefore the LL owners provided responses as end-users themselves. Samples of the questionnaires' iterations are provided as Annexes 3, 4 and 5.

WP1 and this report in particular, are set to provide input to the WPs 2, 3, 4, 6 and 7 and their respective tasks as shown in Figure 1 below:

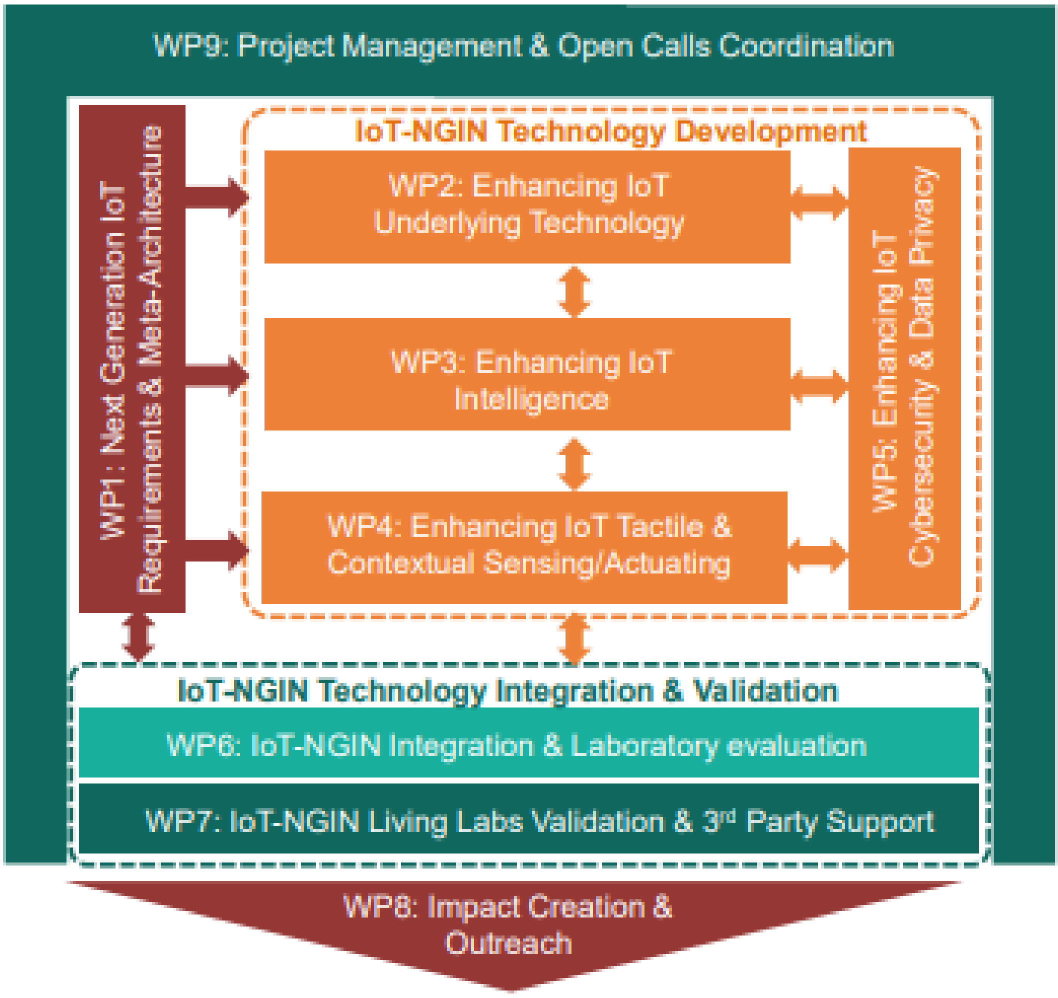

Figure 1: WP Interdependencies.

3 Smart Cities

The concept of a 'smart city' is gaining ground around the globe as more and more cities are using technology to provide services and solve city problems [1]. As presented in the policy document "Mapping Smart Cities in the EU, Helsinki ranked 6th in a list of 468 cities in Europe with a population of over 100,000 residents, with significant and verifiable Smart City activity [2]. This section provides an analysis of the three use cases under the 'Smart Cities' vertical including features and capabilities of each scenario, alongside the needs gathered from the users, the functional and non-functional requirements and the target key performance indicators. The GA has provided a backbone on which we have based these elements on and the LL owners and contributing partners have provided additional information on each use case scenario.

In the section below each use case is presented individually, aligning with its separate objectives, requirements, user needs and target KPIs. To improve the credibility of the use cases, a monitoring framework and feedback must be communicated and confirmed with other WPs so that relevant improvements are identified and addressed on a timely.

3.1 UC1 Traffic Flow Prediction & Parking prediction

The number of cars moving around the city has significantly increased over the years, which has caused several issues with traffic jams and the unavailability of parking space in some key areas. Jätkäsaari is one of the affected areas: it is an island with only two vehicle-carrying connections to the mainland, yet it also hosts a large ferry terminal. Every three hours, a big ferry arrives from Estonia with pedestrians, cars, and large trucks, creating a significant burst of traffic to and from the terminal the current road network has trouble effectively dealing with. The concept of this UC is to implement intelligent technologies in the attempt to predict traffic flow and provide solutions to reduce the formation of traffic jams by, e.g., by dynamically retiming the traffic lights to better match the demand and by helping drivers better time and route their movements in the area. Additionally, similar intelligent technologies are to be used to predict parking availability giving the opportunity to the drivers to find parking spots easier and faster.

3.1.1 UC Scenario

3.1.1.1 Objectives

The main objective of the UC is to efficiently predict traffic flow and parking availability to decrease traffic jams and bottlenecks. Specifically, the UC will present a model that aids the driver in:

- Choosing a less-trafficked road and/or time
- Provision of viable locational information on available parking options
- Demonstration of the application of deep learning technologies for advanced traffic flow prediction including unpredictable conditions like weather, delays and accidents

3.1.1.2 Actors

The actors involved in the use case include:

- Drivers
- Solution provider(s)

3.1.1.3 Background

Traffic jams and looking for parking can take a big portion of the commuter's day. It also adds frustration and considerably increases the pollution caused by cars.

With the modelling of traffic and parking conditions, the end-user (commuter) will be able to plan the commute and route accordingly. The data that will be collected and used for ML purposes will be composed of weather data (and how that affects road & traffic conditions) and road data (number of cars, velocity, fluctuation). The predictive model will also use historical data and public transportation information.

Ideally, the driver could, with small behavioural changes, avoid traffic and know where available parking is located, without needing to look for it aimlessly.

Figure 2: Around the area of Jätkäsaari.

3.1.1.4 Narrative

The use case will try to provide a solution to a common problem in large cities which is traffic inefficiencies. Not only is time wasted driving at suboptimal speeds, it also increases the polluting factor of cars.

Collecting road data (car count, speed etc.) and combining that to weather data as well as public transportation information, could potentially, though ML mechanisms, provide insights on the traffic jams by identifying traffic patterns and then help the drivers avoid them by providing the information in a suitable, non-intrusive way to interested users.

Jätkäsaari Smart junction project produces data on traffic fluency using cameras, radars and lidars installed at the bottleneck intersection of Mechelininkatu/Hietalahdenkatu and Jätkäsaarenlaituri. The data from the junctions includes lane-specific vehicle counts, travel times and stops.

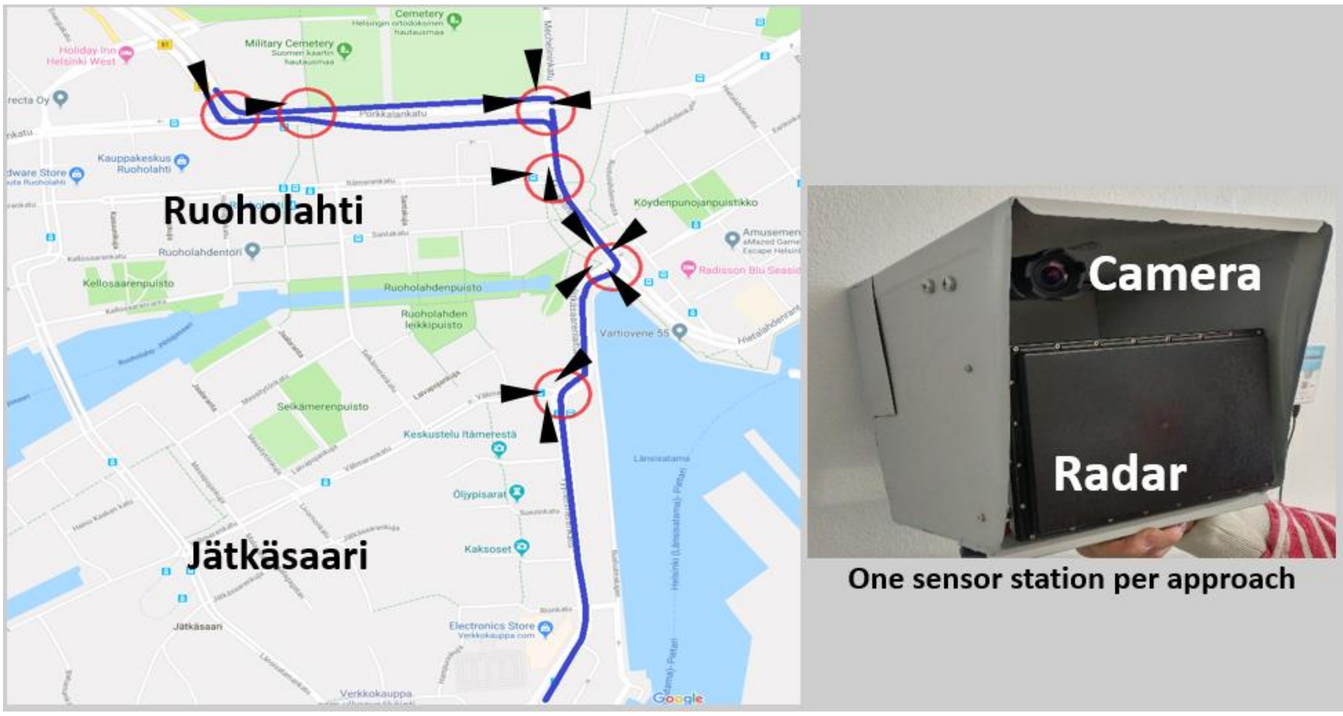

Figure 3: Jätkäsaari Smart Junction data sources.

Current data provided by Digitraffic from TMS (Traffic Measurement System) stations can also be utilized in the pilot. The data contains all sensor data available, from each TMS station, including traffic volume and average speed in both directions. The data is in REST/JSON format, is updated every minute and is under CC4.0 license.

- The API is accessible via http://tie.digitraffic.fi/api/v1/data/tms-data

For parking predictions preliminary specifications have been made and some possible datasets have been identified. Helsingi Region Transport (HSL) provides a 'Park & Ride' service (parking places near train stations) and subsequent data in JSON and GeoJSON format.

- The API is accessible via: https://p.hsl.fi/api/v1/facilities.json

Another dataset useful in predicting and analyzing parking spots are the parking spot usage APIs provided by the City of Helsinki.

- The API description can be found here https://api.parkkiopas.fi/docs/public/
- And here https://hri.fi/data/en_GB/dataset/rajapinta-helsingin-pysakointipaikkojen-kaytosta

3.1.1.5 Risks/ Challenges/ Assumptions

The use case carries the risk of not achieving anonymisation of data and data ownership by correct actors. An additional risk is how a potentially lower quality training material may lead to inaccurate or misleading predictions based on the ML training models.

Also, it is expected that the volume of data available will be very large. Combining potentially heterogeneous data and building a predictive model can be challenging.

3.1.1.6 Features

The features of the "Traffic flow prediction and parking prediction" UC have been extracted by means of use cases[1], used for clarifying concepts implemented in the project, deriving functional and non-functional requirements, and providing some scope for test cases that will be later used to validate the IoT-NGIN framework. The use case for "Traffic flow prediction and parking prediction" is described in Table 1.

Table 1 – "Planning based on predictions" use case of UC1.

Use Case SC1.1: "Planning based on predictions"	
Brief Description	Before leaving a location by car, the user can check suggested routes and avoid traffic jams. Additionally, the user can check available parking places and plan their journey in advance.
Actor(s)	Car user, city officials, MaaS companies.
Priority	High.
Trigger	The car user starts planning as they intent to avoid traffic and find easy parking.
Pre-conditions	Functioning ML model and network capabilities (5G).

3.1.2 Target KPIs

The key performance indicators as defined by FVH the LL owner for UC1, are shown below in Table 2, alongside the method of measurement and the numerical target.

Table 2 - UC1 Key Performance Indicators.

KPI ID	Name	Description	Metric	Method of measurement	Target
KPI_UC1_1	Real-Time Monitoring	Improve efficiency and traffic congestions in twin smart cities	Percentage	Log and analysis	>/=20%

[1] The use cases described in this section refer to the term introduced in [19]as a way to specify functional software requirements.

KPI_UC1_2	Cross-border data models	Number of proposed cross-border data models	Numeric	Number of data models	>4
KPI_UC1_3	Data sources analysis	Number of different types of sensors' data (multispectral/visual camera, RFID) to be analysed	Numeric	Number of different sensors used	>6

3.1.3 UC Requirements

For the purposes of this deliverable report's sections on UC requirements, the following terms are defined. Functional requirements define a system or its component. Additionally, non-functional requirements define the quality attributes of a software system. While a functional requirement describes the functions a software must perform, a non-functional requirement is represented by standards used to judge a specific operation [3].

3.1.3.1 Functional Requirements

The functional requirements of the "Traffic flow prediction and parking prediction" UC are listed in Table 3 below, providing a unique identifier, a description and a foreseen priority level for each requirement.

Table 3 - UC1 Functional Requirements.

ID	Description	Priority
REQ_SC1_F01	The application must take care of constraints imposed by the physical traffic infrastructure: road network capacities, traffic regulations and management policies.	High
REQ_SC1_F02	Gain access to the city's traffic data and parking availability.	High
REQ_SC1_F03	Availability of function on aspects such as weather, events, environmental information from multiple information sources.	High
REQ_SC1_F04	Consideration of streets and parking topologies, locations and alternative routes and parking spots.	High
REQ_SC1_F05	Provision of maps with real-time and real traffic situations with the ability to show alternative routes in case of traffic congestion/interruptions.	High
REQ_SC1_F06	UI for the user including predicted traffic evolution displayed in user-friendly windows.	Medium

REQ_SC1_F07	Ability to show real-time data on parking capacity (full/ empty), updating in real-time	High

3.1.3.2 Non-Functional requirements

The non-functional requirements of the "Traffic flow prediction and parking prediction" UC are listed in Table 4, providing the unique identifier, a short description and the priority level for each requirement listed.

Table 4 - UC1 Non- Functional Requirements.

ID	Description	Priority
REQ_SC1_NF01	Ensuring data integrity and security on all forms of data available.	High
REQ_SC1_NF02	Every unsuccessful attempt by a user to access an item of data or functionality shall be recorded on a database.	Low
REQ_SC1_NF03	Privacy of information and security have to be guaranteed.	High
REQ_SC1_NF04	The application has to guarantee reliability, availability and low latency.	High

3.1.4 User Groups

For UC1 the users were identified as the:

- Citizens
- Public transport planners
- Supply logistic workers
- Smart city residents
- SMEs

3.2 UC2 Crowd Management

In the Jätkäsaari area, many of the people living and working there as well as travelling to and from the ferry terminal are pedestrians or users of the public transport, all of whom are not only affected by the traffic conditions in the area but also aggrevating the traffic jams. To provide them better service through easier and more efficient movement in the area and to reduce the negative effect the pedestrians have on the traffic jams, this use case aims to demonstrate the use of open data, user data and IoT data on crowd management. Traffic fluency will be monitored and processed via cameras installed at bottleneck intersections to achieve better crowd steering based on the application of AI by e.g. retiming the traffic lights based on demand. The use case will also consider monitoring crowd management in the busy ferry terminal during daily peak hours and special events using predictive algorithms.

