Next Generation Meta Operating System

D1.1 Definition and analysis of use cases and GDPR compliance

Document Identification			
Status	Final	Due Date	28/02/2023
Version	1.0	Submission Date	28/02/2023

Related WP	WP1	Document Reference	D1.1
Related Deliverable(s)	D1.2, D1.3	Dissemination Level (*)	PU
Lead Participant	SIM	Lead Author	Simona Bica, Andreea Paunescu, Mircea Vasile,
Contributors	All partners	Reviewers	Rosaria Rossini, ECL; Terpsi Velivassaki, SYN Maria Potop-Butucaru, SU

Keywords:
Use Case, KPI - Key Performance Indicator, Scenario, Story / narrative, Functional requirement, Non-functional requirement, ethics, data protection and confidentiality, GDPR, monitoring, detection, automation, AIoT, AI - Artificial Intelligence, technological mapping

Document Information

List of Contributors	
Name	**Partner**
Simona Bica, Mircea Vasile, Ionut Vlad, Andreea Paunescu	SIM
Panagiotis Karkazis, Alberto Casanova, Astik Samal	MAG
Terpsi Velivassaki, Harry Skianis	SYN
Antonello Corsi	ENG
Prashanth PKP Kumar Pedholla	ASM
Sonja Waechter, Hueseyin Erdogan	CONTI
Georgios Sofianopoylos, Dimitrios Christopoulos	FHW
Iraklis Bourantas, Vagia Kalliontzi, Theodoros Kakardakos	NOVO
Maria Belesioti	OTE
Rosaria Rossini	ECL
Maria Potop-Butucaru	SU

Document History			
Version	**Date**	**Change editors**	**Changes**
0.1	30/11/2022	SIM	Drafting ToC of the deliverable
0.2	06/12/2022	MAG	Insert GDPR compliance section
0.3	31/12/2022	SIM	Contribution for Chapter 3
0.4	09/01/2023	CONTI	Contribution for Chapter 4 and Chapter 7
0.5	19/01/2023 - 31/01/2023	SIM, All	Contribution for Chapter 4
0.6	02/02/2023	MAG	Contribution for Chapter 6
0.7	03/02/2023 - 13/02/2023	FHW, ASM, SIMAVI, CONTI, NOVO, SYN, OTE	Update input for introductory parts, Chapter 3, Chapter 4, Chapter 5 and Chapter 7
0.8	14/02/2023	SIM	Final contribution for Chapter 2, Chapter 7 and Chapter 8
0.9	15/02/2023-20/02/2023	SYN, FHW, NOVO, ENG, SIM, ASM, EMOT, CONTI,	Remove Chapter 7 and include updated contribution about the technologies mapping in Chapter 4. Last updates and validation of input for Chapter 4, Chapter 5 and List of acronyms
0.10	20/02/2023	SIM	Deliverable ready for internal review
0.11	21/02/2023	ECL, SIM	First review finalized; Updates implemented after the first review
0.12	27/02/2023	SU, EMOT, FHW, NOVO, SIM	Second review finalized; Updates implemented after the second review
1.0	28/02/2023	SIM, ATOS	Quality check & final version submission

Quality Control		
Role	**Who (Partner short name)**	**Approval Date**
Deliverable leader	Andreea Paunescu (SIM)	27/02/2023
Quality manager	Rosana Valle (ATOS)	28/02/2023
Project Coordinator	Enric Pages (ATOS)	28/02/2023
Technical Manager	Harry Skianis (SYN)	28/02/2023

Table of Contents

List of Tables

List of Figures

List of Acronyms

Abbreviation / acronym	Description
AGV	Automated Guided Vehicle
E2E	End-to-End
ADAS	Advanced Driver Assistance System
AI	Artificial Intelligence
AIoT	Artificial Intelligence of Things
API	Application Programming Interface
AR	Augmented Reality
AV	Audio-visual
CCTV	Closed-Circuit Television
CDN	Content Delivery Network
CF-DRL	Cybersecure Federated Deep Reinforcement Learning
CMDT	Cybersecure Microservices' Digital Twin
Cobot	Collaborative Robot
COBOT	Collaborative Robot
CPO	Charging Point Operator
CPU	Central Processing Unit
DR	Demand Response
DSO	Distribution System Operator
Dx.y	Deliverable number y belonging to WP x
EC	European Commission
EV	Electric Vehicle
FL	Federated Learning
FR	Functional Requirement
GDPR	General Data Protection Regulation
GPS	Global Positioning System
GPU	Graphical Processing Unit
HD	High Definition
IoT	Internet of Things
KPI	key performance indicator
LL	Living Lab
LV	Low Voltage
MEC	Multi-access Edge Computing
ML	Machine Learning
MLOps	Machine Learnning Operations
mNCC	Federated meta Network Cluster Controller
MOCA	Monetization and Consensus-based Accountability
MOS	Mean Opinion Score
MoSCoW	Must Have; Should Have; Could Have; Won't Have
MPE	Media Production Engine

Abbreviation / acronym	Description
MV	Medium Voltage
NFR	Non-Functional Requirement
NFVI	Network Function Virtualization Infrastructure
OS	Operating System
PRESS	Privacy, data Protection, Ethics, Security & Societal
PTP	Peer-to-peer
QoE	Quality of Experience
QoS	Quality of Service
QR	Quick Response
RAM	Random-Access Memory
RES	Renewable Energy Sources
RFID	Radio Frequency Identification
RTT	Round-Trip Time
SDK	software development kit
SEE	Micro-services Secure Execution Environment
SLA	Service Level Agreement
SLO	Service Level Objective
SMD	Surface Mount Device
SSD	Solid-state drive
TL	Transfer Learning
TSN	Time Sensitive Networking
UC	Use Case
UCD	User-Centred Design
VNF	Virtual Network Function
VR	Virtual Reality
WP	Work Package
DoA	Description of Action
CPO	Charging Point Operator

Executive Summary

The current deliverable is the first report of WP1 activities, corresponding to task *T1.1 - Requirements analysis, use case refinement and target KPIs*, dedicated to the analysis and design stage of implementing the NEMO solution.

The document presents the joint work of the NEMO Consortium regarding the definition of use cases, requirements analysis of the NEMO meta-Architecture and definition of the relevant target Key Performance Indicators (KPIs) for the Pilots within the project.

The document serves as a basis for a common vocabulary and understanding of the NEMO technologies, tools and services in this stage of the project implementation, taking into consideration the needs and requirements of the Pilots.

Within the deliverable, a unitary approach is proposed to describe and monitor the specific activities of the Pilots, based on uniform templates for gathering relevant information about: i) Pilot description, ii) Use Cases description, iii) Use Case target KPIs, iv) Use Case Functional requirements and v) Use Case Non-Functional requirements.

Moreover, the deliverable addresses GDPR/Ethical compliance of the NEMO project, which presents relevant information about ethics and privacy rights, data management plan, protection of personal data and NEMO ethical guidelines, as elaborated in task *T1.3 - Benchmarking definition and GDPR/Ethical compliance*.

1 Introduction

1.1 Purpose of the document

The current deliverable addresses the requirements of *Task 1.1 - Requirements analysis, use case refinement and target KPIs*, which presents the most relevant aspects concerning the business analysis stage of the project, materialized by gathering detailed information about Pilots, defining Use Cases, Functional Requirements and Non Functional Requirements and establishing the KPIs specific to each Use Case.

The deliverable describes the methodological approach specific to this stage of analysis and the particular activities to fulfil the objectives of the task, namely:

- Refine the use cases specific to Pilots, describe the scenarios, capture the real needs and demands of end-users and specify the relevant target technological KPIs for each use case
- Requirements analysis of the NEMO meta-Architecture

The deliverable is drafted in such a way as to ensure a unitary vision of the Pilots and their particularities, from theoretical, methodological, technical and practical perspectives, highlighting also the innovation elements. Relevant aspects regarding the GDPR/Ethical compliance and Data Management Plan are also addressed within the document.

1.2 Relation to other project work

The specific work presented in Task 1.1 is correlated with the activities from all WPs dedicated to the definition and implementation of the NEMO solution: WP2, WP3, WP4 and WP5. The relevant technical aspects and outcomes of this stage of analysis will be considered when drafting the deliverables D1.2 and D1.3 from WP1.

Moreover, taking into consideration the specificity of the business field and the prospects for innovation and exploitation of the project results, the analysis approach is also connected with the activities of WP6.

1.3 Structure of the document

This document is structured in 7 major chapters:

Chapter 1. Introduction: Presents a summary regarding the scope of the deliverable, its structure and relation to other tasks and deliverables.

Chapter 2. Methodological approach: Presents significant aspects about the methodology applied in this stage of analysis.

Chapter 3. Pilots' description and monitoring: Proposes a unitary approach to describe and monitor the Pilots, based on specific design templates to easily follow / track the status of deployment in each Pilot.

Chapter 4. Use cases description and refinement: Presents the specific use cases and the appropriate scenarios for each Pilot. A particular section is dedicated to mapping the existing technologies, based on the specifications from the DoA, with the requirements of each Pilot / Use Case.

Chapter 5. List of Functional and Non-functional requirements: Presents the list of functional and non-functional requirements of the NEMO solution, grouped in three major categories: technological, end-user requirement and operational.

Chapter 6. GDPR Compliance: Presents relevant information about GDPR, ethics and privacy rights, data management plan, protection of personal data and NEMO ethical guidelines, addressing the requirements of task T1.3.

Chapter 7. Conclusions: Presents the conclusions about the current stage of implementing the NEMO solution and further steps to follow during the deployment of the project.

2 Methodological approach

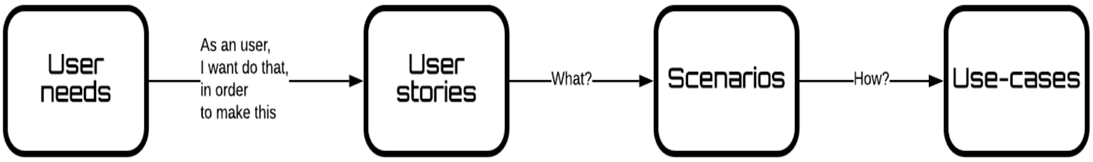
This section presents the relevant aspects concerning the methodological approach specific to the analysis stage of NEMO project, with the purpose to collect, structure, analyse and formalize information from each Pilot.

Within the project implementation, two acknowledged methodologies have been chosen to define the appropriate scenarios, use cases and requirements of NEMO solution - Agile methodology and User-Centred Design (UCD) methodology.

Usually, software development projects include four stages of implementation that are needed to deliver a functional IT system: i) analysis (requirements engineering), design (software engineering), development and testing. During the implementation of the NEMO solution, the Agile methodology will be applied like an iterative and incremental model.

In order to capture the end-users' perspective and involve them in the implementation process, the User-Centred Design (UCD) approach was chosen. The User-Centred Design methodology is applied for gathering reflections on the problems to be solved, user's goals and the real context.

From the user's goals which are formalized through user stories, the analysts should identify the user profiles, define the scenarios and then generate the use cases.



Being a user-driven approach, the UCD methodology presumes the involvement of users from the beginning and in all phases of the solution development in an iterative manner.

Within the analysis stage, the user stories reflect the real needs and requirements of the end-users. The next step in formalizing the user needs is the scenario, a narrative which reflects a real-world example of how one or more people / actors interact with a system. The scenario might describe the steps, events and/or specific actions which occur during this interaction. A use case is a formal presentation of a scenario.

In this particular stage of requirements analysis, a uniform approach for describing and monitoring the Pilots is proposed, based on specific templates designed for gathering relevant information.

Thus, the pilot description includes the following sections:

- Location
- Objective
- Scenarios
- Use cases (short presentation including a brief description of infrastructure and a graphical representation)
- Proposed innovation.

This specific template was submitted to the Pilots and the outcomes are presented in *Chapter 3 - Pilots description and monitoring*.
We have collected, structured and analysed relevant information from each Pilot, by applying a uniform approach based on:

- Use Case Scenarios
- Use Case Requirements
- Use Case KPIs.

Moreover, we have chosen for the proposed use cases corresponding to each Pilot an appropriate template for better representing the features and findings, comprising the following sections:

- ID
- Goal(s)
- Narrative
- Risk / Challenges / Assumptions
- Actors
- Storyline / Features
- Preconditions
- Postconditions
- Trigger events.

This specific template was filled in by the Pilots and the outcomes are presented in *Chapter 4 - Use cases description and refinement*.

The use case functional and non-functional requirements were defined by each Pilot and then centralized in *Chapter 5- List of Functional and Non-functional requirements.* Chapter 5 also describes the methodological approach specific to defining the requirements and prioritizing their development during the project implementation.

3 Pilots' description and monitoring

This chapter presents in a unitary approach a detailed description of the NEMO Pilots, comprising different sections for *context*, corresponding *use cases, scenarios with graphical representation of layers / flows and major component*s of the solution to be implemented, specific *characteristics* and proposed *innovation*.

3.1 Pilot 1, Greece – Smart Farming

3.1.1 Pilot overall description

The Smart Farming pilot activities will be conducted in Agia Sofia estate, which is an organic olive farm located on an untouched, east-facing slope over the Myrtoan Sea. It hosts 2000 olive trees in a grove of 200ha. The Agia Sofia estate is committed to producing high-quality, organic olive oil using sustainable and environmentally friendly methods. The estate's location, soil, and climate are ideal for olive cultivation and the use of the local "Athinoelia" variety and state-of-the-art milling process ensures that the oil produced is of exceptional quality.

Context

Olive fruit fly (scientific name "Bactrocera oleae" or "Dacus oleae (Gmelin)") is the most serious insect pest of olive fruits. It affects the olive tree cultivation causing serious qualitative and quantitative consequences with economic impacts and monetary losses [1]. In the last years, the lack of the usual heat waves that hit Greece every summer combined with the unnaturally high levels of rain, enabled the olive fly to reproduce and threaten the forthcoming production [2]. One of the main techniques to limit the spreading of this pest is by spraying with orthophosphate insecticides [3]. However, extensive use of insecticide, especially if spraying is performed in bulk (by planes or spraying the whole tree), can lead to increased robustness of the olive fly [4]. To this end, smart farmers need to use as less insecticide as possible to control the population of olives flies and boost crop harvesting performance. In such a direction, precision spraying is an alternative solution which can achieve a balance through collaborative intelligent systems. Moreover, with modern techniques such as machine learning, this approach can be also made autonomous, leading to significant cost savings and increased crop performance. In this manner, this Pilot will combine many intelligent components within an olive grove to automate the process of precision insecticide spraying suitable for olive fly containment, while ensuring low energy footprint. More specifically, drones and ground robots, enhanced by information from Synelixis' SynField nodes [5], will execute precision spraying of olive trees and weeds respectively.

Description of the Pilot

Location	**Greece**
Objective	The objective of the pilot is to support organic olives harvesting, facilitating and automating olive fly detection and precision spraying processes by terrestrial and aerial means, employing novel technologies to support such operations while ensuring low environmental footprint.
Scenarios	• Scenario 1 (corresponding to Use Case SF_01): Aerial precision bio-spraying of olive trees with drone. • Scenario 2 (corresponding to Use Case SF_02): Terrestrial Precision Bio-Spraying of weeds under the olive trees.

<table>
<tr><th>Location</th><th>Greece</th></tr>
<tr><td>**Use cases**</td><td>

- SF_01 – **Aerial Precision Bio-Spraying**

This use case will combine micro-clima data collected via Synelixis SynField®[1] IoT nodes and real-time video analysis of olive groves from visual and multi-spectral cameras attached on semi-autonomous drones to identify in real-time where bio- spraying is needed.