3.2.1 UC Scenario

3.2.1.1 Objectives

The main objective of this UC is to:

- Demonstrate the use of AI on advanced crowd prediction and movement control

3.2.1.2 Actors

- Public Officials
- Passengers

3.2.1.3 Background

The Jätkäsaari harbour in Helsinki is one of the most trafficked harbours in the world. In 2017 more than 12 million people went through it. Jätkäsaari being a relatively new district with several ongoing construction sites has caused some transportation challenges. Increased frequency in tram intervals has not solved the problem and lack of space (due to constructions) is decreasing the number of possible actions that can be taken.

Figure 4: The new Jätkäsaari area

3.2.1.4 Narrative

Anonymous monitoring of the crowd movement fluency is expected to provide new insights on how and why bottlenecks form. After pinpointing the key issues, with adequate communication methods, the crowd can be steered and managed to prevent or diminish the effect of bottlenecks.

Figure 5: The ferry terminal in Jätkäsaari

Datasets that can potentially be useful for this use case have been identified. For example, public transport route statistics could be used to analyse what are the best times for commuting. Documentation of the route statistics is publicly available and can be accessed via https://hri.fi/data/en_GB/dataset/hsl-n-nousijamaarat-pysakeittain. Additionally, the Helsinki Region Transport provides passenger numbers in various formats (CSV, KML, ESRI Shapefile, GeoJSON and GeoService). Public transportation stops can be pulled as well from Digitransit via https://digitransit.fi/en/developers/apis/1-routing-api/stops/

Moreover, public transport information could be combined to ferry traffic statistics provided by the Finnish Transport Agency (FTA). The API can provide real-time information on time of arrival and departure as well as the ship and agent name. This information can be accessed via https://hri.fi/data/en_GB/dataset/hsl-n-nousijamaarat-pysakeittain. This information could then be combined with the location and availability of city bikes for additional options. This data is accessible through an XML interface at https://api.digitransit.fi/routing/v1/routers/hsl/bike_rental. Finally, the numbers of cyclists can also be used to shape a general picture, these numbers comprise publicly available data that can be accessed at https://hri.fi/data/en_GB/dataset/helsingin-pyorailijamaarat

3.2.1.5 Risks/Challenges/Assumptions

An identified challenge this use case is faced with is the ongoing construction sites in Jätkäsaari that may hinder efforts to reduce bottlenecks. Acting proactively and gathering the relevant data on the location and hours of the construction will help better organise the work.

3.2.1.6 Features

A feature of the "Crowd Management" UC was extracted by means of a use case, designed to clarify concepts implemented in the project and derive requirements. It aims to provide some scope to the test case later to be used to validate the IoT-framework, described in Table 5.

Table 5 - "Proactive information on potential bottleneck" use case of UC2.

Use Case SC3.2.1: "Proactive information on potential bottleneck"	
Brief Description	Beforehand knowledge of potential bottleneck causing events enable the user (e.g. harbour official) to route passengers differently.
Actor(s)	Public officials, passenger.
Priority	High.
Trigger	A boat is about to dock in the Jätkäsaari harbour.
Pre-conditions	The user is logged into the service/application.

3.2.2 Target KPIs

The "Crowd Management" UC will be evaluated against KPIs and targets are shown below in Table 6.

Table 6 - UC2 Key Performing Indicators.

KPI ID	Name	Description	Metric	Method of measurement	Target
KPI_UC2_1	Real-Time Monitoring	Improved efficiency and traffic congestions in twin smart cities	Percentage	Analysis and calculation	>20%
KPI_UC2_2	Cross-border data models	Number of proposed cross-border data models	Numeric	Number of data models	>4
KPI_UC2_3	Data Sources analysis	User-generated data sources to be integrated and analysed	Numeric	Number of sources analysed	>6

3.2.3 UC Requirements

3.2.3.1 Functional Requirements

The functional requirements of the "Crowd Management" UC are listed in Table 7 below, providing a unique identifier, a brief description and the foreseen priority level for each requirement.

Table 7 - UC2 Functional Requirements

ID	Description	Priority
REQ_SC2_F01	The application has to be able to integrate many different data sources (the exact number will be defined at a later stage)	High
REQ_SC2_F02	The application has to provide maps with the crowd real-time situation	High
REQ_SC2_F03	The application has to show a list of the predicted actions to smart handle the crowd	Medium
REQ_SC2_F04	The application must suggest a list of alternative routes to avoid bottleneck creation	High

3.2.3.2 Non-functional requirements

The non-functional requirements of the "Crowd Management" UC are listed below in Table 8, providing the unique identifier, a short description and the priority level for each requirement listed.

Table 8 - UC2 Non-functional Requirements

ID	Description	Priority
REQ_SC2_NF01	Every unsuccessful attempt by a user to access an item of data or functionality shall be recorded on a database	Medium
REQ_SC2_NF02	Privacy of information and security have to be guaranteed	High
REQ_SC2_NF03	The application has to guarantee reliability, availability and low latency	High

3.2.4 User Groups

For UC2 the users were identified as the:

- Boat passengers
- Bottleneck area residents
- City officials
- Inhabitants of the smart city
- SMEs that can build on top of it their innovative services

3.3 UC3 Co-commuting solutions based on social networks

Traffic nowadays has become extremely dynamic. Hence, obtaining data from a single source might be insufficient for effecting solutions to avoid both the formation of traffic jams but also providing drive-around solutions. However, a vast majority of citizens generate a huge amount of data shared on social media. Therefore, UC3 aims to provide commuting solutions based on anonymous data available from social networks. The use case is designed to offer the utilisation of IoT data with virtual citizen-generated IoT data from social networks to demonstrate the use of advanced AI in the provision of co-commuting solutions at the neighbourhood level and cross-border. UC3 user experience will be validated with selected questionnaires for the commuters. Targeted interviews are conducted to confirm the perceived effect on the business case.

The scope of the UC3 is to demonstrate the data flow and provide the proof of concept of such service as feasible. The scope of the project does not include a ride-sharing service so the UC3 will focus on the information flows used to demonstrate the potential benefit of the IoT-NGIN concept on advanced stream processing in the mobility domain.

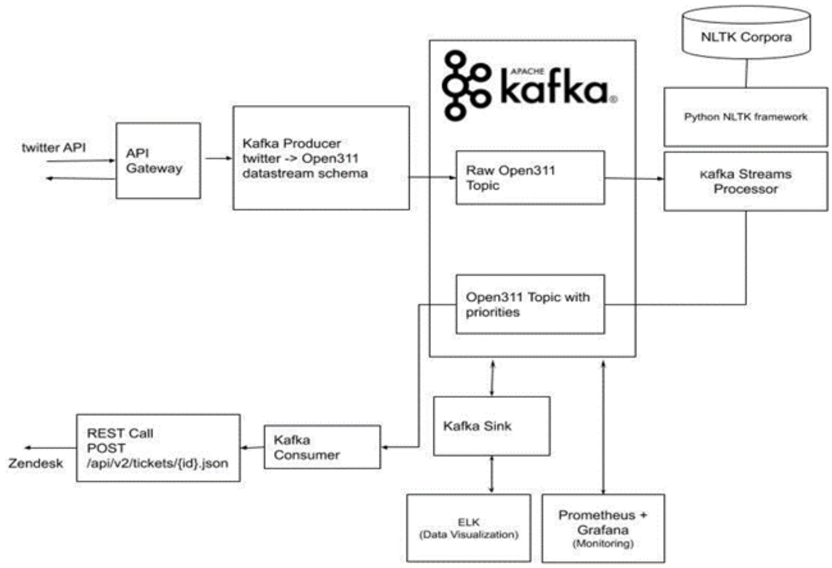

Figure 6: Main technical components involved in UC3.

3.3.1 UC Scenario

3.3.1.1 Objectives

This UCs main objective is to:

- Utilize open data sets and citizen volunteered data to design accessible on-demand, co-commuting solutions on social networks.

3.3.1.2 Actors

The actors involved in the use case are:

1. Platform actors
2. Users (that act as data providers as well as data consumers)
3. Involved SMEs

3.3.1.3 Background

As described in the GA, UC3 on "Co-commuting solutions based on social networks", will make use of the Urban Open Platform and Lab (UOP.Lab) developed in the project *"Finest Twins"*[2] and extend its functionality. The platform enables knowledge and tools to transfer for SMEs.

3.3.1.4 Narrative

UC3, suggests alternative ways of commuting instead of using a personal vehicle. The alternatives will be made available to the commuter from a pool of aggregated data drawn from APIs, co-commuting networks, automatic buses, shared cars. This use case will combine IoT data with virtual citizen generated IoT data from social networks to demonstrate the use of advanced AI in the provision of co-commuting solutions at the neighbourhood level and cross-border. Functionality of the UOP.Lab will be extended with further support with access to 4G/5G and edge cloud along with smart city sensors and equipment such as autonomous buses.

3.3.1.5 Risks/Challenges/Assumptions

One identified challenge is the potential friction between the cultural norm and the "new way". Co-commuting solutions are generally conceived as good ideas, however, their implementation in everyday life is hard to achieve. One of the challenges of the use case is the contribution to change in the habitual and cultural norms.

Other risks involve the misuse and/or misidentification of data that could lead to errors in analysis.

The assumption is that Co-commuting solutions based on the social networks will further enrich the awareness of transportation needs by utilizing social media, especially Twitter. Stream processing functionalities will be provided that can contain advanced analytics such as Natural Language Processing (NLP) e.g. for identifying experienced traffic interruptions. For spatial interpretation, methods such as clustering or density analysis. The advanced analytics together with the information from Crowd Management will be enabling the future development of co-commuting services that benefit from AI predictive demand recognition techniques.

3.3.1.6 User Groups

For UC3 the users were identified as the:

- Commuters (work, hobbies, recreation)

3.3.1.7 Features

Features of the "Co-commuting solutions based on social networks" UC have been extracted by means of use cases used to clarify concepts implemented in the project. The use case is described in Table 9 below.

[2] http://www.finesttwins.eu/

Table 9 - "Public API interfacing" use case of UC3.

Use Case SC3.1: Public API interfacing	
Brief Description	Instead of commuting with a personal vehicle, the user can check available alternatives from an aggregated and curated pool. The pool draws from public transportation APIs, automatic busses, shared cars, co-commuting networks, etc.
Actor(s)	Citizen, city officials, MaaS companies.
Priority	High.
Trigger	The user opens the web interface or launches an app.
Pre-conditions	Data pipelines working (API interactions).

3.3.2 Target KPIs

The "Co-commuting solutions based on social networks" UC will be evaluated against KPIs and targets are shown below in Table 10.

Table 10 - Key Performance Indicators UC3.

KPI ID	Name	Description	Metric	Method of measurement	Target
KPI_UC3_1	Data Sources analysis	User-generated data sources to be integrated and analysed	Percentage	Number of sources	>6
KPI_UC3_2	Cross-border data models	Number of proposed Cross-border data models	Numeric	Number of cross-border models	>4

3.3.3 UC Requirements

3.3.3.1 Functional Requirements

The functional requirements of the "Co-commuting solutions based on social networks" UC are listed in Table 11, providing a unique identifier, description and foreseen priority level for each requirement.

Table 11 - UC3 Functional Requirements.

ID	Description	Priority

REQ_SC3_F01	Gain the required access and approval to the relevant social media API and data.	High
REQ_SC3_F02	UI for user in order to both see a summarized version of the data for a specific location & the output of the AI-based solution.	High
REQ_SC3_F03	Data will be gathered after consent of the volunteers is granted, which will then be anonymized.	High
REQ_SC3_F04	Public transportation API access (HSL public transport, Whim API).	High
REQ_SC3_F05	Automatic bus data access, if available.	High

3.3.3.2 Non-functional requirements

The non-functional requirements of the "Co-commuting solutions based on social networks" UC are listed in Table 12, providing a unique identifier, a short description and the priority level for each requirement listed.

Table 12 - UC3 Non-functional Requirements.

ID	Description	Priority
REQ_SC3_NF01	The IoT-NGIN platform should work on all main operating systems (OS).	High
REQ_SC3_NF02	The IoT-NGIN platform should enable the integration of various heterogeneous data points (exact number will be defined at a later stage).	High
REQ_SC3_NF03	The application of IoT-NGIN should be easy to use and support UX features.	High

4 Smart Agriculture

The future of Agriculture is undoubtfully digital, with smart agriculture and precision farming taking off, further supported by the rise of the latest technologies, but also mandated by the COVID-19 outbreak. *MarketsAndMarkets* reports that "post-COVID-19, the global digital agriculture market size is estimated to grow from USD 5.6 billion in 2020 and is projected to reach USD 6.2 billion by 2021, recording a CAGR of 9.9%" [4]. The same report attributes the projected increase to increased demand for agricultural food products, the shift in consumer preferences to higher standards of food safety and quality, as well as the lack of availability of labour during COVID-19.

Internet-of-Things (IoT), Artificial Intelligence (AI), Edge Computing, Digital Twins, Distributed Ledger Technologies (DLTs), accompanying myriads of devices such as sensors, actuators, drones and robots, pose great potential in enhancing the efficiency of irrigation, spraying and harvesting processes. These are technologies which will be exploited in the IoT-NGIN Smart Agriculture use cases. Specifically, the project will experiment with the IoT-NGIN framework in the Smart Agriculture Living Labs against two use cases:

- Crop diseases prediction
- Sensor aided crop harvesting

4.1 UC4: Crop diseases prediction. Smart irrigation and precision aerial spraying

Crop diseases can be in many cases predicted or early detected using micro-climate measurements (mainly temperature and humidity in the air, the leaves and the soil), crop image processing and visual analytics [5]. Within IoT-NGIN UC#4 "**Smart irrigation and precision aerial spraying**", crop diseases prediction will be experimented, utilizing:

- microclimate measurements acquired via SYN SynField precision agriculture IoT nodes [6],
- images and real-time video analysis of the crop and the leaves captured from visual and multi-spectral cameras located on semi-autonomous drones flying over the orchard.

The use case aims to optimize precision aerial spraying based on real-time video analysis conducted at two levels; either locally (on the drone), based on already trained ML models, or remotely (at the edge) based on federated Machine Learning (ML). As a result of this ML processing, the drones will be able to dynamically modify their trajectory, achieving optimal, precision aerial spraying limited only in areas of predicted/detected disease rather than the whole orchard. Moreover, orchard micro-climate data can be made available to 3rd parties under IoT-NGIN data sovereignty guarantees.