The bio-spraying decision will be based on ML models, which will run on the end devices (drones), while increased model performance and increased energy efficiency will be investigated during the training process through Cybersecure Federated Deep Reinforcement Learning (CF-DRL) and flexible deployment of the training jobs across the IoT, edge and cloud resources available.

The infrastructure components involved in the first use case "SF_01" include:

- Edge server, primarily accommodating data persistence and operations at the edge, such as data persistence, Machine Learning (ML) training, etc.
- Agricultural drone (for short 'Agri drone'), acting as IoT nodes responsible for on-device detection of olive tree infections and aerial spraying
- SynField devices, acting as IoT nodes, collecting sensor measurements about the environmental, crop and soil conditions
- Cloud server, primarily hosting heavy operations or server-side components.

It has to be noted that in the context of NEMO, the use case will investigate flexible deployment scenarios for the involved technologies, allowing to meet different objectives, such as cost reduction, energy efficiency and green energy usage.

The foreseen infrastructure topology is depicted in Figure 1.

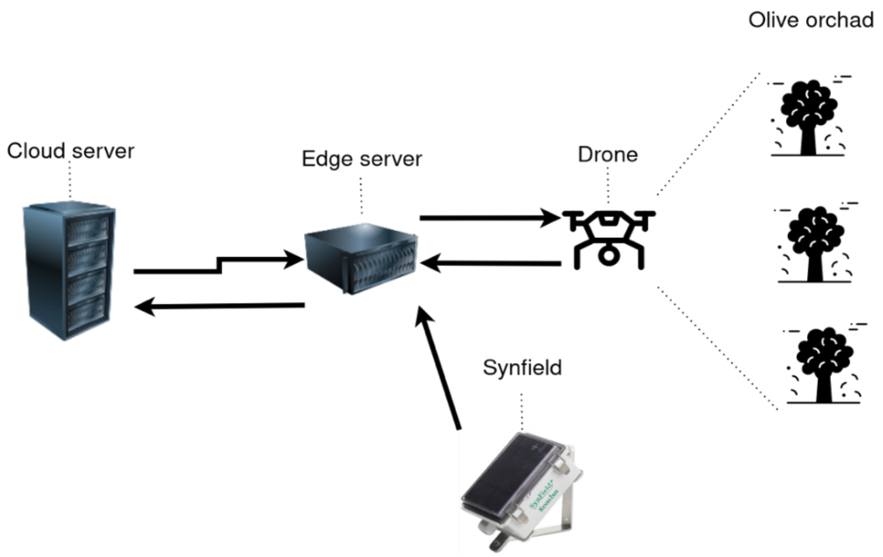


Figure 1: Infrastructure topology of SF_01

</td></tr>
</table>

[1] SynField nodes are the hardware (IoT) devices of Synelixis' SynField Smart Agriculture platform: https://www.synfield.gr

<table>
<tr><th>Location</th><th>Greece</th></tr>
<tr><td></td><td>

- SF_02 – Terrestrial precision Bio-spraying

In this use case semi-autonomous robots equipped with cameras will be used to locate weeds and enable optimal precision spraying with organic insecticide, a process that is done manually so far. The robots' will move autonomously in the olive grove and will perform spraying at the spots in which weeds will be detected. The use case relies on ML models running on the robot for the detection of the weeds, as well as the autonomous movement, which includes object detection for potential obstacles (e.g. trees) and humans present in the grove.

The infrastructure of this use case is similar to the SF_01 and involves:

  - Edge server, primarily hosting data persistence and local ML model training
  - Agri robot, as an IoT device mainly responsible for terrestrial spraying, but able to execute services with low resource requirements
  - SynField device, as an IoT device, able to collect sensor readings and communicate them to some edge or cloud server
  - Cloud server, providing the most powerful node in the Living Lab (LL) setup and able to host services with highly diverse resource requirements.

The foreseen topology is depicted in Figure 2.

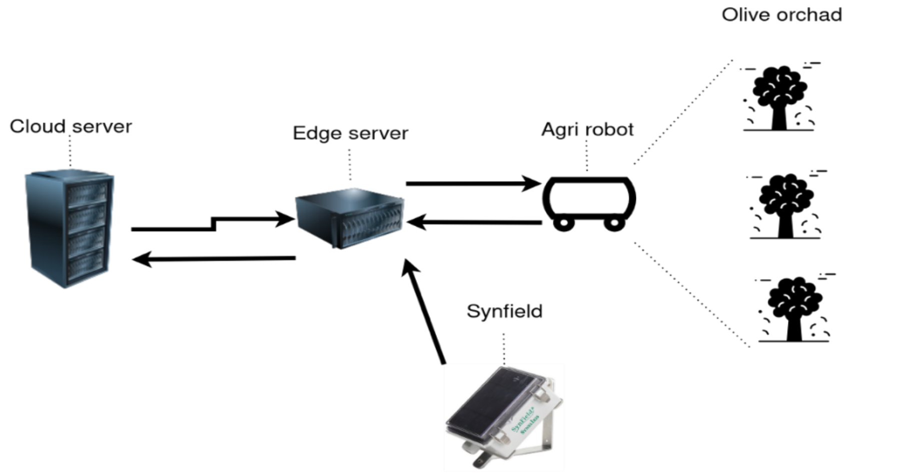


Figure 2: Infrastructure topology of SF_02

</td></tr>
</table>

Location	Greece
Proposed innovation	The implementation of the aforementioned use cases introduces innovations in the Smart Farming domain, through a number of software and hardware components coherently communicating and collaborating towards effectively addressing of olive trees' infections by fruit flies. More specifically the proposed innovations include: • Enhancement of precision bio-spraying with advanced multimodal machine learning models, which will lead to cost benefits for the farmer by both increased and high-quality production and less use of insecticides. • Enforcement of safety within a field with the enhancement and adoption of state-of-the-art object detection models for the Smart Farming terrestrial bio-spraying case. • Increased energy efficiency through the use of innovative algorithms properly adapting training and inference parameters, such as maximum GPU operational watts, as well as through flexible deployment of services supporting the Smart Farming cases across the IoT-edge-cloud continuum, optimizing the use of available resources. • Reduction of network overhead (consequently energy, CO_2 emissions) by moving operations closer to the edge. Choice of the operational component will be done intelligently and dynamically. • Effective support of open collaboration and innovation by making an extensive set of datasets (micro-clima, visual and multi-spectral images/video, irrigation and biospraying schema) available via the European Open Science Cloud (EOSC)

Table 1: Greece - Smart Farming

3.2 Pilot 2, Italy – Smart Energy & Smart Mobility

3.2.1 Pilot overall description

The Terni pilot will utilize 4 Medium/Low Voltage substations, a 200 kW photovoltaic local generation plant, which often has an electricity surplus, generated from fluctuating Renewable Energy Sources (RES) and 65 smart Electric Vehicle (EV) chargers. In the electricity distribution network, ASM owns more than 10 Power Quality Analyser and two PMUs, which act as synchro phasor gathering data from primary substations and secondary substations. In addition, about 100 near real-time Smart Meters will provide data for particular points of delivery of the distribution network. Moreover, a fleet of six leased EVs offered by EMOT will be part of the pilot infrastructure together with at least 3 additional smart EV chargers.

Context

ASM Terni and EMOT, supported by ENG and TSG will realise driver-friendly scenarios for smart city mobility and dispatchable charging of EVs based on RES demand-response along with human-centred smart micro-contracts and micro-payments.
The trial aims to reduce the impact on the distribution network from RES that cause voltage fluctuations. Within NEMO, ASM will utilise innovative high tech power sensors, which realise advanced protection for Medium Voltage/Low Voltage (MV/LV) substation breakers and smart meters in RES, buildings and offices to measure and balance electricity generation/consumption.

Description of the Pilot

<table>
<tr><th>Location</th><th>Italy</th></tr>
<tr><td>Objective</td><td>

Monitoring the electricity smart grid under NEMO framework to ensure the stability.
Improving RES load balancing via EV chargers
Implementing smart parking in the living lab using the traffic flow data.

</td></tr>
<tr><td>Scenarios</td><td>

Scenario 1 (corresponding to Use Case SE_01): Optimizing the grid operations by analysing voltage fluctuations.
Scenario 2 (corresponding to Use Case SE_02): Improving Renewable Energy Sources (RES) load balancing via EV chargers. Supporting citizens eco-mobility in a smart city using the historical data available.

</td></tr>
<tr><td>Use cases</td><td>
SE_01 – Smart Grid Flexibility
Infrastructure:

5 Power Quality Analyzers
RES units (180kW & 60kW PV array)
Smart Meters

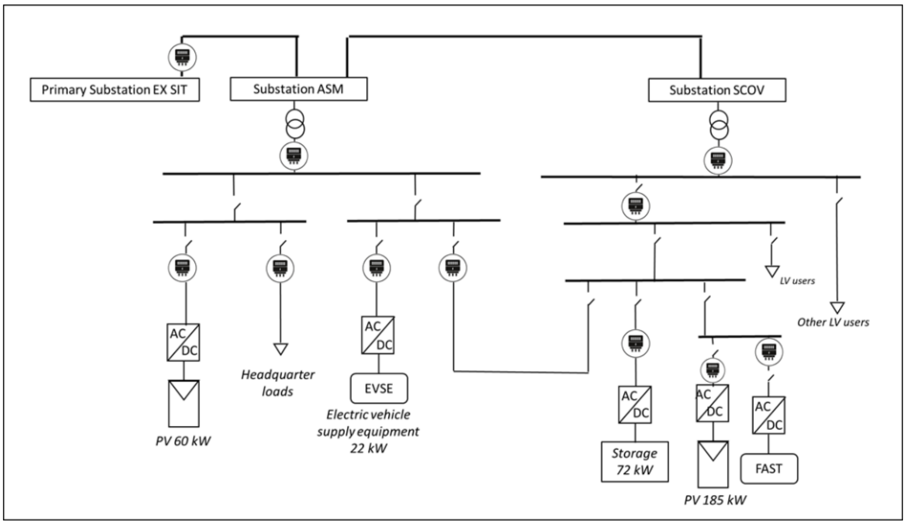


Figure 3: SE_01 – Smart Grid Flexibility
SE_02 – Smart Mobility/City
Infrastructure:

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

</td></tr>
</table>

<table>
<tr><th>Location</th><th>Italy</th></tr>
<tr><td></td><td>

Figure 4: SE_01 – Smart Grid Flexibility</td></tr>
<tr><td>Proposed innovation</td><td>
Deal with Time Sensitive Networking (TSN) and several thousand of nodes using the Cybersecure Microservices' Digital Twin (CMDT) concept.
Validate Twin Green Clouds infrastructure for micro-services migration in Italy and in Germany
Advanced Cybersecure Federated Deep Reinforcement Learning (CF-DRL) analytics to create models and provide alarms, along with traffic and parking prediction.
Validate NEMO user acceptance from a citizen viewpoint by utilizing the NOVO smart city platform in Terni
</td></tr>
</table>

Table 2: Italy - Smart Energy & Smart Mobility

3.3 Pilot 3, Germany – Smart Manufacturing & Industry 4.0

3.3.1 Pilot overall description

The leadplant of CONTI for advanced driver assistance systems (BU ADAS) is located in Ingolstadt, Germany. The plant has a high level of automation in production and logistics as well as high specialization in cobots and AGVs. Innovative manufacturing processes are set up in Ingolstadt for the first time and upon successful verification are transferred to the other ADAS sites.

Context

Robotics in general and particularly Cobots have a strong impact within highly automated production facilities. As market demands transformation and demographic change induce new challenges on mass production, CONTI, the responsible of Trial 4 dedicated to Smart Manufacturing & Industry 4.0, has already undergone feasibility and profitability assessment for the application of flexible Cobots in upcoming assembly facilities. In parallel, CONTI investigates Cobots and Automated Guided Vehicle (AGVs) with respect to the strict requirements of electronic production and has gained deep insight into industrial needs and problem settings.

Working with the specific solution Standard Automated Replenishment Application (SARA) in the production flow of the Pilot is depicted in Figure 5. The figure illustrates the way of communication between the components of the solution within the factory, to understand the place where NEMO intervenes in the complete automation of manufacturing flows.

Figure 5: SARA - Standard Automated Replenishment Application in the production flow

Description of the Pilot

Location	**Germany**
Objective	• More efficient use of employees and improved ergonomics • More flexible material removal • Better just in time delivery (no longer clocked in 30 min.) • Expansion to include backend production (till date only front end)
Scenarios	• Scenario 1 (corresponding to Use Case SM_01): Fully automated indoor logistics/supply chain. • Scenario 2 (corresponding to Use Case SM_02): Human-centred indoor factory environment safety.
Use cases	• SM_01 – ***Fully automated indoor logistics/supply chain*** This use case targets ADAS manufacturing. Currently, handling and transport of material (SMD-Components) from Auto Store to production sites is performed manually every 30 minutes. By utilizing a 3D-Vision-Camera for Bin Picking Application, integrated Barcode Scanner and collaboration between different robot systems (one Cobot and several types of AGVs), we aim to fully automate the controlled material picking from Auto Store and autonomous transfer to the production line.