The use case will be executed using an infrastructure topology similar to the one depicted in Figure 7. Specifically, the living lab will feature the following types of nodes, namely:

- Sensors, which are able to monitor the soil, leaf and weather conditions
- SynField devices, which may integrate a number of sensors, as well as communicate with other nodes via external connectivity (e.g. WiFi or cellular)
- Drones, which are equipped with multi-spectral cameras and will capture images of the crops, potentially revealing hints about their health

- Edge server, which will collect the data acquired from both sources, namely SynField devices and drones, while it will support the Digital Twin services of UC4
- Cloud server, which will conduct computationally intensive tasks of IoT-NGIN, which are not possible or efficient to be executed at the edge devices

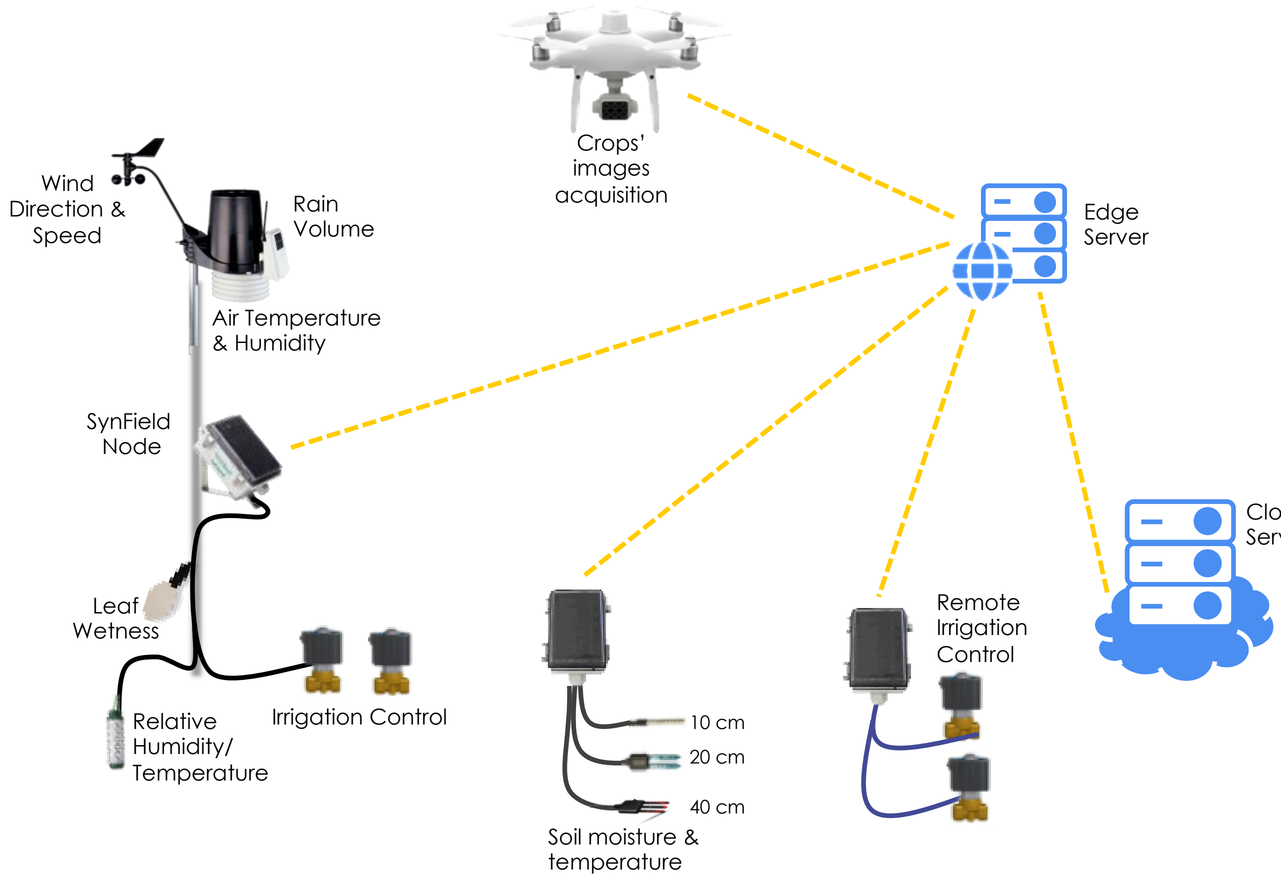

Figure 7: Infrastructure topology for UC4.

The *SynField* platform provides Precision Agriculture and Controlled Irrigation solutions and has been developed by Synelixis. Each SynField node may be used as a data source, interfacing with a number of micro-clima, leaf or soil sensors. Indicatively, the attached sensors may monitor soil temperature and humidity, air temperature and humidity, the rain volume, the wind direction and speed, etc. Moreover, a camera can be optionally attached to SynField nodes for visually monitoring the crop conditions. In this use case, the input sources will be extended by involving drones equipped with multispectral cameras, which will provide images of crops, which can be used to detect anomalous conditions. Likewise, the images captured by drones will be forwarded to the edge server for immediate analysis and inference, while they will be further forwarded to the cloud server for persistence and supporting ML training.

In addition, the SynField nodes may be used for imposing control actions via a number of actuators that can be connected on them. In IoT-NGIN, remote irrigation control actuators will be attached in order to enable smart irrigation.

The SynField system is remotely connected via cellular network to a remote server, in order to provide the acquired data to the data analytics and ML modules of the SynField platform. In IoT-NGIN, data analytics, as well as some ML prediction steps (e.g. inference) will take place at an edge server. Data storage and heavier ML tasks will be executed at the cloud server, located at SYN premises.

The SynField nodes can be controlled remotely, either automatically, based on the AI outcomes, or manually via the SynField Control application, which as a mobile application, or via the SynField Dashboard, available as a web application. The SynField Dashboard provides monitoring information, statistical data, configurable notifications and rules. A registered user may access information about their SynField Nodes, their sensors, the fields, where SynField nodes are installed, as well as the desired services and automation (e.g. solenoid valve).

The system has been already installed at multiple locations across Greece, Germany, Italy, Spain, Denmark, Finland and India.

4.1.1 Use Case Scenario

4.1.1.1 Objectives

The main objectives of UC4 can be summarized as:

- Improvement of the prediction of crop disease,
- Optimization of precision aerial spraying

Both objectives are crucial to enhancing digital agriculture, as they have a positive impact on the product quality and quantity, the minimization of the production losses, as well as the environmental footprint.

4.1.1.2 Actors

The actors involved in the use case include:

1) The Smart Farmer, who is responsible for the crop production management
2) The Cooperative(s), who can be third-party entities, providing agricultural advice, such as agronomists.

4.1.1.3 Background

Early detection or, even better, the prediction of crop diseases remains a major challenge in agriculture, even under smart farming scenarios. This results in high quantities of crops being affected, considerably lowering the quantity and quality of production. Accordingly, ineffective crop disease prediction and detection leads to considerable losses for the farmer, as well as to significant customer dissatisfaction, further deteriorated by the lack of opportunity to cover the customer needs soon.

Ideally, crop diseases' prediction is desired, affected by the external factors, such as the weather conditions, possibly highly differentiated across adjacent areas due to microclimatic effects, as well as by seasonality or geographical parameters.

For example, in days of high humidity or great temperatures differences, crop infection is quite probable. Indeed, farmers would like to be given some indication on the specific items or even areas, in which infection is most probable. In addition, fine-grained information of infection probability can be used to guide the irrigation and spraying activities. Such automated irrigation and spraying plans, based on crop disease prediction information, would lead to increased effectiveness of spraying, yet with lower pesticide consumption. Consequently, this yields significant environmental and financial benefits, while increasing the quantity and quality of production.

Let assume that Smart Farm "SM" is used for cultivating crop "C" and is located in an area which is highly affected by microclimatic changes; hence, weather predictions for a wider area are not always precise for the Smart Farm. As Smart Farm "SM" may suffer from crop diseases, affected by the weather, the responsible Smart Farmer "F" would like to optimize its production, while reducing environmental and financial costs. Therefore, the Smart Farmer "F" desires to rationalize the irrigation and spraying processes in Smart Farm "SM". Also, Smart Farmer "F" cooperates with an Agronomist "A", who provides advice about crop diseases, irrigation and spraying plans.

4.1.1.4 Narrative

Smart Farm "SM" is equipped with an appropriate number of SynField devices, monitoring the environmental and plant conditions via a number of sensors. Also, the Smart Farm "SM" is equipped with drones, capturing images of the leaves. The Smart Farmer "F" would only need to check the status of their field on their smartphone, as captured by both the Synfield sensors and the drone images. Moreover, the field status can be automatically controlled, by planning and performing automatic spraying of areas, which are most probable to be infected.

IoT-NGIN calculates crop disease predictions in real-time, based on the weather, the sensor measurements and the leaves' images.

The Agronomist "A" can access the crop disease predictions and suggest irrigation and spraying rules.

The Smart Farmer "F" is provided with both the predictions and suggested rules via the IoT-NGIN platform. The farmer could select to perform automatically or manually the indicated irrigation or spraying plan.

The Smart Farmer may access the collected data and predictions in a user-friendly way and select to share them with third parties, assuming privacy and data sovereignty requirements are respected.

The platform should be able to identify both expected and unexpected changes in external factors affecting crop disease through information received from Synfield sensors, drones, the weather, as well as cooperating farmers. Also, the platform should be smart enough to identify short- or long-term changes, affecting crop health, in order to feed accordingly the watering and spraying processes.

4.1.1.5 Risk/Challenges/Assumptions

The use case considers risks of:

- inaccuracy in the predictions because of limited training data or ML/FL restrictions and
- inaccurate predictions run the risk of suboptimal irrigation and spraying

However, IoT-NGIN will minimize those risks, leveraging on existing datasets available for Living Lab experimentation, to the extent possible. Alternatively, publicly available datasets will be used. Moreover, IoT-NGIN will be based on state-of-art solutions to support the highest possible prediction accuracy, extending the background work of partners. In any case, the solution adopted will be no worse than the current solutions. However, the combination of multi-source data is expected to yield better prediction, anyway. It has to be noted that the predictions are used to assist both farmers and agronomists, who take the final decision as per irrigation and spraying, also considering the field monitoring. As a result, even in the unlikely event of inaccurate predictions, their effect can be manually controlled.

4.1.1.6 User Groups

For UC4 the identified user groups are:

- Field workers
- Field owners
- Cooperatives
- Drone pilots

4.1.1.7 Features

The features of the "Smart irrigation and precision aerial spraying" UC have been extracted by means of use cases, which are used for clarifying concepts implemented in the project. They derive from functional and non-functional requirements and act as providers of some scope for test cases that will be later used to validate the IoT-NGIN framework. These use cases are described in Table 13, Table 14 and Table 15.

Table 13 - "Configure data sharing parameters" use case of UC4.

Use Case SA4.1.1: Configure data sharing parameters	
Brief Description	The Smart Farmer configures the sharing parameters, referring to the monitoring data acquired by sensors and cameras on their Smart Farm. If the sharing functionality is on, then this data can be made available to third parties, ensuring data privacy and sovereignty.
Actor(s)	Smart Farmer
Priority	High
Trigger	The Smart Farmer launches the graphical user interface of the Smart irrigation and precision aerial spraying use case.
Pre-conditions	IoT-NGIN is deployed and operational. Data are collected via SynField sensors and drones' cameras.

Table 14 - "Access predictions" use case of UC4.

Use Case SA4.1.2: Access predictions	
Brief Description	The Smart Farmer accesses the predictions associated with their crops' health, as well as the relevant irrigation and spraying actions/plans. The Smart Farmer views the accuracy of the predictions and decides to apply automated smart irrigation and spraying or apply irrigation/spraying manually.
Actor(s)	Smart Farmer
Priority	High

Trigger	The Smart Farmer launches the graphical user interface of the Smart irrigation and precision aerial spraying use case and predictions are available.
Pre-conditions	IoT-NGIN is deployed and operational. Weather and plant measurements and plant images have been acquired and provided to the AI modules of IoT-NGIN. The Smart Farmer is signed in the IoT-NGIN "Smart irrigation and precision aerial spraying" app.

Table 15 - "Configure devices/orchards/users" use case of UC4.

Use Case SA4.1.3: Configure devices/orchards/users	
Brief Description	The Smart Farmer visualizes on the "Smart irrigation and precision aerial spraying" UI the list of available IoT devices connected to the IoT-NGIN platform on their Smart Farm or the list of available orchards or even users. The Smart Farmer adds or removes IoT devices if new devices have been installed on or removed from their Smart Farm, respectively. Similarly, the Smart Farmer adds or removes orchards or users.
Actor(s)	Smart Farmer
Priority	High
Trigger	The Smart Farmer launches the graphical user interface of the Smart irrigation and precision aerial spraying use case.
Pre-conditions	IoT-NGIN is deployed and operational. IoT devices are compatible with IoT-NGIN specifications and are installed/removed from the Smart Farm. The Smart Farmer is signed in the IoT-NGIN "Smart irrigation and precision aerial spraying" app.

4.1.2 UC Target KPIs

The "Smart irrigation and precision aerial spraying" UC will be evaluated against the KPIs and targets tabulated in Table 16.

Table 16 - UC4 Key Performance Indicators.

KPI ID	Name	Description	Metric	Method of measurement	Target
KPI_SA1_01	Irrigation improvement	Reduction in the water needed for irrigation compared to manual irrigation	Difference in quantity of water between the two cases	Log analysis and calculation	20%
KPI_SA1_02	Aerial spraying improvement	Reduction in pesticides used for spraying	Difference in quantity of pesticides	Log analysis and calculation	20%

		compared to manual irrigation	between the two cases		
KPI_SA1_03	Product quality improvement*	Increase in quantity of fruits harvested compared to manual irrigation and spraying	Difference in quantity of fruits harvested between the two cases	Log analysis and calculation	>/=15%
KPI_SA1_04	Sensor compatibility	Number of sensors tested for connectivity with IoT-NGIN Smart Agriculture app	Number of sensors	Log analysis	>9

*The crop production quantity falls within the main business interest for Smart Agriculture. Although this may be highly affected by external factors and it might be highly varying across harvests, yet benefits are expected to be realized within the project timeframe. To this, we will try to increase the accuracy of the pilot results within the project lifetime, exploiting the available land plots to the extent possible for receiving reliable comparative results.

4.1.3 UC Requirements

4.1.3.1 Functional Requirements

The functional requirements of the "Smart irrigation and precision aerial spraying" UC are listed in Table 17, providing a unique identifier, description and foreseen priority level for each requirement.

Table 17 - UC4 Functional Requirements.

ID	Description	Priority
REQ_SA1_F01	The platform should provide access to measurements.	Low
REQ_SA1_F02	The platform should provide options to manage/view sensors/devices.	Low
REQ_SA1_F03	The platform should provide options to manage/view orchard.	Low
REQ_SA1_F04	The platform should provide options to manage users.	Low

REQ_SA1_F05	The platform should provide predictions of crop diseases, based on ML/FL performed over sensor measurements and drone images/videos.	High
REQ_SA1_F06	The platform should provide prediction accuracy probability.	Medium
REQ_SA1_F07	The platform should provide automated irrigation and aerial spraying based on crop disease prediction.	High
REQ_SA1_F08	The platform should provide access to irrigation and aerial spraying data.	Low
REQ_SA1_F09	The platform should provide support for microclimate measurements sharing, respecting data sovereignty and privacy requirements.	High
REQ_SA1_F10	The platform must monitor the weather and plant conditions.	High
REQ_SA1_F11	The platform must be able to retrieve plant photos via drones.	High
REQ_SA1_F12	The monitoring devices must support network connectivity.	High
REQ_SA1_F13	The monitoring devices must be able to communicate data to and receive control commands from the IoT-NGIN platform.	High
REQ_SA1_F14	The platform should allow the eligible user to provide irrigation and spraying suggestions.	Medium
REQ_SA1_F15	The platform should allow the user to view the irrigation and spraying suggestions.	High
REQ_SA1_F16	The platform should allow the user to execute manually the recommended irrigation or spraying plans.	Medium

4.1.3.2 Non-functional Requirements

The non-functional requirements of the "Smart irrigation and precision aerial spraying" UC are listed in Table 18 providing the unique identifier, a short description and the priority level for each requirement listed.

Table 18 - UC4 Non-functional requirements.

ID	Description	Priority
REQ_SA1_NF01	The IoT-NGIN platform must respect security and privacy requirements.	High
REQ_SA1_NF02	IoT-NGIN should support High Availability features.	High
REQ_SA1_NF03	The UC4 Application of IoT-NGIN should support UX features.	High

REQ_SA1_NF04	The UC4 Application of IoT-NGIN should be vendor-independent.	High
REQ_SA1_NF05	The UC4 Application of IoT-NGIN should be scalable in terms of adding/removing devices or device types and integrating hundreds of devices.	High

4.2UC5: Sensor aided crop harvesting

Manual harvesting is a labour-intensive operation that could have a significantly higher footprint on the total production costs compared to mechanical harvesting [7]. The COVID-19 lockdowns have had a great impact on the availability of labour staff [8] [9], involved also in the harvesting processes. On the other hand, manual harvesting is usually preferred as a more favourable method to products' quality [10]. IoT-NGIN Use Case #5 "**Sensor aided crop harvesting**" will experiment with a hybrid, semi-mechanical crop harvesting use case, in which Automated Guided Land Vehicles (AGLV) will support human-workers by autonomously carrying the crates to the loading point. We will experiment with agriculture AGLV serving as carrier machines, by enabling them to locate and avoid workers (for safety reasons) and trees (for operating reasons). The correlation between crates and trees can be automated using RFID tags on crates, while long-range RFID readers may be mounted at the loading points. Wearable devices can collect location data and workers' activity data. This approach is beyond current research, however proof concept will be provided within the project.