Location	Germany

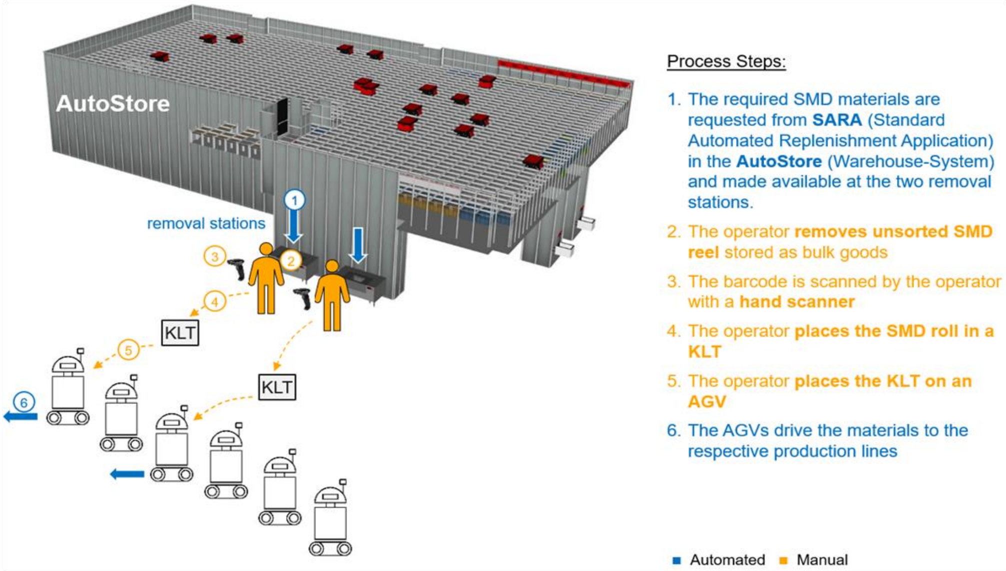


Figure 6: Flow of operation and components - Current situation

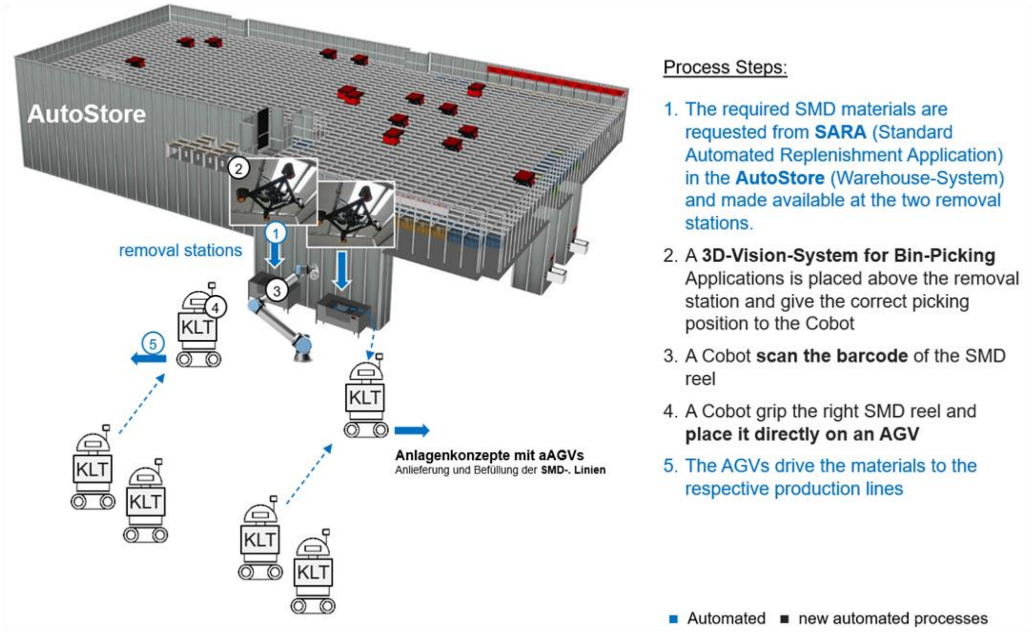


Figure 7: Flow of operation and components - Future state

- SM_02 – ***Human-centred indoor factory environment safety***

This use case will provide a high precision AGV localization layer merging real time localizations info obtained from cognitive sensors (safety cameras, radar and Lidar).

A high speed and ultra-low latency (TSN) private wireless network will support massive data uploads to the edge cloud facilities, where Artificial Intelligence (AI) functions will detect the position of each body and build a "safety shell" around it to ensure human-

Location	Germany
	centred safety, while federated CF-DRL will enable model transfer learning to the AGVs to enable autonomous avoidance of potential collision between AGVs, or between a worker and an AGV.
Proposed innovation	• Combine 3D Vision, heterogeneous networks, edge (remote) and semi-autonomous (on-device) CF-DRL/ Transfer Learning, enabling fully automated SMD-Components recognition and transfer to production site. • Improved collision protection for employees in highly automated production areas and enable closer cooperation between people and machines. • Digital power-train optimization (production, process, asset and energy) in brown field factories • Improvement of mass production in factories with a high degree of automation • Validate NEMO user acceptance from an industry employee viewpoint by validating efficiency and productivity

Table 3: Germany - Smart Manufacturing & Industry 4.0

3.4 Pilot 4, Greece – Smart Media & XR

3.4.1 Pilot overall description

The pilot will implement two use cases that will test the boundaries of live media capture and user involvement as well as enhance the VR experiences using sensorial stimuli and bio data. The first use case is about how to enhance live race events and enhance the visitor and broadcasting, viewing experience. The second use case has two parts one is about enhancing a VR HMD experience with bio data and the second part is about enhancing a VR Dome theatre show with sensorial data such a gesture and voice recognition and provide a general framework to which various sensorial effects can be subscribed.

Context

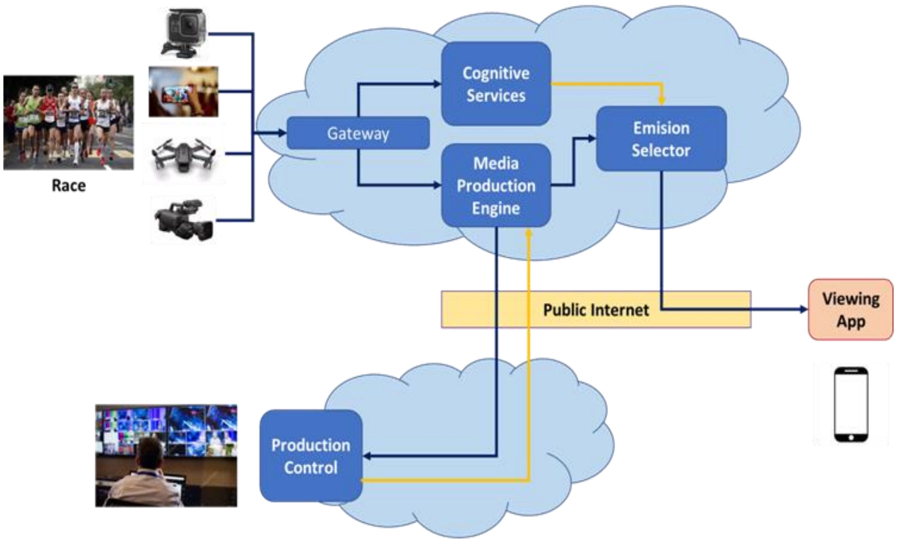
Within the Pilot dedicated to Smart Media & XR, the NEMO framework will be applied in two use cases:

- The round of Athens case - Test boundaries of live media capture and user involvement
- The XR time machine case - Test boundaries of enhancing an experience using sensorial stimuli and biodata.

These developments will be used for enhancing the VR HMD and Dome Show experience described above, with the following benefits:

- Low cost / high quality multi-user experience
- Change how people perceive culture
- Streamline operation
- Use the power of IoT and edge computing for XR Educational Applications

Description of the Pilot

Location	**Greece**
Objective	Investigate advanced networking and data processing through NEMO capabilities, such as: • At AIoT level, through AV and image analysis using ML techniques, calculate location of a user and multi-users' relevant movement to personalize the view/sound. • Speech / gesture recognition. • At the edge cloud level, for automated processing and rendering of virtual and augmented objects. • At cloud level to enable true shared experience even with remotely located users.
Scenarios	• Scenario 1, corresponding to Smart Media/ City Use Case SC_01 • Scenario 2, corresponding to Extended Reality (XR) Use Cases: o XR_01 - VR Experience about ancient Workshop of sculptor Phidias o XR_02 - Enhance AV experience in the Tholos Dome Virtual Reality (VR) Theatre
Use cases	• SC_01 – ***Smart Media / City***  Figure 8: SC_01 – Smart Media / City topology Media content is captured by runners and spectators along the running circuit of Run of Athens, using smartphones/tablets and GoPro cameras, a few professional and drone cameras. The audience has the option to improve their contributions and can interact with contributors in case of specific race incidents. It is expected to enhance the live sport event spectating experience by enriching the content through AI driven data and content analysis.