The infrastructure elements through which UC5 "Sensor aided crop harvesting" will be executed will interact as depicted in Figure 8. The use case will be realized in the Smart Agriculture Living Lab, both in lab and outdoor environment.

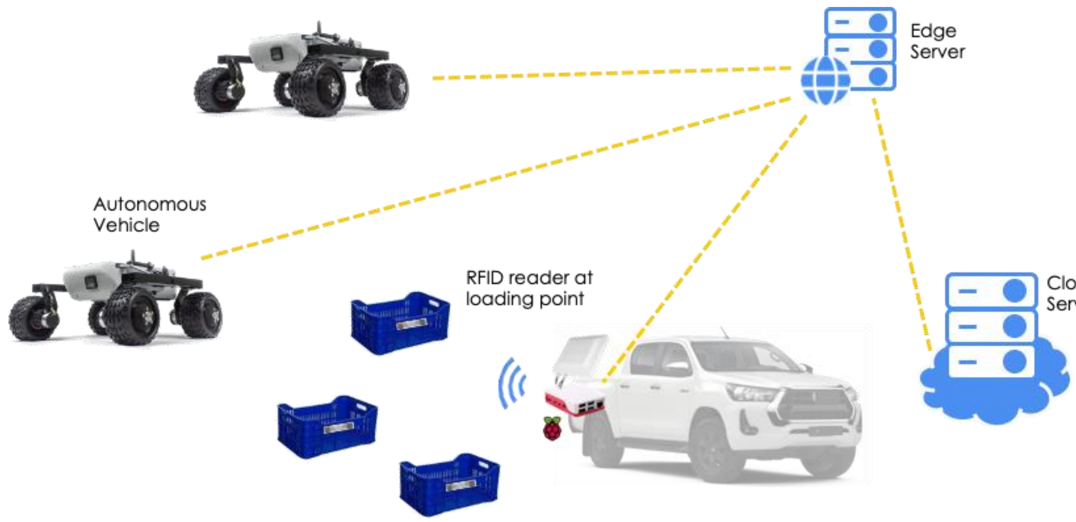

Figure 8: Infrastructure topology for UC5.

The validation of UC5 will deploy the following types of devices or nodes:

- Crate equipped with RFID tag
- RFID reader at the mounting point
- Mini-computer connected to the RFID reader at the mounting point, such as a Raspberry Pi [11]
- Mobile robot, equipped with a camera

- Edge Server, responsible for data persistence and running the Digital Twin services for UC5.
- Cloud Server, which undertakes the execution of computationally intensive tasks of the IoT-NGIN framework, which would be inefficient to run on the edge, such as model training tasks of Machine Learning and Federated Machine Learning functionalities of the platform.

Specifically, autonomous movement in outdoor environments will be experimented via mobile robots, equipped with cameras and which will be guided via ML algorithms for localization and obstacles' avoidance. The mobile robots are intended to acquire images of their environment and inject them to the edge server, which will operate the AI services for localization and obstacle avoidance, also supported by the cloud server for the heavy computations.

Moreover, the traceability of the harvesting process will be experimented via monitoring the crates arriving at the loading point. Each crate will be equipped with an RFID tag, allowing tracking both the amount, as well as the time and location of the crops harvested via an RFID reader installed at the loading point. The RFID readings will be injected to the edge server, as well, which will run crop harvesting management services.

4.2.1 Use Case Scenario

4.2.1.1 Objectives

The main objectives of UC5 can be summarized as:

- Optimization of the crop harvesting process,
- Operational costs' reduction
- Improvement of quality of services related to harvesting and loading

4.2.1.2 Actors

The actors involved in the use case include:

1) The Smart Farmer, who is responsible for the crop harvesting management
2) The Farm Workers, performing crop harvesting and whose work is complemented by mobile robots

4.2.1.3 Background

The harvesting process can be quite costly and time-consuming when relying only on manual harvesting. After the COVID-19 outbreak and the continuous lockdowns, the availability of labour has declined, while at the same time, the demand for high-quality products has increased. This situation is expected to sustain, considering the projections for population increase by 2050 by the UN. In addition, timely harvesting is crucial to the quality of the products as well as to the health of the crops [12].

While mechanical harvesting can also negatively affect the quality of the grains harvested, it can support, rather than substitute, manual harvesting.

Let assume that Smart Farm "SM" is in the harvesting season and there is a shortage of human workers. Smart Farmer "F" has increased demand for their high-quality products, which must be harvested soon

4.2.1.4 Narrative

The harvesting process in Smart Farm (hereafter referred to as "SM") would be significantly enhanced by introducing mobile robots as complementary workers to human workers. Indeed, both humans and mobile robots could cooperate in a synergetic way, exploiting humans' comparative benefits (such as fine motor skills, inherent classification, error spotting, etc.) along with machine capabilities in carrying, transporting and loading crops to optimize the harvesting process.

In this perspective, mobile robots can support human workers by autonomously carrying the crops' crates to the loading point. Mobile robots will operate transparently, without distracting humans' activity, ensuring the safety and wellness of both the humans and the farm. Human workers will collect the harvested crops in crates, located close to the tree(s) they come from. As soon as the crate is full, the mobile robots will transport it to the loading point. In the meantime, it will detect and avoid humans, trees or other obstacles, before having contact with them. Upon arrival at the loading point, the crate will be identified for crop management purposes. At the end of each day, the Smart Farmer F will be able to access information about the collected crops, the crates involved, the mobile robots, as well as the quantity of crops collected.

The "Smart Agriculture - Crop Harvesting" UC of IoT-NGIN should be able to identify both expected and unexpected events affecting the mobile robots' route in real-time.

4.2.1.5 Risks /Challenges /Assumptions

The use case raises questions on risks, challenges and assumptions which will be further addressed during the trials. One risk has been identified within this use case scenario relating to the incorrect calculation of the workers' location which may result in injuries and general disruptions. However, this risk will be minimized by extensive testing and validation of the use application with objects, rather than humans, before tested with humans. Additionally, two assumptions are made (i) that the workers' location and activity information is always available and (ii) that RFID technology works effectively within the UC.

4.2.1.6 User Groups

For UC5 the identified user groups are:

- Field workers
- Field owners
- Cooperatives
- Drone pilots

4.2.1.7 Features

The features of the "Sensor-aided crop harvesting" UC are identified via use cases described in Table 19, Table 20 and Table 21below.

Table 19 - "Configure data sharing parameters" use case of UC5.

Use Case SA4.2.1: Configure data sharing parameters	
Brief Description	The Smart Farmer configures the sharing parameters, referring to the monitoring data acquired by mobile robots on their Smart Farm. If the sharing

	functionality is on, then these data can be made available to third parties, ensuring data privacy and sovereignty.
Actor(s)	Smart Farmer
Priority	High
Trigger	The Smart Farmer launches the graphical user interface of the Sensor aided crop harvesting use case.
Pre-conditions	IoT-NGIN is deployed and operational. Data are collected via AGLVs connected to the IoT-NGIN platform.

Table 20 - "Configure mobile robots, orchards, users" use case of UC5.

Use Case SA4.2.2: Configure AGLVs, orchards, users	
Brief Description	The Smart Farmer visualizes on the "Sensor aided crop harvesting" UI the list of available mobile robots connected to the IoT-NGIN platform on their Smart Farm or the list of available orchards or even users. The Smart Farmer adds or removes mobile robots, if new devices are intended to be used or existing ones are intended to be removed from their Smart Farm, respectively. Similarly, the Smart Farmer adds or removes orchards or users.
Actor(s)	Smart Farmer
Priority	High
Trigger	The Smart Farmer launches the graphical user interface of the Sensor aided crop harvesting use case.
Pre-conditions	IoT-NGIN is deployed and operational. Mobile robots are compatible with IoT-NGIN specifications and are added to/removed from the Smart Farm. The Smart Farmer is signed in the IoT-NGIN "Sensor aided crop harvesting" app.

Table 21 - "Manage mobile robots' operation" use case of UC5.

Use Case SA4.2.3: Manage mobile robots' operation	
Brief Description	The Smart Farmer initiates the operation of mobile robots and accesses data derived from its operation, regarding the crates carried, the destination, etc. Based on these, the Smart Farmer may keep/access statistical records of the loads, the time required for carrying per orchard, etc. and thus rationalize their harvesting processes.
Actor(s)	Smart Farmer
Priority	High
Trigger	The Smart Farmer launches the graphical user interface of the Sensor aided crop harvesting use case.
Pre-conditions	The Smart Farmer launches the graphical user interface of the Sensor aided crop harvesting use case, on the menu option referring to mobile robots' operation.

4.2.2 UC Target KPIs

The "Sensor aided crop harvesting" Use Case will be evaluated against the KPIs defined in Table 22.

Table 22 - UC5 Key Performance Indicators.

KPI ID	Name	Description	Metric	Method of measurement	Target
KPI_SA2_01	Farmer safety	Collisions of mobile robots with human workers	Number of collisions	Log analysis, observation	0
KPI_SA2_02	System reaction	System reaction in emergency cases	Reaction time	Log analysis	<1 sec
KPI_SA2_03	Carrier time improvement	Reduction of the time needed for carrying crates to the loading point, compared to manual carrying	Average difference of time for the same route	Log analysis, calculation	>/=10%

4.2.3 UC Requirements

4.2.3.1 Functional Requirements

The functional requirements for UC5 derived from the use cases described in subsection 4.2.1.6 and are listed below in Table 23. The table lists the requirements with a unique identifier, a short description and the level of priority.

Table 23 - UC5 Functional Requirements.

ID	Description	Priority
REQ_SA2_F01	Mobile robots must support autonomous operation.	High
REQ_SA2_F02	Mobile robots should be able to understand which crates they should carry.	Medium
REQ_SA2_F03	Mobile robots must be able to follow a route or reach a destination.	High

REQ_SA2_F04	The crates must be identifiable at the loading points via RFID technology.	High
REQ_SA2_F05	Mobile robots must support network connectivity, such as WiFi or cellular.	High
REQ_SA2_F06	The platform must ensure collected data sovereignty and integrity.	High
REQ_SA2_F07	The platform should provide access to collected data.	Low
REQ_SA2_F08	The platform should provide options to manage/view the connected mobile robots.	Medium
REQ_SA2_F09	The platform should provide options to manage users.	Low
REQ_SA2_F10	The platform must be able to calculate mobile robots' routes in real-time.	High
REQ_SA2_F11	The platform must be able to identify and avoid obstacles such as humans and trees in real-time.	High
REQ_SA2_F12	The platform must be able to schedule carrier plans, based on real-time data.	Medium
REQ_SA2_F13	Mobile robots must be able to provide data to and receive control commands from the IoT-NGIN platform.	High
REQ_SA2_F14	The platform UC app should allow the user to view the routes and carrier plans.	Low
REQ_SA2_F15	The platform should allow the user to cancel or manage the carrier plans or routes.	Low

4.2.3.2 Non-functional Requirements

The non-functional requirements identified for UC5 are listed in Table 24 providing a unique identifier, a brief description and the priority level.

Table 24 - UC5 Non- functional requirements.

ID	Description	Priority
REQ_SA2_NF01	The IoT-NGIN platform must respect security and privacy requirements	High
REQ_SA2_NF02	IoT-NGIN should support High Availability features	High
REQ_SA2_NF03	The UC5 Application of IoT-NGIN should be easy to use and support UX features	High
REQ_SA2_NF04	IoT-NGIN should be scalable in terms of adding/removing devices and integrating hundreds of devices	High

5 Industry 4.0

Industry 4.0 refers to the means of automation and data exchange in manufacturing technologies including among others (big data and analytics, augmented reality, additive manufacturing, simulation, horizontal and vertical system integration, autonomous robots as well as cloud computing), the IoT Internet of Things. It serves a role to help integrate and combine the intelligent machines, human actors, physical objects, manufacturing lines and processes across organizational stages to build new types of technical data, systematic and high agility value chains [13]. Industry 4.0 is presented with three use cases within the IoT-NGIN to be validated in two LLs: the BOSCH facilities in Barcelona and the ABB facilities in Helsinki.

5.1 UC6 Human-centred safety in a self-aware indoor factory environment

Automation in heavy industrial settings is becoming more and more common, however, when machines work alongside humans both their safety needs to be ensured. This use case will demonstrate the safety parameters in factories where human workers and automated guided vehicles work together.

5.1.1 UC Scenario

5.1.1.1 UC Objectives

The UC objectives are:

- Improvement of safety parameters inside factories with high levels of automation, particularly in those where humans and optimized automation systems such as Automated Guided Vehicles (AGVs) co-work together.
- Demonstrate IoT-NGIN contextual IoT based on human-centric sensing to predict, identify and avoid collisions between humans and AGVs and between different types of AGVs.
- Federate and interwork IoT for localization, 5G for high-speed wireless and edge computing and distributed AI self-learning to analyse input from multiple sensors, RFID nodes and cameras.

5.1.1.2 Actors

The actors involved in this use case are:

1. Factory workers
2. Factory Managers
3. Factory security- responsible personnel

5.1.1.3 Background

Automation in the industry has advanced into all activities, including delivery and pick-up of goods. AGVs are a mature technology, even though they have some limitations. New wireless data transmission technologies, the Internet of Things and the use of Artificial Intelligence combined, can overcome many of such limitations by providing the AGVs with information on their environment and getting data from them. This can give a connected AGV fleet the ability to regulate the speed of vehicles instead of stopping suddenly to avoid a collision. AI algorithms can recalculate the optimal route in real-time and provide alternative routes if the planned one has too many delays. In addition, the AGV use rate can be optimized by going where they are most needed instead of following a fixed pattern. All these improvements provide increased safety for workers, and an increase in productivity derived from fewer supply shortages and bigger use of resources.

5.1.1.4 Narrative

IoT-NGIN will provide a high precision IoT localization layer merging real-time localization obtained from Ultra-Wide Band (UWB) sensors and a solution providing Visible Light Positioning (VLP). In addition, safety cameras will be deployed to monitor areas with reduced visibility. A high speed and ultra-low latency wireless access network to support quick notifications and massive data uploads will also be deployed based on a combination of 5GNR technology, using private spectrum at 3.5 GHz, and high-speed Wi-Fi using unlicensed spectrum at 5 GHz. The data from the sensors provide a full description of the environment and how it is changing. It allows to model moving objects and skeletonizes human bodies to detect the position of each body part and build a "safety shell" around it to ensure human-centred safety.

The factory will feature edge computing resources that will be used to support a set of virtual AI functions that will process the real-time location of the AGVs, the real-time stream coming from the safety cameras. The AI functions will determine a potential collision between AGVs, or between a worker and an AGV and will issue an early warning.

The system will have to plan an optimal route for each AGV and recalculate it depending on potential obstacles along the route while ensuring operator safety at all times. To do that, the system will have to recognize all potential obstacles and detect where they are moving or not. Based on obstacles position and movement, the system will have to decide if a collision is possible and what measures must take to avoid it. Especially the system will have to detect all humans and human-guided vehicles since human safety is at the centre of the use case and must override any other consideration.

5.1.1.5 Risks/Challenges/Assumptions

Three risks were identified signifying the importance of protecting the human workers as well as the machines both of whom co-work in the factory. These risks are listed below:

1. Risk of not detecting potential collisions.

2. Risk of cameras information not being available while workers are on their jobs.

3. Physical safety risk for workers and machines.

5.1.1.6 User Groups

The identified users for UC6 are identified below:

- Factory workers
- Security responsible person
- Factory owner

The specific end-user requirements and needs are:

1. Improve the production line efficiency and decrease the number of collisions between AGV in the factory to zero
2. Workflow optimization
3. Reduce accidents in factory environment
4. Ability to store the system information

5.1.1.7 Features

The features of the "Human-centred safety in a self-aware indoor factory environment" UC have been extracted by means of use cases used for explaining concepts implemented in the project, give rise to the lists of requirements and attempt to provide some scope for test cases that will later be used to validate the IoT-NGIN framework. These use cases are presented in Table 25 and Table 26below.

Table 25 - "AI-powered route planning" use case of UC6.

Use Case IN1.1.1: AI-powered route planning	
Brief Description	AI-powered route planning for Automated guided Vehicles
Actor(s)	AGVs, Human Workers, server
Priority	Medium
Trigger	Human worker request AGV to be dispatched to a certain destination
Pre-conditions	AI server is operational, Images from cameras at request time are available

Table 26 - "AI configuration for collision prevention" use case of UC6.

Use Case IN1.1.2: AI configuration for collision prevention	
Brief Description	Collision prevention to avoid collisions that may harm human workers in the factory
Actor(s)	AGVs, server
Priority	High
Trigger	AI Engine detects a collision risk
Pre-conditions	AI server detects humans standing in place or moving in a trajectory that makes collision with AGV possible

5.1.2 Target KPIs

The "Human-centred safety in a self-aware indoor factory environment" UC will be evaluated against the KPIs and targets presented in Table 27.

Table 27 - UC6 Key Performance Indicators.

KPI ID	Name	Description	Metric	Method of measurement	Target

KPI_IN1_01	Human safety	Collisions of AGVs with humans or human-guided vehicles	Number of collisions	Image analysis, data log analysis	0
KPI_IN1_02	Planning efficiency	Deviation of actual route time to the planned time	Average time difference between both times for all routes	Server clock, data log and calculation	<5% of average planned time
KPI_IN1_03	Planning improveme nt	Reduction of route time between start and end of living lab	Average difference of time for the same route	Server clock, data log and calculation	10%
KPI_IN1_04	AGV occupatio n	Time the AGV spends carrying goods	Percentage	Data log and calculation	>85% active time (the time when the AGV is intentionally idle will not be counted)

5.1.3 UC Requirements

5.1.3.1 Functional Requirements

The functional requirements of the “Human-centred safety in a self-aware indoor factory environment” UC are listed in Table 28, providing a unique identifier, description and foreseen priority level for each requirement.

Table 28 - UC6 Functional Requirements.

Requirement ID	Description	Priority
REQ_IN1_F01	Established criteria for triggering an alarm depending on the obstacle type and movement.	Medium
REQ_IN1_F02	Avoid all collisions with humans or human-guided vehicles. IoT NGIN AI functions shall detect potential collisions between AGVs and between	High

	workers and AGVs with location information and cameras real-time stream.	
REQ_IN1_F03	All potential obstacles are identified and correctly classified (human, human-driven vehicle, AGV, others). Information on position and movement is provided in real-time.	Medium
REQ_IN1_F04	Allow manual control of AGVs to certain users.	Medium
REQ_IN1_F05	The UC application has to use a deep learning algorithm to determine potential collisions and how to avoid them.	High
REQ_IN1_F06	The service has to provide real-time information of all the moving things and workers in the factory.	High
REQ_IN1_F07	Warnings shall be provided when a collision might occur and AGVs must stop.	High
REQ_IN1_F08	Minimize additional time for the AGV to reach the destination due to obstacle presence. AGVs positions will be tracked in real-time.	Medium
REQ_IN1_F09	Production workflow to be optimized according to current (location) data and production requirements.	Medium
REQ_IN1_F10	Real-time position tracking.	Medium

5.1.3.2 Non-functional Requirements

The non-functional requirements of the "Human-centred safety in a self-aware indoor factory environment" UC are listed in Table 29 providing the unique identifier, a short description and the priority level for each requirement listed.

Table 29 - UC6 Non-functional requirements.

Requirement ID	Description	Priority
REQ_IN1_NF01	The application has to guarantee reliability, availability and low latency.	Medium
REQ_IN1_NF02	AI functions must predict collisions with a minimum accuracy and reliability.	Medium
REQ_IN1_NF03	Edge computing resources shall be robust and horizontally scalable.	Low

REQ_IN1_NF04	Resources must ensure minimum latency.	Medium
REQ_IN1_NF05	The application should consider environment interferences (including, but not limited to radio signals from other wireless networks, vibrations, electromagnetic interferences from machines in the factory, poor lighting, electrical network fluctuations, etc).	Medium
REQ_IN1_NF06	Personnel self-security must have absolute priority over any other factor.	High
REQ_IN1_NF07	The algorithm must consider that a human-driven vehicle might be in the factory.	High
REQ_IN1_NF08	No personal data is gathered or processed, so that it is not possible to identify any person on the shop floor.	Medium

5.2 UC7 Human-centred augmented reality assisted build-to-order assembly

The AR use case in ABB's facilities involves the assembly & wiring of ABB's drive cabinet products. Following the objectives of UC6, this UC aims to assist human workers in the assembly line with visualization of the different assembly phases in the proprietary tools. Digital models of the cabinets are developed which contain both mechanical and electrical CAD data. These digital models are used to visualize the different assembly phases to the assembly worker in the proprietary Smart Wiring™ software created by EPLAN and provide assistance and instructions for assembling. The models are also used to create an AR application for training, sales, and/or maintenance purposes, either using AR classes, mobile devices, or small industrial screens.

5.2.1 UC Scenario

5.2.1.1 UC Objectives

The main objectives for UC7 include:

- Provide complete digital 3D-models of electrical cabinets for EPLAN's Smart Wiring™ software and AR applications
- Provide a Digital Twin as an AR experience for training, sales, and maintenance purposes
- Produce AR models/data for IoT-NGIN T4.4
- Increase production quality with assembling and wiring instructions
- Increase maintenance quality and performance with QR -code scannable 3D -model of the cabinet onsite
- Increase the visuality of training by AR experience

5.2.1.2 Actors

The actors involved in this UC are:

1. Designers
2. Factory workers
3. Maintenance workers
4. Factory managers

5.2.1.3 Background

Traditionally, electrical cabinet products have been assembled with using printed documentation and the wiring has been followed from so called “wiring lists”. Assembly of the components inside the cabinet is being followed from printed 2D -views of the cabinet models and differences in wiring has been happening according to who has assembled the cabinet. The customer has had only the information of the needed space of the cabinet and estimated visualisation of the inside view before the actual delivery of the cabinets and in the maintenance work, the worker would have needed to open the cabinet and search for the component in question with an assumption that the documentation inside the cabinet door isn’t updated and relevant anymore at this point.

Example of the situation today:

- Paperless production with server based online software that supports phased assembly and provides live wiring status in multi-site production environment for process control.
- Scattered, incomplete and imprecise product data for cabinet products that requires engineering and product knowledge through-out manufacturing chain.
- Line-up level 3D documentation is missing for customers and production, but general 3D assembly drawings are cabinet-specific representing mechanical assembly with only the main components.
- Product documentation is missing information on the physical location of engineered components and wiring routes.
- Circuit diagrams, bill of materials and 2D dimensional drawings configured for standard cabinet product.

The expected situation as a result of this IoT-NGIN -project:

- Paperless production with server based online software that supports phased assembly and provides live wiring status in multi-site production environment for process control.
- 3D digital cabinet model for precise cabinet builds.
- Line-up level product documentation including locations and information for all components and wiring routes.
- Improved and harmonized product quality when products are engineered and documented to details.
- Automated wire markings and device labels from circuit diagrams to marking machine.
- Assembly instructions visualized using augmented reality directly to the assembler.

Circuit diagrams converted to assembly instructions: table view of all wires and connections and as-built 3D view with electrical components and wiring routes.

5.2.1.4 Narrative

The AR use case in ABB's facilities, which involves the assembly & wiring of ABB's drive cabinet products, will aim to streamline the frequency converter assembly process at the ABB site, by providing real-time guidance to factory workers and AR -possibilities for training, sales, and/or maintenance purposes, either using AR classes, mobile devices, or small industrial screens.

5.2.1.5 Risks/Challenges/Assumptions

There are no identified risks which would have been occurred by developing the assemble and wiring process towards AR assisting possibilities. The risk of incorrect product and component information has been along all the time and detailed digital model will decrease this possibility.

The challenge for AR assisted assembly is the large variety of optional modules and customization options. Devices are built to order, meaning that the order-specific information must be digitally available or manually given as input to the augmented reality system. Digital models created in design phase will need more precision while more data and details will be included to the model, and it will take time to convert the current models to include the needed extra details.

5.2.1.6 User Groups

The identified users for UC7 are listed below:

- Designers
- Factory workers
- Maintenance workers
- Factory managers
- Customers

The specific end-user requirements and needs are:

1. Improve the security and efficiency of the assembly process line, improve the product quality, and improve the employee training
2. Optimization of the assembly line processes
3. The workers are provided with contextual information
4. Line-up level product documentation including detailed data of used components

5.2.1.7 Features

The features of the "Human-centred Augmented Reality assisted build-to-order assembly" UC have been extracted by means of use cases, which are used for clarifying concepts implemented in the project, forming functional and non-functional requirements, and providing some scope for test cases that will be later used to validate the IoT-NGIN framework. These use cases are described in Table 30, Table 31and Table 32 below.

Table 30 - "Assembly and wiring assistance" use case of UC7.

Use Case IN5.2.1: "Assembly and wiring assistance"	
Brief Description	Assembly or maintenance worker uses digital models to visualize the different assembly phases in the proprietary Smart Wiring™ software and are being given assistance and instructions for assembling and wiring.

Actor(s)	Device operator, maintenance operator, server
Priority	High
Trigger	Smart Wiring™ software, AR glasses, mobile devices, or small industrial screens
Pre-conditions	Digital models of the cabinets are developed which contain both mechanical and electrical CAD data

Table 31 - "QR -code scannable 3D -model of the cabinet" use case of UC7.

Use Case IN5.2.2: "QR -code scannable 3D -model of the cabinet"	
Brief Description	Cabinet has a QR-code which can be scanned using a mobile app to identify the type of cabinet in question and fetch the relevant information from a server.
Actor(s)	Device operator, maintenance operator, server
Priority	Medium
Trigger	QR-code read with mobile phone
Pre-conditions	3D model of the cabinet and related QR-code created and attached to the cabinet

Table 32 – "AR enhanced personalized IoT sensing and actuating" use case of UC7.

Use Case IN5.2.3: "AR enhanced personalized IoT sensing and actuating"	
Brief Description	The AR software & tools provided by task 4.4 will be used to create an AR application which utilizes the digital model of the cabinet. The AR application can manipulate the digital model and can be used for training, sales and/or maintenance purposes.
Actor(s)	Device operator, maintenance operator, server
Priority	Low
Trigger	QR-code read with mobile phone
Pre-conditions	The AR application will run on mobile devices as an app

5.2.2 UC Target KPIs

The "Human-centred Augmented Reality assisted build-to-order assembly" will be evaluated against the KPIs and targets listed in Table 33.

Table 33 - UC7 Key Performance Indicators.

KPI ID	Name	Description	Metric	Method of measurement	Target

KPI_IN2_01	Assembly quality improvement	Decrease wiring mistakes, harmonize assemblies	Difference between earlier assemblies	Log analysis	20%
KPI_IN2_02	Onsite 3D models available	Cabinet model available from QR code	Numeric	Availability	≥1
KPI_IN2_03	Digital Twin	Contain full mechanical and electrical CAD data	Numeric	Number of data models	>5

5.2.3 UC Requirements

5.2.3.1 Functional Requirements

The functional requirements of the "Human-centred Augmented Reality assisted build-to-order assembly" UC are presented in Table 34, giving a unique identifier, a description and expected priority level for each requirement.

Table 34 - UC7 Functional Requirements.

Requirement ID	Description	Priority
REQ_IN2_F01	The assembly and wiring application in production must be tailored both for screens (no.1 target) and mobile phone	High
REQ_IN2_F02	Assembly and wiring assistance application must work smoothly without remarkable latency	High
REQ_IN2_F03	QR -application must be tailored for mobile phone	High
REQ_IN2_F04	Component data of the digital model must be available through QR -code	High
REQ_IN2_F05	Digital models must fulfil the image standards/quality of being used with AR glasses	High

5.2.3.2 Non-functional requirements

The non-functional requirements of the "Human-centred Augmented Reality assisted build-to-order assembly" UC are listed in below, providing the unique identifier, a short description and the priority level for each requirement listed.

Table 35 - UC7 Non- functional requirements.

Requirement ID	Description	Priority
REQ_IN2_NF01	Guaranteed reliability, availability, and minimum latency for QR- and AR -solutions	Medium
REQ_IN2_NF02	No personal data from the user is gathered or processed while using the QR -application	Medium

5.3UC8 Digital powertrain and condition monitoring

This use case deals with industrial systems and data collection, specifically in the context of powertrains, for which two lab setups exist at the ABB site. Aside from direct process control, data gathered in industrial applications is also used for higher-level supervisory tasks and condition monitoring. IoT-devices, 5G telecommunication and cloud platforms can be leveraged to better utilise novel ideas in these areas, such as federated AI and DLT-based solutions.

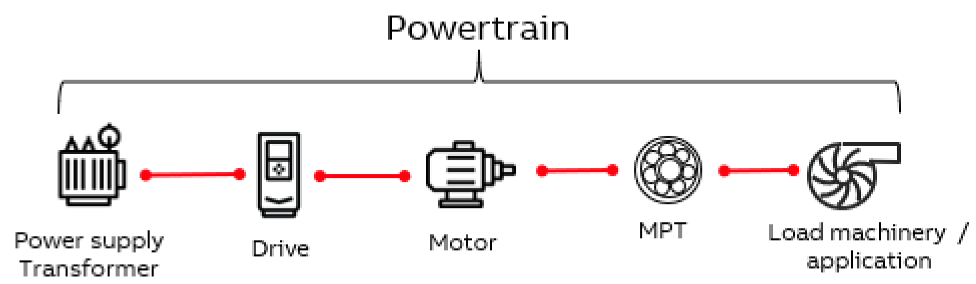

Figure 9: Diagram of powertrain ensemble

5.3.1 UC Scenario

5.3.1.1 UC Objectives

The UC objectives include:

- Condition monitoring and predictive maintenance of powertrains and drive units using federated machine learning.
- Parameter tuning and optimization (e.g. in terms of energy consumption) of drive units using federated learning.
- Simplifying the commissioning process of new sensors and devices using cloud systems and 5G connectivity.
- Interconnecting existing systems and devices, creating an IoT-environment which conforms to the meta-architecture specified by IoT-NGIN, facilitating the use of federated AI and DLT-based solutions.

5.3.1.2 UC Actors

The actors involved in this UC are:

1. Device operators
2. Maintenance workers
3. Factory managers

5.3.1.3 Background

ABB has a large install base of devices, consisting of both wired legacy equipment using traditional factory protocols, as well as next-generation IoT-devices utilizing advancements made in telecommunications (5G) and software (cloud computing). The main device of interest is the drive unit, which is used to control the motor, as depicted in Figure 54. Drive data is accessed via its control panel, of which IoT-specific versions exist. Additionally, various sensors such as ABB's Smart Sensor™ are also used to gather additional information about the powertrain such as vibration data from the motor. ABB's IoT-version of the drive control panel is designed to operate with an existing cloud implementation on the Azure platform and cannot facilitate new implementations conforming to the IoT-NGIN meta-architecture at the device level. To pilot the results of the NGIN-project, a middleware node or gateway device will be used to host the necessary services and containers. Whether this device should be considered an IoT-device representing a powertrain, or as a higher-level edge cloud node, is unclear. Data produced by the fleets of devices and sensors is abundant, however, the tools to aggregate and use this data are lacking. Federated AI and distributed edge cloud architectures are explored as ways to more effectively utilize the data that is being produced.