Location	Greece

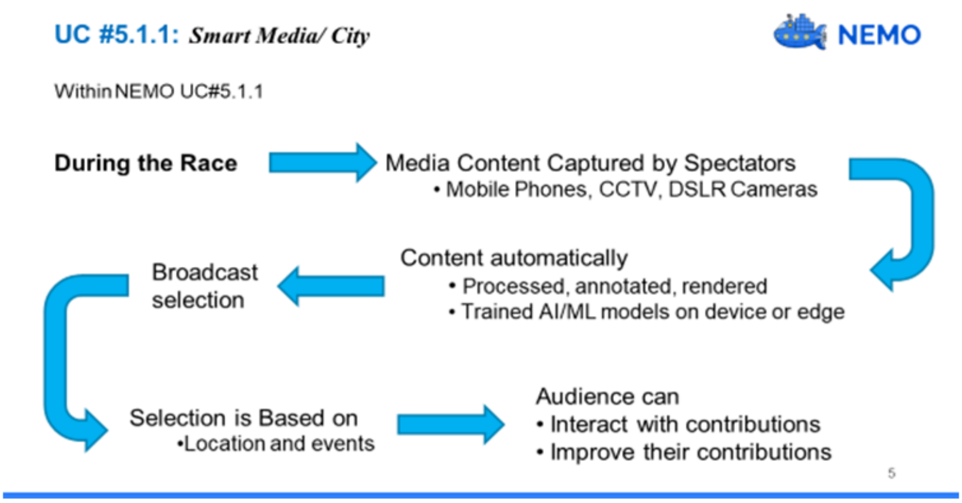


Figure 9: SC_01: Smart Media/City infrastructure and flow processes

- ***XR Use Cases***

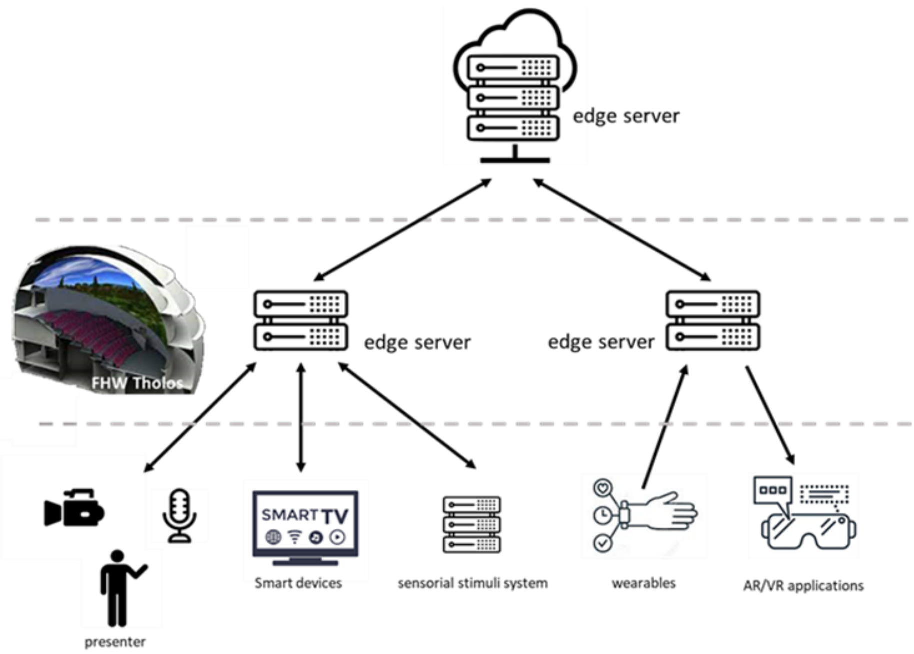


Figure 10: XR Use Cases

XR_01: *VR Experience about ancient Workshop of sculptor Phidias*

- Learn and participate in actions and activities of ancient workshop
- Usage of heterogeneous IoT devices (Wearables, AR/VR headsets etc.)
- Collect/Analyse biometric data during experience
- Estimate emotional/physical status and alter experience
- ML algorithms trained and executed in IoT-Edge to Cloud Continuum
- VR/AR application receives status and adapts the experience.

Location	Greece
	XR_02: *Enhance AV experience in the Tholos Dome VR Theatre* • Analyse speech and position of museum-educator presenter • Voice and Gesture based recognition based on ML in IoT-to-Edge-to-Cloud continuum • Trigger events in real time that are going to be consumed by multi-sensorial stimuli systems, AR/VR glasses, wearables, and smart displays outside the Tholos • Create framework for supporting multi-sensorial stimuli (wind, heat, etc.) and actions based on external devices.
Proposed innovation	• Changing the way to perceive culture by people • Using AI technologies and algorithms for spectating experience and analyse the participants behaviour • Use the power of IoT and Edge for XR Educational Applications

Table 4: Greece - Smart Media & XR

4 Use cases description and refinement

This chapter presents in a common approach a detailed description of the Use Cases specific to Pilots, comprising different sections for *goals*, *narrative*, *risks/ challenges/ assumptions*, *actors*, *storyline/ features*, *preconditions*, *postconditions*, *trigger events*, *use cases target KPIs*, *use cases functional requirements* and *use cases non-functional requirements*.

A Use Case is a description of those ways an end-user wants to 'use' a system. Thus, the use case specifies how the user and system can interact to achieve the goals defined in the use case scenarios. The first version of the 9 proposed use cases (two per each Pilot) was presented in DoA.

This chapter presents an updated and refined version of the use cases from DoA, using a uniform template for organizing information, based on the scenarios described by the Pilots in the previous chapter. As presented herein-before in Chapter 2, a scenario reflects a real-world example of how one or more actors interact with a system. It might describe the steps of a flow / process, events and/or actions which occur during the interaction. A Use case is considered a formal presentation of a scenario.

4.1 Pilot Smart Farming

4.1.1 Use Case 1: Aerial Precision Bio-Spraying

4.1.1.1 Use Case description

USE CASE:	**Aerial Precision Bio-Spraying**
ID	SF_01
Goal(s)	Protect the olive trees from olive fruit fly through aerial spraying. Optimize the use of bio-spraying, without compromising organic certification.
Narrative	It is a hot and wet day in Smart Farm. Conditions are such that the possibility to have a fruit fly is high. Unfortunately, the farmer is committed to other tasks and cannot perform manual spraying on time. No worries, their drones will be guided by the NEMO ecosystem to perform spraying automatically. Initially, it performs on-device inference, but later it is considered more beneficial from a resource usage perspective to run this service at the edge. Another day the weather is cloudy, but new datasets have been collected for training; anyway, training will be shifted in time when the weather will be sunny and thus the training device may use grid's solar power. Indeed, the exact device which will run the operations, will be defined by NEMO, complying with the agreed Service Level Agreements (SLAs).
Risk / Challenges / Assumptions	Inaccurate predictions could be derived because of limited training data or ML/FL restrictions. Inaccurate predictions may lead to the risk of suboptimal spraying. This risk is planned to be minimized by leveraging on existing datasets available for Living Lab experimentation, to the extent possible. Alternatively, publicly available datasets will be used. Moreover, NEMO will be based on state-of-art solutions to support the highest possible classification accuracy, extending the background work of partners.
Actors	Smart Farmer
Storyline / Features	Based on the information provided by the platform, the smart farmer may decide to apply the automated smart spraying or manual spraying. The drone may fly autonomously over the grove, capturing images of the trees and predicting infections in real time, based on ML classification models. Upon weeds' detection, drones may automatically spray in that location.

USE CASE:	Aerial Precision Bio-Spraying
	The platform may decide to postpone a training session due to lower CO_2 emissions foreseen in the future. The platform may suggest to move training operations (or some other heavy tasks) to devices more likely to be renewably powered. The smart farmer can access information regarding the autonomous spraying procedure. The smart farmer may initiate a new ML training session, possibly in a collaborative way among federated training nodes. The system natively supports flexible allocation of data and workloads considering the Smart Farmers' requirements. The Smart Farmer may configure its preference towards the goals to be met during the allocation of resources. Indicatively, these may relate to reduced costs or green energy usage.
Preconditions	NEMO is deployed and operational. Data are collected via SynField sensors and drone cameras. Weather and plant measurements and plant images have been acquired and provided to the AI modules of NEMO. The Smart Farmer is signed in the NEMO "Aerial precision Bio-spraying" app. IoT devices installed/removed from the Smart Farm.
Postconditions	Smart farming operations can be automatically applied. The Smart Farmer is provided with the capability to monitor or control their Smart Farming operations remotely.
Trigger events	The Smart Farmer triggers aerial bio-spraying operations via the graphical user interface of the Aerial precision bio-spraying application or set rules are satisfied based on monitored metrics.