5.3.1.4 Narrative

Industrial systems are typically restricted systems operating within a local network, where process data is considered sensitive and to be protected. Therefore, aggregating device data, for example from identical drive units located at different sites belonging to different parties, is generally not possible. A common problem in the field of machine learning is the generation of large enough training data sets to construct an effective model, which holds especially true for industrial settings. Federated learning offers a solution to this problem. Model training is done locally and the training results are delivered forward to the cloud to be aggregated to form a global machine learning model. Effectively, data from all available devices is being utilized, while still preserving the privacy of the participating device owners.

5G connectivity technology enables digital remote services for powertrains efficiently for green field and brown field use cases. At the ABB site, gateway devices will be used to interconnect traditional factory systems utilising wired connections and protocols, to an IoT-NGIN compliant pipeline. Various IoT-sensors and devices will also be used, to explore different avenues of condition monitoring and further enhance the powertrain's digital representation.

5.3.1.5 Risks/Challenges/Assumptions

Connecting a drive unit that is directly responsible for motor control to an external cloud system may present a risk in terms of personnel and equipment safety. The interfacing should be done in a way that the control aspects of the drive are isolated from the IoT-NGIN system and any external networks.

Aggregating the training results to form a global federated model may prove to be a challenge. The magnitudes of the quantities used to evaluate a machines or devices condition are tied to both the type of device in question, i.e., its model and dimensions, as well as the operating point at the time the data was gathered. For powertrains, typical operating point quantities of interest would be speed and torque. These values need to be considered when building a machine learning model, either by encoding them into the input data or producing separate models for each device type and operating point. Encoding the operating point into the input data may prove to be more useful for applications where these quantities constantly fluctuate.

5.3.1.6 User Groups

The identified users for UC8 are listed below:

- Maintenance workers
- Factory / Device operators
- Factory managers

The specific end-user requirements and needs are:

1. Reduce powertrain downtime by doing predictive maintenance enabled by federated AI
2. Tuning of drive parameters to reduce energy consumption and increase device lifetime
3. A Holistic (digital) view of the powertrain and associated IoT-devices and sensors

5.3.1.7 Features

The features of the "Digital powertrain and condition monitoring" UC have been extracted by means of use cases, which are used for clarifying concepts implemented in the project, forming functional and non-functional requirements, and providing some scope for test cases that will be later used to validate the IoT-NGIN framework. These use cases are described in Table 36, Table 37, Table 38 below.

Table 36 - "Predictive maintenance for device malfunction prevention" use case of UC8.

Use Case IN5.3.1: Predictive maintenance for device malfunction prevention	
Brief Description	A Plant manager or device operator is warned that a device has drifted outside of bounds that can be considered normal operation. A closer examination reveals an impending fault which would have led to a critical system fault if left unchecked. Predictive maintenance reduces resulting in downtime.
Actor(s)	Device operator, maintenance worker
Priority	Medium
Trigger	Novelty detection with AI
Pre-conditions	Sensors, Federated AI

Table 37 - "Configuration of device parameters" use case of UC8.

Use Case IN5.3.2: "Configuration of device parameters"

Brief Description	A Device operator receives a warning that a device is using more energy than what is considered normal for the device and application process in question, indicating a possible misconfiguration of the device parameters.
Actor(s)	Device operator, Factory manager
Priority	Medium
Trigger	Novelty detection with AI
Pre-conditions	Global federated AI model

Table 38 - "Smart interfacing of devices use case of UC8.

Use Case IN5.3.3: “Smart interfacing of devices”	
Brief Description	A Plant manager has added IoT-devices which utilize the IoT-NGIN framework and wants to have a holistic view of all the devices including ones belonging to an existing supervisory control and data acquisition (SCADA) system.
Actor(s)	Plant manager, device operator
Priority	Medium
Trigger	-
Pre-conditions	-

5.3.2 UC Target KPIs

The “Digital powertrain and condition monitoring” UC will be evaluated against the KPIs and target tabulated in Table 39below.

Table 39 - UC8 Key Performance Indicators.

KPI ID	Name	Description	Metric	Method of measurement	Target
KPI_IN3_01	Sensor data	Different types of sensors’ data to be analysed	Numeric	Number of successful interfaces	> 5
KPI_IN3_02	ML Models	Number of implemented ML models	Numeric	Number of ML models	>/= 3

KPI_IN3_03	Digital powertrains	Number of digital twins to be created using an NGIN conformant pipeline	Numeric	Number of digital twins	> 3

5.3.3 UC Requirements

5.3.3.1 Functional Requirements

The functional requirements of the "Digital powertrain and condition monitoring" UC are listed in Table 40 with a unique identifier, a description and assigned a level of priority.

Table 40 - UC8 Functional Requirements.

Requirement ID	Description	Priority
REQ_IN3_F01	IoT-device data must be accessible to device owner from edge node to generate a holistic view.	Medium
REQ_IN3_F02	IoT-device data must be protected so that only the owner of the device has access to the data.	High
REQ_IN3_F03	IoT-NGIN should provide a framework to implement federated learning.	High

5.3.3.2 Non-functional requirements

The non-functional requirements of the "Digital powertrain and condition monitoring" UC are listed in Table 41with a unique identifier, a description and assigned a level of priority.

Table 41 - UC8 Non-functional requirements.

Requirement ID	Description	Priority
REQ_IN3_NF01	Support for batch data processing	Medium

REQ_IN3_NF02	Time synchronization of IoT-devices	Medium

6 Smart Energy

Smart energy has been used in several cases both at the European level as well as at the country level [14]. Smart energy is in a nutshell, the process of using devices for energy-efficiency. It focuses on powerful, sustainable renewable energy sources that promote greater eco-friendliness while driving down costs. In today's modern era, smart energy proves increasingly important, with forward-thinking companies making smart energy systems a top priority. This increased investment in smart energy systems poses many benefits to consumers, the environment, and energy providers at large.

Technologies that are already widely in use by the wind power industry, such as drones and thermal imaging for inspections, will make the operations of solar projects to be more efficient, as will developing technologies such as artificial intelligence. The "Smart energy" domain processes the use of devices to achieve energy efficiency and surrounds powerful, sustainable renewable energy sources that promote greater eco-friendliness while driving down costs. In the IoT-NGIN, the smart energy domain is represented in two use cases to be tested in the ASM Terni smart energy grid. Both use cases will be based on the concept of Digital Twin for the electrical distribution network and Electrical Vehicles, significantly useful for the grid operation, along with the latest requirements on cybersecurity. IoT-NGIN will investigate advanced AI/ML-based analytics to train models tracking the health of the grid along with urban traffic scenario and traffic predictions to provide timely alarms when the system is approaching unstable operational boundaries, which could lead to power failures.

6.1 UC9 Move from reacting to acting in smart grid monitoring and control

This use case is expected to implement a smart energy pilot implemented by ASM, the Terni municipal electricity and gas distribution network operator and EMOT in Terni (Italy). The trial will demonstrate a) the capability of smart grid asset performance management and b) creating human-centred smart micro-contracts and micro-payments in a fully distributed energy marketplace. UC9 will be hosted in the real ASM Smart Grid Active Network in the region of Umbria. The pilot will include smart meters, photovoltaic cell controllers, energy customers (i.e. ASM offices).

6.1.1 UC Scenario

6.1.1.1 Objectives

- Use of edge PMU for power grid phasor measurements
- Improvement of the distribution grid operation and the power quality

6.1.1.2 Actors

The actors involved in this use case involve:

1. Grid Operators
2. Distribution System Operators

6.1.1.3 Background

In a distribution network, ASM owns more than 10 Power Quality Analyzer and 2 PMUs which act as synchro phasor gathering data from primary substations and secondary substations. The trial aims to reduce the impact on the distribution network from RES, that cause voltage arising over the limits. In addition, about 100 near real-time Smart Meters will provide data for particular points of delivery of the distribution network. Innovative advanced protection schemes will be suggested to guarantee more efficiency of MV/LV breakers. The scenario is based on the deployment of an acquisition unit. The unit will transmit samples to edge software. The calculated phasors will be transmitted to a database. Data analysis will demonstrate the adequacy of measurements to new protection schemes.

6.1.1.4 Narrative

About 100 near real-time Smart Meters will provide data for particular points of delivery of the distribution network. Innovative advanced protection schemes will be suggested to guarantee more efficiency of MV/LV breakers. The scenario is based on the deployment of an acquisition unit. The unit will transmit samples to edge software. The calculated phasors will be transmitted to a database. Data analysis will demonstrate the adequacy of measurements to new protection schemes.

The trial will demonstrate the capability of smart grid asset performance management and creating human-centred smart micro-contracts and micro-payments in a fully distributed energy marketplace. The pilot will include smart meters, photovoltaic cell controllers, energy customers (i.e. ASM offices), Electrical Vehicles (EV) and EV Chargers in the area of Terni. The Terni pilot will utilize 4 substations and focus on the Medium Voltage/Low Voltage network branch managed by the SCOV secondary substation.

With the aim of testing UC9 in the Terni trial, the following infrastructure will be exploited:

- Four substations;
- 180kW PV array;
- Six electric vehicles;
- Three charging stations.

The 180 kW Photovoltaic local generation plant often has an electricity surplus, generated from fluctuating renewable energy sources (RES). Moreover, a fleet of six leased EVs (Renault Zone), offered by EMOT will be part of the pilot infrastructure together with at least 3 smart EV chargers (one 52 kW fast charger and two 22 kW ones).

The trial presents 12 Wally power quality analysers, implemented at ASM headquarter assets and at primary substations; moreover, 2 PMU will be installed at a primary and at a secondary substation.

Figure 10: 180kW PV plant7: 180 kW PV plant.

Figure 11: ASM Headquarters.

Figure 12: EVSE (Electric Vehicle Supply Equipment).

Data analysis will highlight the quality of the high-tech sensor system. Historical data will be the basis to evaluate the possible voltage instability cases with and without new high-quality measurements. This risk will be considered during the development phase.

6.1.1.5 Risks/Challenges/Assumptions

The main challenge is the usage of a huge amount of data and data sources which is dramatically higher than the current data sizes managed by the DSO in the current workflow. Another challenge is related to the improvement of power quality through the new high-tech power sensors.

The main risk is the reliability of the measurements; as a matter of fact, a fast and wrong measure could bring to a wrong protection tripping. Another risk is to arise negative effects due to inaccurate data evaluations.

6.1.1.6 User Groups

The identified users for UC9 are:

- Grid operators
- DSOs

6.1.1.7 Features

The features of "Move from acting to reacting in Smart Grid monitoring and control" UC, are described in Table 42 below.

Table 42 - "Leverage of IoT device data" use case of UC9.

Use Case SE6.1.1: Leverage of IoT device data	
Brief Description	In order to increase network stability, DSO leverages the huge amount of data gathered from IoT devices (i.e., Power Quality Analysers, PMU, Smart Meters).
Actor(s)	DSO, technical partners

Priority	High
Trigger	Real-time evaluation of the parameters gathered from the field
Pre-conditions	Data are continuously collected from the field

6.1.2 UC Target KPIs

The "Move from Reacting to Acting in Smart Grid Monitoring & Control" UC will be evaluated against the KPIs defined in Table 43 below.

Table 43 - UC9 Key Performance Indicators.

KPI ID	Name	Description	Metric	Method of measurement	Target
KPI_UC9_1	Time granularity	Time granularity for monitoring	Seconds (s)	Measure the field data amount collected	< 1s
KPI_UC9_2	Interaction capability	Information exchanged by devices	Number of measurements	Evaluating the deployment of project solution in the whole distribution network Measure the field data amount collected	> 100.000 measurements/minute
KPI_UC9_3	Event detection time	Event detection time using the digital twin concept	Seconds (s)	Measure the field data amount collected	< 50 ms
KPI_UC9_4	Reduce the probability of Smart Grid failure	Reduce the probability of Smart Grid failure due to voltage instability at least	Probability (%)	Evaluation of measured data leveraging data of the network	25 % reduction in comparison with daily average value
KPI_UC9_5	Flexibility exploitation	Increase urban Electrical	Percentage (%)	Evaluation of measured data leveraging	20 % in comparison with daily

		Vehicles charging efficiency		data of the network	average value
KPI_UC9_6	Percentage of lost (missed) measurements	Relative number of missing data	Percentage (%)		<1%

6.1.3 UC Requirements

6.1.3.1 Functional Requirements

The functional requirements for UC9 are listed below in Table 44, with a unique identifier, a short description and the expected level of priority.

Table 44 - UC9 Functional Requirements.

Requirement ID	Description	Priority
REQ_SE1_F01	Based on sampled data, phasors are calculated with high precision and the synchronization process should be very fast. Indeed, innovative reconfiguration and self-healing schemas should rely on appropriate measurements	High
REQ_SE1_F02	High-tech power sensors should be useful to elaborate on new strategies, in order to improve the power quality in a secure way. Smart Meter should help this process	Medium

6.1.3.2 Non-Functional Requirements

The non-functional requirements of the "Move from Reacting to Acting in Smart Grid Monitoring & Control" UC are listed in Table 45, providing a unique identifier, a brief description and the priority level.

Table 45 - UC9 Non-functional requirements.

Requirement ID	Description	Priority
REQ_SE1_NF01	An acquisition unit shall stream data to an edge node. The edge node shall then process this data to produce phasors. The phasors are then transmitted to the grid operator.	High

REQ_SE1_NF02	Secure communication of sensitive data related to the infrastructure should be provided.	Medium
REQ_SE1_NF03	The 5G availability should allow achieving better performances in data transmission.	Medium

6.2UC10 Driver-friendly dispatchable EV charging

Within this use case, electric vehicles (EV) and EV Chargers in the area of Terni (Italy) will be involved. The Terni pilot will utilize 4 substations and focus on the Medium Voltage/Low Voltage network branch managed by the SCOV secondary substation, which serves a 200 kW Photovoltaic local generation plant, which often has an electricity surplus, generated from fluctuating renewable energy sources (RES). A fleet of six leased EVs, offered by EMOT, will be part of the pilot infrastructure together with at least 3 smart EV chargers (one 52 kW fast charger and two 22 kW ones). Moreover, this UC will exploit energy monitoring carried out by means of IoT smart meter deployed at each block of energy unit. IoT-NGIN will provide optimized grid management via EV charging smart scheduling using Digital Twin concept and advanced AI/ML-based analytics, along with the latest requirements on cybersecurity.

6.2.1 UC Scenario

6.2.1.1 UC Objectives

The objective of this UC is to charge EVs with renewable energy aiming to power the eMobility with clean energy and help DSOs keep the grid stable in a condition of high penetration of distributed renewable energy plants.

6.2.1.2 Actors

The actors involved in the use case include:

1. EV Owners, EV Fleet Managers
2. Prosumers
3. DSOs

6.2.1.3 Background

With the aim of testing UC10 in the Terni trial, the following infrastructure will be exploited:

- Four substations;
- 180kW PV array;
- Six electric vehicles;
- Three charging stations.

The Italian trial ASM present substations are equipped with twelve Teamware Wally A RTU power quality analyser and implemented at ASM headquarters assets and at primary substations;

moreover, two phasor measurements units (PMU) installed at a primary and secondary substation. Furthermore, ASM 180kW PV array is connected to the SCOV substation.

Regarding electric vehicles, two models will be used: Renault ZOE and Nissan LEAF and can be seen in Figure 13.

Renault ZOE, the acronym of ZerO Emissions, is a five-door supermini electric car produced by the French manufacturer Renault. The ZOE involved in UC10 is powered by two different battery packs: a 22-kWh lithium-ion battery pack weighing 290 kg and a 41-kWh lithium-ion battery pack weighing 305 kg, driving at 65 kW (87 bhp; 88 PS) synchronous electric motor supplied by Continental (the Q210). Maximum torque is 220 N·m (162 lb-ft) with a top speed of 135 km/h (84 mph). The NEDC cycle range is 210 km (130 mi). Renault estimates that in suburban use the ZOE has about 150 km of autonomy for the 22-kWh model and 280 km for the 41-kWh model. The car features a charging system called "Caméléon" (Chameleon) charger that allows the ZOE to be charged from 3 kW to 22 kW [15].

The Nissan LEAF, the acronym of Leading, Environmentally Friendly, Affordable, Family car, is an electric propulsion car introduced by Nissan on the markets in December 2010. It is equipped with an 80 kW (109 hp) synchronous AC electric motor. The first version equipped a lithium-ion battery, consisting of 48 modules and each of them contains 4 cells for a total of 192, with a capacity of 24 kWh with an autonomy of 199 km NEDC cycle. Nissan LEAF recharges in alternating current or indirect current. In AC, LEAF uses an on-board charger with a maximum power output of 7.4 kW (32A maximum current, 230V, single-phase) with the Type 2 socket. In DC it uses the CHAdeMO standard up to 50 kW of power output [16].

Figure 13: Nissan LEAF and Renault ZOE connected to SpotLink EVO.

The above EVs will be charged via three smart charging stations involved in the UC10 trial, two 22 kW charging stations (SpotLink EVO) and one 50 kW charging station (Efacec QC45).

The SpotLink EVO charging station with two type 2 sockets, recharges up to 32 A for each socket; it has IP54 protection grade, the impact resistance is IK08 and the protection system is differential type A and type B, with an automatic unlocking of the connector in case of power failure. It is equipped with a single-board computer that allows real-time monitoring and remote management of the charging station such as power output modulation, energy price management and remote charging session start&stop; charging session status is displayed on a 7" touch screen. SpotLink EVO connectivity is through RJ45 port (LAN) or modem, its nominal voltage is 230 VAC in monophase or 400 VAC in three phases and its nominal frequency is 50 Hz. The SpotLink EVO charging station is shown below in Figure 14.

Figure 14: Emotion SpotLink EVO.

The QC45 quick charging station provides a rapid battery charge and supports two EVs simultaneous AC and DC charging with multiple power output options. The QC45 is a flexible and open charging station able to charge in a standalone mode or integrated with any network with any central system. The QC45 has DC output with power up to 50 kW and optional AC output with power up to 43 kVA. The battery charging status is displayed on a TFT colour screen. The QC45 has high quality and robust enclosure with corrosion protection, equivalent to stainless steel, to ensure extended equipment lifetime [17].

6.2.1.4 Narrative

Grid monitoring is expected to provide EV driver-friendly scenarios for dispatchable charging based on demand-response (DR) mechanism enabled by smart micro-contracts and micro-payments. Advanced AI/ML-based analytics will be used to obtain accurate grid status forecasting, in order to increase DR benefits and avoid unstable operational boundaries, which could lead to failures.

For the UC10, grid monitoring and energy data transmission from substations will be carried out by smart meters and power quality analysers using MQTT protocol; data format will be JSON and the sampling rate is 1-5 s; furthermore, an ASM server farm and a virtual machine will be involved in the demonstration activities. ASM devoted server will have a 30 GB hard disk and 8 GB RAM.

EMOT will use a server machine for the UC10, having a two core 3.1 GHz CPU, a 50 GB HDD, a 4 GB RAM and Ubuntu 16.04 LTS operating system.

EMOT charging stations will exchange data through a Teltonika RUT230 modem connected to a single-board computer, a Raspberry Pi 3, with a CPU of quad-core ARM Cortex A53 1.2 GHz, an SD of 16 GB, a RAM of 1 GB and a Raspbian Stretch 4.14 operating system; charging station protocols are OCPP (application protocol for communication between charging stations and EMOT central management system) and WebSocket (computer communications protocol, providing full-duplex communication channels over a single TCP connection). The charging station data format is JSON and the sampling rate is one second.

Regarding EV monitoring, EMOT will use an on-board diagnostic (OBD) device to retrieve data from the EV; OBD is an IoT component, based on a Raspberry Pi 3 and Carberry; Carberry represents the link between car electronics and Raspberry Pi, which allows the development of end-user applications. OBD utilize a TCP/IP communication to a TCP/IP server. The network connectivity of the OBD device is via data SIM, thanks to a Raspberry module that works as a modem, and the server is a python software; OBD protocol is MQTT and the sampling rate is 5 seconds. The OBD connects to the diagnostic interface from which it is able to extract the information from the electric vehicle control unit using the CAN-bus protocol. The output data format of the OBD is an ASCII string; when the data is sent to the server, it is reorganized into a wrapper, thus obtaining a grouping of the data in JSON format.

6.2.1.5 Risks/Challenges/Assumptions

Using electric mobility as a source of flexibility for balancing the grid in conditions of high penetration of distributed renewable energy plants is an advantageous solution that avoids the implementation of new power lines and new energy storage plants; nevertheless, at the same time, it strongly exposes electrical power and energy system, significantly increasing the impact of potential cyber-attacks, which could compromise the supply of the electricity service causing outages, by hacking the Demand Response mechanism on which the interaction between the DSO and the EV users is based. Considering that, IoT-NGIN will research towards protection of IoT systems against cyber-attacks to assist ML-based anomaly detection and implement novel low and medium interaction adversarial nets to identify malicious or suspicious IoT nodes.

6.2.1.6 User Groups

The identified users for UC10 are:

For UC10:

- EV Owners
- EV fleet managers
- DSOs
- Prosumers

The end-user needs for UC10 include:

1. Clear and simple registration and authentication processes on the e-Mobility platform
2. The e-Mobility platform must allow users to consult historical data
3. The e-Mobility platform must show users the environmental and economic benefits of their involvement in DR campaigns

6.2.1.7 Features

The features of the "Driver-friendly dispatchable EV charging" UC have again been extracted by means of use cases. The below use cases provide clarifications on some of the concepts implemented in the project while creating the lists of functional and non-functional requirements. Last, they provide some scope for the test cases that will be later used to validate the IoT-NGIN framework. These use cases are described below in Table 46 and Table 47.

Table 46 - "Grid Forecasting" use case for UC10.

Use Case SE6.2.1: Grid Forecasting	
Brief Description	In order to estimate energy demand for the DR campaign, DSO must have consumption and production forecasts at the grid level
Actor(s)	DSO
Priority	High
Trigger	Forecasting of energy demand, which will be calculated every day
Pre-conditions	Consumption and production data should be constantly collected

Table 47 - "Driver-friendly DR Execution" use case of UC10.

Use Case SE6.2.2: Driver-friendly DR Execution	
Brief Description	Based on grid forecasting, DSO creates a DR campaign to obtain energy flexibility via dispatchable EV charging
Actor(s)	DSO, Charging Station Managers, EV owners
Priority	High
Trigger	Forecasts indicate forthcoming reverse power flow to be mitigated
Pre-conditions	DSO, charging station managers and EV owners are registered on e-Mobility platform

6.2.2 UC Target KPIs

The "Driver-friendly dispatchable EV charging" UC will be evaluated against the KPIs and targets are shown below in Table 48.

Table 48 - UC10 Key Performance Indicators.

KPI ID	Name	Description	Metric	Method of measurement	Target
KPI_UC10_1	Real-Time Monitoring	Time granularity for monitoring	Second (s)	Measure the data gathering sampling rate	< 1 s

KPI_UC10_2	Big Data Collection	Interaction capability	Measurements /minutes	Measure the field data amount collected	> 100.000 measurements /minute
KPI_UC10_3	Electricity Surplus Management	Reduction of reverse power flows	kWh/day	Measure the energy that flows from the user networks in the substations	About 10 kWh/day
KPI_UC10_4	EV User Experience #1	Increase EV charging efficiency	Monetary savings	Measure the money saved involving EV users in demand-response (DR) campaigns	money saved: 0.05 €/kWh
KPI_UC10_5	EV User Experience #2	Increase EV charging efficiency	Renewable energy %	Measure the percentage of renewable energy used to charge the EVs involved in DR campaigns	> 50%

6.2.3 UC Requirements

6.2.3.1 Functional Requirements

The functional requirements of the "Driver-friendly dispatchable EV charging" UC are listed in Table 49 below. The table provides the unique identifier, a short description and the foreseen priority level for each requirement.

Table 49 - UC10 Functional Requirements.

Requirement ID	Description	Priority
REQ_SE2_F01	A platform hosting charging station manager and EV owners shall be implemented and deployed.	High
REQ_SE2_F02	e-Mobility platform shall be enabled for user registrations.	Medium

REQ_SE2_F03	As there will be more than one charging station involved in the trial, each individual charging station must have its own unique identifier.	Medium
REQ_SE2_F04	As there will be more than one electric vehicle involved in the trial, each individual electric vehicle must have its own unique identifier.	Medium
REQ_SE2_F05	Charging station must be connected to the internet to be integrated into the platform.	High
REQ_SE2_F06	Electric vehicle must be connected to the internet to be integrated into the platform.	High
REQ_SE2_F07	Charging station must provide energy data to be involved in DR campaigns; data shall be stored for result evaluation.	Medium
REQ_SE2_F09	Platform must ensure interoperability between charging station and an electric vehicle to ensure the charging session execution during DR campaigns.	High
REQ_SE2_F10	DSO shall be able to forecast electricity production/consumption and estimate flexibility need.	Medium
REQ_SE2_F11	DSO must be able to select the charging stations involved in a specific DR campaign.	High
REQ_SE2_F12	e-Mobility platform must be able to execute smart micro-contracts.	High
REQ_SE2_F13	e-Mobility platform must be able to process micro-payments.	High

6.2.3.2 Non-functional Requirements

The non-functional requirements of the "Driver-friendly dispatchable EV charging" UC are listed in Table 50, providing the unique identifier, a short description and the priority level for each requirement listed.

Table 50 - UC10 Non-functional requirements.

Requirement ID	Description	Priority
REQ_SE2_NF01	e-Mobility platform shall be capable to manage multiple users without affecting its performance.	Medium

REQ_SE2_NF02	e-Mobility platform shall be portable. So, moving from one OS to other OS does not create any problem.	Medium
REQ_SE2_NF03	e-Mobility platform login shall be processed by 3 seconds.	Low
REQ_SE2_NF04	Charging station ping shall be under 200 ms.	Medium
REQ_SE2_NF05	Electric vehicle ping shall be under 200 ms.	Medium
REQ_SE2_NF06	Data shall be consistent, reliable, transparent and accessible only to authorized users.	High
REQ_SE2_NF07	Store data in a safe and tamperproof manner.	High

7 Ethics and GDPR Compliance

The IoT-NGIN Consortium understands that research has ethical implications. In this chapter, we demonstrate the commitment to respect the ethical standards and rules of H2020. We also confirm that the ethical standards and guidelines of Horizon2020 [18] will be rigorously applied, regardless of the country in which the research takes place. In light of the ethical questions potentially raised by the project, IoT-NGIN relies on adequate safeguards in the conduct of its research and the design of the project outcomes, described below. Deliverable D1.1 is drafted during the initial stages of the project life cycle. This chapter is drafted to provide an overview of the compliance management activities as opposed to going into more specific legal or ethics issues. Therefore, in order to avoid repetition, deliverable D1.1 focuses more on the Use Cases and their specifications and requirements. Very specific, project-wide ethics compliance efforts including all consortium partners are described in WP10 deliverables addressing the Ethics Requirements (D10.1, D10.2, D10.3 and D10.4). In terms of management of the research information as well as the processing of personal data, more information can be found in deliverable D7.2 "Data Management Plan". Finally, deliverable D 4.1 "Next Generation IoT PRESS Analysis & Confidentiality Requirements" provides much more in-depth information concerning ethics compliance management, privacy and data protection issues, societal requirements and information security requirements.

7.1 Compliance Management

7.1.1 Overall approach:

The consortium is committed to compliance with the Regulation establishing Horizon 2020, Art. 19 "Ethical principles", General Data Protection Regulation (GDPR) as well as principles ensuring the respect of human dignity, fair distribution of research benefits while protecting the values, rights and interests of the research participants.

7.1.2 Ethics as an integral part of Project Management

We review ethics issues as a standing item in our regular management meetings. IoT-NGIN follows a structured approach to identifying, assessing and disposing of ethical and data protection issues. All partners will have equal responsibility for meeting ethical and legal requirements in the context of the work they undertake in the project. During the project, PRI leads the internal monitoring of the implementation of the ethics requirements by the consortium. This way, the ethical issues that might be raised by IoT-NGIN will be continuously addressed during the project's lifecycle.

7.2 Ethics Requirements for Research Activities

7.2.1 Research involving humans

IoT-NGIN will touch on issues of human subject research ethics, notably in project activities involving partners and stakeholders. Such issues may include informed consent, trust and fairness. The consortium partners are familiar with the ethical challenges associated with research involving humans, given their training and previous experience in research methodology. They are familiar with the processes needed to meet and exceed these requirements when conducting workshops, meetings and research tasks. These activities are constantly updated and monitored.

7.2.2 Inclusion / Exclusion Criteria

The project will take measures to ensure there is no discrimination or harm from the recruitment, exclusion or inclusion process. When engaging stakeholders, we will consider factors such as the purposes of the research, whether participants may be susceptible to coercion or undue influence, selection criteria, including gender balance, the consent management, among other factors.

7.2.3 No children or adults unable to give informed consent

In case this is needed at any stage of the project life cycle, IoT-NGIN will recruit only adults able to provide their informed consent to participate. No person unable to express a free and informed consent for age-related reasons, ongoing medical and/or psychological conditions, mental incapacity, will be enrolled in any of the research activities of the project.

7.2.4 Information sheets and informed consent process

In case this process is needed, the partners will advise external project participants that their participation is entirely voluntary. The consortium will obtain (and clearly document) their informed consent in advance. Participants will be provided with Information Sheets and consent forms in a language and terms fully understandable to them. These will describe the aims, methods, and implications of the interviews, workshops and online survey, the nature of their participation, and any benefits or risks (e.g., to privacy) that might be involved. They will also explicitly state that participation is voluntary and that participants have the right to terminate the interview or refuse to participate and to withdraw their participation, or data at any time — without any consequences.

7.2.5 Gender Equality

The consortium addresses sex, gender and equality issues in the constitution of the consortium itself. The consortium will be respectful of gender equality and will ensure there is no discrimination on the basis of a person’s sex during the project’s research and activities. Gender balance will be respected in research teams and taken into account in the decision-making process.

7.3 Data Protection Requirements and Measures for Safeguarding Privacy

IoT-NGIN will rely on the processing of personal data for research purposes, especially concerning contact details and opinions of those participating in the workshops and pilots. Our research will comply with the relevant EU and national data protection laws. The project will collect and process data only if, and insofar as, it is necessary for its research. In practice, this means that we intend to fully adhere to the data minimisation principle. We will ask any research participants for their informed consent, as noted above, and provide them with a clear description of the procedures that will be used for data control. Participants in project activities will be given clear information about how their data will be collected and protected during the project and either destroyed or reused at the end of the research. The project coordinator will provide all partners with detailed procedures for the recruitment of participants and data collection.

7.3.1 Purpose Limitation (processing of data for scientific research only)

For the personal data processed in the scope of the project, the applicable legislation is the GDPR. The partners will gather informed consent from any project participant in view of the provisions of Art. 9.2 GDPR. IoT-NGIN is a research project being carried out in the public interest and may have a substantial impact. Further, in the case where processing is necessary for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes in accordance with Article 89(1) based on Union or Member State law which shall be proportionate to the aim pursued, respect the essence of the right to data protection and provide for suitable and specific measures to safeguard the fundamental rights and the interests of the data subject.

7.3.2 The lawfulness of the processing

Processing personal data is necessary to achieve the research purposes of the project. The lawful basis on which IoT-NGIN is processing personal data includes consent (for individuals participating in the research external to the consortium). Consortium partners are processing personal data in the respect of their local laws.