4.1.1.2 Use Case Target KPIs

KPI ID	Name	Description	Measurement / Assessment method	Target
KPI_SF_01_1	Aerial bio-spraying improvement	Reduction in insecticides used for aerial spraying compared to the bulk case	Log analysis and calculation	20%
KPI_SF_01_2	Production improvement	Increase in quantity of fruits harvested compared to the fruits harvested regarding manual spraying case	Log analysis and calculation	>/=15%*
KPI_SF_01_3	Sensor compatibility	Number of sensors tested for connectivity with NEMO Smart Agriculture app	Log Analysis	>9

*Production improvement is aimed to reach 15% by both use cases GRSF_01 and GRSF_02

4.1.1.3 Use Case Functional requirements

FR ID	Description	MoSCoW
SF_01_FR01	The platform must provide access to measurements.	M
SF_01_FR02	The platform must provide options to manage/view sensors/devices.	M
SF_01_FR03	The platform must provide options to manage users.	M
SF_01_FR04	The platform should support ML/FL training and ML model sharing/serving.	M
SF_01_FR05	The platform should provide ML classification accuracy probability.	S
SF_01_FR06	The platform should support automated aerial spraying.	S
SF_01_FR07	The platform should support monitoring of SLOs, e.g. related to energy consumption or CO2 emissions.	S
SF_01_FR08	The platform must respect data sovereignty and privacy requirements.	M
SF_01_FR09	The platform must support collection of monitoring data, such as the weather and plant conditions.	M
SF_01_FR010	The platform must support retrieving photos via drones.	M
SF_01_FR011	The monitoring devices must support network connectivity.	M
SF_01_FR012	The monitoring devices must be able to communicate data to and receive control commands from the NEMO platform.	M
SF_01_FR013	The platform should be able to perform alternative scheduling or geographical distribution of smart farming services based on user goals.	S
SF_01_FR014	The Smart Farmer should be able to define strategies for the use of available resources.	S

4.1.1.4 Use Case Non Functional requirements

NFR ID	Description	MoSCoW
SF_01_NFR01	The NEMO platform must respect security and privacy requirements.	M
SF_01_NFR02	NEMO should support High Availability features.	S
SF_01_NFR03	The Smart Agriculture Application of NEMO should be vendor-independent	S
SF_01_NFR04	The NEMO platform should be scalable in the sense of providing additional resources when computationally heavy tasks are initiated.	S

4.1.2 Use Case 2: Terrestrial Precision Bio-Spraying

4.1.2.1 Use Case description

USE CASE: Terrestrial precision Bio-spraying	
ID	SF_02
Goal(s)	• Semiautonomous robots equipped with cameras will be used to locate weeds and enable optimal precision spraying with organic insecticide (pyrethrin). • Using NEMO CF-DRL, the robots will be able to move, while avoiding workers (safety) and trees (operating reasons).
Narrative	Within an olive grove, weeds are often seen near the roots of the olive trees since irrigation is performed close to them. These weeds often attract olive flies which hare a threat to olive trees. The smart farmer is equipped with agri robots and SynField nodes, which are used to predict or detect infections and be able to control olive fly population by spraying in areas of interest while avoiding any collision with trees and humans. The procedure is autonomous and can be scheduled and customized in a way that it exploits available resources both for data persistence, model training and inference, while respecting the Smart Farmer's requirements expressed as SLAs.
Risk / Challenges / Assumptions	Incorrect calculation of the workers' location or failed recognition may result in injuries and general disruptions. Two assumptions are made (i) that the workers' location and activity information is always available and (ii) the classification algorithm of crops will work with optimal accuracy.
Actors	Smart Farmer
Storyline / Features	Based on the data collected by the smart field devices, the smart farmer may initiate robots' operation in selected groves. The robots may move autonomously in the grove, capturing images of the trees close to the root and detecting weeds in real time, based on ML classification models. Upon weeds' detection, robots may automatically spray in that location. The mobile robot moves autonomously within the field, avoiding obstacles such as human workers and trees. The safe movement of the robots relies on ML model for object detection supporting collision avoidance towards trees and humans. The smart farmer can access information regarding the autonomous spraying procedure. The smart farmer may initiate a new training session, possibly in a collaborative way among federated training nodes. The system natively supports flexible allocation of data and workloads considering the Smart Farmers' requirements. The Smart Farmer may configure its preference towards the goals to be met during the allocation of resources. Indicatively, these may relate to reduced costs or green energy usage.
Preconditions	NEMO is deployed and operational. Data are collected via mobile robots and SynField devices connected to the NEMO platform. Mobile robots and sensing devices are compatible with NEMO specifications. The Smart Farmer is signed in the NEMO "Terrestrial Precision Bio-Spraying" app.

USE CASE:	Terrestrial precision Bio-spraying
	The Smart Farmer launches the graphical user interface of the Terrestrial Precision Bio- Spraying use case and manages terrestrial bio-spraying.
Postconditions	Location and activity data are available to the smart farmer. The smart farmer has the ability to remotely monitor or control Smart Farming operations.
Trigger events	The Smart Farmer launches the graphical user interface of the Terrestrial Precision Bio-Spraying use case and selects an activity related to terrestrial bio-spraying. When an obstacle is detected by the mobile robot, the mobile robot automatically changes its trajectory. When weeds are detected, the spraying activity is performed. When energy efficiency conditions are met, heavy computations can be transferred within the cloud-edge-IoT continuum or shifted in time.

4.1.2.2 Use Case Target KPIs

KPI ID	Name	Description	Measurement / Assessment method	Target
KPI_SF_02_1	Spraying outdoor localization precision	The spraying precision of the robot.	Log Analysis	<10 cm
KPI_SF_02_2	Production improvement	Increase in quantity of fruits harvested compared to the fruits harvested regarding manual spraying case.	Log Analysis, observation.	>/=15%**

**Production improvement is aimed to reach 15% by both use cases GRSF_01 and GRSF_02.

4.1.2.3 Use Case Functional requirements

FR ID	Description	MoSCoW
SF_02_FR01	Mobile robots must support autonomous operation.	M
SF_02_FR02	Mobile robots must be able to understand the weeds they should spray.	M
SF_02_FR03	Mobile robots must be able to follow a route or reach a destination.	M
SF_02_FR04	Mobile robots must support network connectivity, such as Wi-Fi or cellular.	M
SF_02_FR05	The platform must respect data sovereignty and integrity.	M
SF_02_FR06	The platform must provide access to collected data.	M
SF_02_FR07	The platform must provide access to the devices.	M

FR ID	Description	MoSCoW
SF_02_FR08	The platform must provide options to manage users.	M
SF_02_FR09	The platform must be able to calculate mobile robots routes in real-time.	M
SF_02_FR010	The platform must be able to identify and avoid obstacles such as humans and trees in real-time.	M
SF_02_FR011	Mobile robots must be able to provide data to and receive control commands from the NEMO platform.	M
SF_02_FR012	The Smart Farmer should be able to define strategies for the use of available resources.	S

4.1.2.4 Use Case Non Functional requirements

NFR ID	Description	MoSCoW
SF_02_NFR01	The NEMO platform must respect security and privacy requirements.	M
SF_02_NFR02	NEMO should support High Availability features.	S
SF_02_NFR03	NEMO should be flexible and scalable in the sense of exploiting available resources according to set goals.	S

4.1.3 Technological alignment to NEMO

The implementation of Smart Farming use cases relies on a set of functionalities provided by the NEMO ecosystem. Considering that NEMO provides a meta-OS for the IoT-Edge-Cloud continuum, the pilot needs to adopt and instantiate the NEMO meta-architecture, allowing integration and management of available resources by the NEMO ecosystem.

Moreover, the Smart Farming use cases rely on AI support at different levels. ML models are foreseen for detection of olive trees' infections, detection of weeds, as well as the detection of objects/obstacles which need to be avoided by Agri robots. The use cases are demanding in this regard, as inference needs to be provided in real-time, providing feedback to potential actuation, e.g., triggering spraying operations or trajectory changes. On the other hand, models' accuracy and performance need to be quite high, in order to avoid false actuation. To this end, collaborative training and advanced training methods will be exploited in order to exploit knowledge gained by collaborating peers, without sharing their data. These operations align to the functionality provided by NEMO's MLOps and CF-DRL.

A significant topic in supporting the use cases is the availability of resources (compute, network, storage). Realizing real-time inference services relies on fast and secure communications. The pilot may thus benefit from the creation and management of micro-slices to support fast and reliable communications between IoT devices, edge and cloud nodes involved in the pilot. In addition, the exploitation of available resources under diverse criteria (e.g., energy consumption, resource usage, cost, etc.) is mandatory for ensuring both the feasibility and sustainability of the defined use cases. In this regard, the NEMO functionalities towards policy/SLA management, as well as meta-orchestration of services across available nodes is also planned to be experimented in this pilot.