7.3.3 Exercise of data subject rights

In case human participants will be involved in our research activities, and to safeguard and ensure the exercise of data subject rights, consortium partners responsible for processing personal data will provide data subjects with all the necessary information including:

- Contact details of the data controller(s);
- Purpose of the processing and its legal basis;
- Legitimate interests of the controller and third parties;
- Categories of personal data and their sources;

- Recipients or categories of recipients of personal data;
- Transfers, if any, to third countries and safeguards;
- Retention periods and criteria.

7.3.4 Technical and organisational measures for ensuring the protection of personal data

Where the processing of personal data is involved, appropriate privacy-enhancing technologies will be applied to the storage and transmission of that data between partners. Once the data has been used for its intended purposes within the project, it will be deleted to avoid the accidental risk of future disclosure (unless required to be kept for legal or contractual purposes). All partners of the consortium will adopt good practice data security procedures in the project. This will help avoid unforeseen usage or disclosure of data, including the mosaic effect, i.e., obtaining identification by merging multiple sources). Measures to protect data include access controls via secure log-ins, installation of up-to-date security software on devices, regular data backups, etc.

7.3.5 Adequate security measures for storage and handling of personal data

IoT-NGIN will use state-of-the-art technologies for secure storage, delivery and access of personal information, as well as managing the rights of the users. In this way, there is a very good level of guarantee that the accessed, delivered, stored and transmitted content will be managed by the right persons, with well-defined rights, at the right time. State-of-the-art firewalls, network security, encryption and authentication will be used to protect collected data. Firewalls prevent the connection to open network ports, and exchange of data will be through consortium known ports, protected via IP filtering and password.

7.3.6 Security enforcement within the project

The collected data will be stored in a secure server, only visible to the research site network, in a locked room at each of the research locations. Authentication will be required to access stored data on the research site. Authorized researchers will have access to the recorded anonymous data after authentication with a centralized server and on a need-to-know basis.

7.3.7 Data protection approvals

To comply with a potential request from an Ethics Panel or a Review, the project partners will confirm the details of their organisation's data protection officer and will provide a copy of an opinion or confirmation from the data protection officer that all data collection and processing will be carried out according to EU and national legislation, in cases this is requested. Copies of this will be filed (by the project coordinator) and made available to the European Commission upon request. If the position of a data protection officer is not established in an organisation, partners engaging in data processing activities will provide a project-specific data protection policy covering these activities.

7.3.8 Secondary use

It is not likely that during the project, consortium partners further process previously collected personal data ("secondary use"). Any personal data falling under this category will be processed only in strict accordance with relevant rules and ethics principles. If necessary, the consortium will confirm the legal basis for these data processing activities and demonstrate their availability to the consortium.

7.4 Continuous Compliance Monitoring

Privacy, Data Protection, Ethics and Security issues are monitored on multiple levels of project management, both within the consortium's internal procedures and externally – via independent oversight.

7.4.1 Data Management Plan

One of the most important requirements within IoT-NGIN is the correct management of acquired data and produced data across the different technical outcomes of the project. The project addresses data management from two points of view:

- DMP as an ethics requirement (describing the life cycle of personal data processed within the project: how it is collected, for what it is used, how it is protected and finally deleted/archived). This is part of Task 1.3 "Verification framework benchmarking & GDPR compliance". In close collaboration with the coordinator as well as other consortium partners, PRI is in charge of implementing the DMP focusing on personal data processing activities. This will ensure adherence to privacy laws and regulations, handling of anonymization processes where applicable, handling of informed consent processes for participants external to the consortium, processes associated with secure storage of incident handling datasets and more.
- DMP as part of Open Data Pilot Requirement (mandatory deliverable as the consortium takes part in the Open Data Pilot. The focus here is on the management of research information in general and making it as open as possible and in accordance with the FAIR principles). This is part of Task 7.1 "Open Data Management Plan & Pilots Set-up" and D7.1 "Data Management Plan (DMP)".

Both documents are considered as living registries and it is up to all project partners to provide timely reporting in case of changes in their data management practices throughout the project. Finally, the activities described here feed into the risk management component of IoT-NGIN.

7.4.2 Data Protection Manager

Due to the nature and sensitivity of its activities, the IoT-NGIN relies on an additional internal compliance role – the DPM – assigned to PRI. This is a supervisory/advisory role of the project working in close collaboration with the Coordinator, all WP and Task leaders and provides a liaison between the project consortium and external oversight body – the Security Advisory Board.

7.4.3 Security/Ethics Advisory Board

An external component of the ethics compliance monitoring, the advisory board ensures that any information including personal data during project activities will be handled appropriately in a way that will not lead to potential misuse. The independent board members will be invited to review any of the deliverables of interest to them during each year's reporting period and to offer their views on ethical and social issues concerning the project and/ or to which they may offer some ideas for solutions.

7.4.4 Legal and Ethical component of Exploitation Activities

Ensuring legal and ethical compliance for the project outcomes directly enhances their potential for adoption by the potential end-users. Positive compliance results will be used as an enabler for the exploitation activities of the project outcomes.

8 Conclusion

This deliverable report responds to Task 1.1 "Requirements analysis, use case refinement and target KPIs" of WP1 and the work performed under this Task in Months 1-6. This report provides a presentation of functional and non-functional requirements alongside refinement and analysis of the use cases scenarios. Additionally, the target KPIs are presented however attention must be drawn to the fact that these will be revisited and recalculated within the work to be performed in WP7. Moreover, the user groups and their needs were identified and presented in this report as an additional verification of the project's user-centric approach. Last, a thorough methodology of GDPR compliance is shared to ensure the project's consideration of data privacy and security.

This deliverable constitutes a primary version of redefining the use cases and offers a comprehensive and robust analysis of the requirements and user needs within the four domains of the IoT-NGIN project.

During the whole implementation of the project, D1.1 will provide input to:

- WP2 on the enhancement of IoT underlying technology
- WP3 on the enhancement of IoT intelligence
- WP4 on the enhancement of tactile and contextual sensing/actuating
- WP5 on the enhancement of IoT cybersecurity and data privacy
- WP6 on the IoT-NGIN integration and LL evaluation
- WP7 on the LL validation

Provision of input in the abovementioned WPs, the report aims to fulfil the GA objective of defining in detail appropriate post-exploitable use cases linked to specific target technological KPIs. The use cases will be evaluated in WP6 and validated in WP7 hence the various requirements and KPIs will be revisited and redefined within the tasks responding to these two WPs if and as needed.

Testing and validation of the UC cases in the LLs will be largely based on requirements and key performing indicators provided in this deliverable parallel to the rest of the validation processes and planning. The relevant validation results after the testing will be documented in Deliverables D6.3: "Interoperable IoT-NGIN meta-architecture & laboratory evaluation", D7.2: "Trial site set-up, initial results and DMP update", D7.3: "IoT-NGIN Living Labs use cases intermediate results" and D7.4: "IoT-NGIN Living Labs use cases Assessment and Replication guidelines". Enhancement of the GDPR framework and ethical guidelines, alongside a data management plan will be provided with deliverables D4.1:" Next Generation IoT PRESS Analysis & Confidentiality Requirements" and D7.1:" Data Management Plan (DMP)" respectively.

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Annex 1 Use Case Requirements: Iteration 1

First iteration table for capturing use case requirements. Sample of the Smart Cities use cases.

		Objectives/ Goal	End-user Group	End-user group needs	Functional Requirements	Non-functional Requirements	Pre condition	Post condition	Other Requirements (Operational,QoS, QoE)
SMART CITIES eBOS AALTO SU CAP i2CAT FVH ENG RWTH EMOT	Living Lab Leader: **FVH** Description of action from the GA	1a) FVH 3a) FVH 1b) ENG 2a) FVH 2b) ENG							
1. Traffic Flow Prediction & Parking prediction	• Model and train distributed AI models on traffic flow and parking prediction in a greedy layer wise fashion by utilizing basic geography with historical data •Traffic and parking prediction ML models will be federated at the edge cloud •5G communications will be used for: interconnecting sensors, gather IoT data in real-time and store it at the edge and run smart AI-based simulations to perform what- if analysis when transport is interrupted (e.g.: due to extreme weather, man-made or technical hazards)	Less time looking for parking = less pollution. Spreading"rush	Citizens, public transport planners, supply logistic workers	Shorter travel times, solution to "last mile" challenges. This should be integrated into existing and used	Access to traffic data. Function of aspects such as weather, events etc. UI for user.	Data integrity	Functionin g ML model and network		
		1)To re-route traffic in case of transport interruction 2)Parking prediction	Inhabitants of the smart city and SME that can built on top of it their innovative services	1)Lower time spent in the traffic Jam 2) Intelligent re-routing of the traffic paths 3) Mission critical services for public autorithies (hospital, police)	• The application has to take care of constraints imposed by the physical traffic infrastructure: road network capacities, traffic regulations and management policies • It has to take care of streets and	• Every unsuccessful attempt by a user to access an item of data or functionality shall be recorded on a database • Privacy of information and security have to be guarantee	The user is logged into the service/ap plication	• Information on availability of parking spaces • Traffic flow prediction and	QoS
2. Crowd Management	•Demonstrate the use of open data, user data and IoT data on traffic fluency through cameras and radars installed at the bottleneck intersections for crowd steering based on the application of AI. •Consider crowd management of the busy Helsinki-Tallinn cross-border commuter harbour during peak hours and in case of unexpected events based on predictive algorithms.	Smart handling of crowd steering on commuter Harbour during peak hours	Inhabitants of the smart city and SME that can built on top of it their innovative services	Complete resolution of crowded situation	• The application has to integrate many different data sources • The application has to provide maps with the crowd real time situation • It has to show a list of the predicted actions to smart handle the crowd • It has to suggest a list of advices to avoid bottleneck creation	• Every unsuccessful attempt by a user to access an item of data or functionality shall be recorded on a database • Privacy of information and security have to be guarantee • The application has to guarantee reliability, availability and low latency	The user is logged into the service/ap plication	Information about crowd management and how was resolved the bottolneck problems	QoS
		Decrease traffic jams and waiting times f.ex. In Jätkäsaari harbour	Boat passengers, residents of bottleneck area, city officials.	Instructions on how to avoid bottlenecks. This should be integrated into existing and used platforms.	Human flow data (amount, time, place, direction). Boat capacity data and predictions.		Data pipelines working (API interactio ns)		Cameras are not aesthetically pleasing and especially do not build a trusting environment in the city. Cameras should be
3. Co-commuting solutions based on social networks	•Combine IoT data with virtual citizen generated IoT data from social networks to demonstrate the use of advanced AI in provision of co-commuting solutions in neighbourhood level and cross-border. The use case will take avail of the Urban Open Platform and Lab (UOP.Lab) developed in Finest Twins project and extend its functionality. The platform enables knowledge and tools transfer for SMEs	Money and time saved because of efficient transportation solutions.	Commuters (work, hobbies, recreation)	Easy to use interface for sharing information/booking rides etc. This should be integrated into existing and used platforms.	Access to relevant social media API. UI for user.	Accessibility, interoperability			

Sheet1 Sheet3

Annex 2 UC Requirements: Iteration 2

Sample of second iteration for the Industry 4.0 use cases.

SMART MANUFACTURING	GA-stated requirements	Functional Requirements	Non-functional requirements	Users
UC 6:Human-centered safety in a self-aware indoor factory environment	The factory will feature edge computing resources that will be used to support a set of virtual AI functions that will process the real-time location of the AGVs, the real time stream coming from the safety cameras. The AI functions will determine a potential collision between AGVs, or between a worker and an AGV and will issue an early warning	Definition of robust createria to assess the distance at which trigger an alarm	The application has to guarantee reliability, availability and low latency	Factory workers, Factory Manager, Security responsible personnel
		IoT NGIN AI functions shall detect potential collisions between AGVs and between workers and AGVs with location information and cameras real-time stream		
		The service has to provide information about the environment	AI functions must predict collisions with a minimum accuracy and reliability	
		The service has to provide the possibility to manually act and control a single AVGs	Edge computing resources shall be robust and horizontally scalable	
			Resources must provide a minimum latency	
	BOSCH facilities: the combination of UWB and VLP will provide cm-level accuracy to accurately track the real-time positions of the AGVs, which will be equipped with inexpensive UWB and CMOS tracking sensors		Robustness against environment interferences.	
		It has to use a deep learning algorithm as LSTM and RNN to determine potential collisions and how to avoid them	Personnel security must have absolute priority over any other factor	
			Algorithm must consider that human-driven vehicles might be in the factory	
		The service has to provide real time information of all the moving things and workers in the factory	If possible, location of AGV and moving objects must be provided to workers, too	
	ABB facilities: the data will be used to monitor sub-assembly location and movement, and to optimize production workflow	Warnings shall be provided when a collision might occur and AGVs must stop		
		AGVs positions will be tracked in real-time		
		Production workflow shall be optimized according to current (location) data and production requirements		

Annex 3 User Questionnaire: Iteration 1

Sample of general questions for the first iteration.

QUESTIONS
What industry are you in?What is your field of expertise?
What features would you like the next IoT devices to have?/What do you expect of the next generation IoT?
How would tactile internet address your needs as a user?
How will federation of data help you in the day-to –day operations?
How many devices are supported?
What are the characteristics of the next generation IoT that you would like to be implemented in electric mobility?
Would you be interested in a driver-friendly Demand-Response (DR) mechanism?
Considering tactile internet and user-centric dimensions, how do you imagine a driver-friendly DR mechanism?
How many substations are equipped with RTU and/or PMU?

Annex 4 User Questionnaire: Iteration 2

Sample of questions for the second iteration.

User needs (*examples)
What is the source of the data you want to exploit? (Vehicles, Robots, Plants, IoT Devices, ...)
What is the type of the data you want to exploit? (Images, Videos, Raw/Tabular data, Do not know, ...)
What is the privacy level of the data you want to exploit? (Private, Public, Do not know, ...)
Would you like IoT-NGIN services to provide real–time data processing or batch data processing on the datasets? (Real-time, batch, Do not know)
What kind of services would you like IoT-NGIN to provide from your data? (e.g.: Prediction of traffic Flow, Crop diseases prediction, object recognition and classification, ...)
In which infrastructure could you have IoT-NGIN intelligence services running? (e.g.: Industry computers, Robots, IoT Devices, Do not know, ...)

Annex 5 User Questionnaire: Final Iteration

Sample of the Smart Energy focused user questionnaire.

General Questions
Organization Name
Position
Email address (optional)
What industry are you in?
What is your field of expertise?
Technology
Would you like predictions to be provided on demand, periodically or automatically?
Would you like to have access to your measurements?
Would you like to have the option to manage your monitoring devices?
Do you think that your business can benefit from ML predictions?
Are there any doubts to use AI technology in your business?
Would you like your system to operate automatically and apply controls, based on calculated predictions, or would you like to have the last call?
Data
What is the source of the data you want to exploit? (Vehicles, Robots, Plants, IoT Devices, …)
What kinds of devices are you collecting monitoring data from?
What is the type of the data you want to exploit? (Images, Videos, Raw/Tabular data, Do not know, …)
Under which circumstances would you be willing to use your monitoring data for automation in your field?
What is the privacy level of the data you want to exploit? (Private, Public, Do not know, …)
Would you be willing to share data for cross-sector applications?
Would you like IoT-NGIN services to provide real–time data processing or batch data processing on the datasets? (Real-time, batch, Do not know)
Can you give an estimation of the volume of your data (e.g. per day/month/year)
What is the frequency of your data? (How often are you collecting data)
Applications - Smart Energy
Do you think that AI-based proactive grid management is useful?
What are the smart grid assets upon which power quality applications can work?
Can you give an estimation of the computing resources of those assets?
At which timeframe are monitoring data from relevant assets available? (monthly, daily, hourly, real-time,other)
Are there special requirements on data communication? (speed, frequency, privacy, availability, etc)
Can you describe a case when fast communication and reaction is needed, as a result of grid monitoring?
Which are the main factors affecting flexibility prediction in a distributed energy marketplace? Could you think of unpredictable factors affecting the flexibility availability at the very last moment? (e.g. failure, destruction of charging stations)