Last, but not least, the Smart Farming LL will support third party development and validation activities. Therefore, the exposure of NEMO-native functions through an SDK or API is relevant for the development of applications and services which may be validated in the LL.

The foreseen exploitation of NEMO developments within the Smart Farming trial is briefly presented in Table 5.

NEMO functionalities	Foreseen exploitation
AIoT Architecture	Instantiation in the LL
Cybersecure Microservices' Digital Twin (CMDT)	Microservices' discovery and profiling
MLOps via CF-DRL	ML model training Model sharing Model serving
Federated meta Network Cluster Controller (mNCC)	Micro-slices creation & management
Micro-services Secure Execution Environment (SEE)	Secure deployment and execution of microservices
PRESS, Safety & Policy enforcement framework	Controlled data sharing/management and definition of strategy for resource management
Cybersecurity & Digital Identity attestation	Advanced access control to devices and microservices
meta-Orchestrator	Flexible allocation of services across IoT, edge, cloud resources
Intent-based migration SDK (R11)	Development of smart farming services and applications

Table 5: NEMO technology alignment for the Smart Farming trial

4.2 Pilot Smart Energy & Smart Mobility

4.2.1 Use Case 1: Smart Grid Flexibility

4.2.1.1 Use Case description

USE CASE:	**Smart Grid Flexibility**
ID	SE_01
Goal(s)	• Improvement of the distribution grid operation and the power quality • Reducing impact on the grid due to voltage variations
Narrative	NEMO will investigate advanced AI/ML based analytics to identify potential local energy grid discrepancies and monitor power quality to provide timely alarms when the system is approaching unstable operational boundaries, which could lead to power failures. Also, this would be beneficial for balancing intermittent feed-in from Renewable Energy Sources.
Risk / Challenges / Assumptions	The risk would be the ability to detect faults with the help of new installed sensors. The challenge is improving grid observability with the use of new installed sensors.
Actors	• Distribution System Operator (DSO) • Prosumers

USE CASE: Smart Grid Flexibility	
	• Producer • RES unit
Storyline / Features	This use case is expected to implement a smart energy pilot by ASM, the Terni municipal electricity and gas distribution network operator. The trial will demonstrate the capability of smart grid asset performance management and optimize the grid operations by deploying NEMO solutions. The trial will be hosted in the real ASM Smart Grid Active Network in the region of Umbria. The pilot will include High tech power sensors, smart meters, photovoltaic cell controllers, energy customers (i.e. ASM offices).
Preconditions	• Grid Data availability • Accurate forecast information • Data collection should be in real time • NEMO is deployed and operational
Postconditions	• DSO is presented with a proper vision on the power quality of the grid based on real time measurements. • Maintaining the voltages within acceptable limits.
Trigger events	• Real-time evaluation of the parameters

4.2.1.2 Use Case Target KPIs

KPI ID	Name	Description	Measurement / Assessment method	Target
KPI_SE_01_1	Time granularity	Time granularity for monitoring	Measure the field data amount collected	< 1s
KPI_SE_01_2	Interaction capability	Information exchanged by devices	Evaluating the deployment of project solution in the whole distribution network. Measure the field data amount collected	> 100.000 measurements/minute
KPI_SE_01_3	Reduce the probability of Smart Grid failure	Reduce the probability of Smart Grid failure due to voltage instability at least	Evaluation of measured data leveraging data of the network	25 % reduction in comparison with daily average value
KPI_SE_01_4	Flexibility exploitation	Increase urban Electrical Vehicles charging efficiency	Evaluation of measured data leveraging data of the network	20 % in comparison with daily average value

4.2.1.3 Use Case Functional requirements

FR ID	Description	MoSCoW
SE_01_FR01	The platform has the capability to monitor the real-time data from the sensors deployed in the grid	M
SE_01_FR02	DSO must be able to forecast electricity production/consumption and estimate flexibility	M
SE_01_FR03	High-tech power sensors should be useful to elaborate on new strategies, in order to improve the power quality in a secure way	S
SE_01_FR04	Based on sampled data, phasors are calculated with high precision and the synchronization process must be very fast. Indeed, innovative reconfiguration and self-healing schemas should rely on appropriate measurements.	M

4.2.1.4 Use Case Non Functional requirements

NFR ID	Description	MoSCoW
SE_01_NFR01	Secure communication of sensitive data related to the infrastructure should be provided.	M
SE_01_NFR02	The 5G availability should allow achieving better performances in data transmission.	C

4.2.2 Use Case 2: Smart Mobility/City

4.2.2.1 Use Case description

USE CASE: Smart Mobility/City	
ID	SE_02
Goal(s)	• Improve Renewable Energy Sources (RES) load balancing via EV chargers • Predict traffic flow/parking prediction via EV chargers and parking positions • Support citizens eco-mobility in a smart city scenario combining crowd sourcing info and public transportation, weather/noise data, along with historical data and analysis of CCTV/traffic
Narrative	Currently the transition to renewable energy and electric mobility is proceeding in parallel, creating new opportunities and new obstacles: by increasing the number of electric vehicles, the amount of electricity that must be supplied increases and, therefore, a needed strengthening of power lines follows; moreover, this energy will progressively come from intermittent and non-programmable renewable energy plants, resulting in an energy balancing challenge. In this context, a cooperation mechanism between DSO (Distribution System Operator), CPO (Charging Point Operator) and EV (Electric Vehicle) users allows both a power lines improvement limitation and grid stability enhancement by coordinating EV charging.

USE CASE: Smart Mobility/City	
	DSO monitors the electricity grid and, thanks to an accurate forecasting system based on ML models, will be able to identify how, when and where to charge electric vehicles for grid balancing. CPO will then be able to offer advantageous charging price at DSO-selected charging stations, attracting more EV users.
Risk / 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 limits the implementation of new power lines and new energy storage systems; nevertheless, at the same time, it strongly exposes electrical power and energy system to cyber-attacks, which could compromise the supply of the electricity service.
Actors	• DSO • CPO • EV Users
Storyline / Features	Driver-friendly scenarios for smart city mobility and dispatchable charging of EVs based on RES demand-response (DR) along with human-centred smart micro-contracts and micro-payments.
Preconditions	• Consumption and production data should be constantly collected • DSO and CPO platforms must implement a Demand/Response (DR) marketplace
Postconditions	• Involve EV users in DR campaign for flexibility provision
Trigger events	• Forecasting system indicates forthcoming grid balancing needs to be fulfilled

4.2.2.2 Use Case Target KPIs

KPI ID	Name	Description	Measurement / Assessment method	Target
KPI_SE_02_1	Real-Time Monitoring	Time granularity for monitoring	Measure the data gathering sampling rate	< 1 s
KPI_SE_02_2	Big Data Collection	Interaction capability	Measure the field data amount collected	> 100.000 measurements/minute
KPI_SE_02_3	EV User Experience #1	Increase EV charging efficiency	Measure the money saved involving EV users in DR campaigns	money saved: 0.05 €/kWh
KPI_SE_02_4	EV User Experience #2	Increase EV charging efficiency	Measure the percentage of renewable energy used to charge the EVs involved in DR campaigns	> 50%

4.2.2.3 Use Case Functional requirements

FR ID	Description	MoSCoW
SE_02_FR01	DSO must have access to a grid monitoring platform.	M
SE_02_FR02	CPO must have an electric mobility platform.	M
SE_02_FR03	Electric mobility platform shall be enabled for EV user registrations.	S
SE_02_FR04	As there will be more than one charging station involved in the trial, each individual charging station must have its own unique identifier.	S
SE_02_FR05	As there will be more than one electric vehicle involved in the trial, each individual electric vehicle must have its own unique identifier.	S
SE_02_FR06	Charging station must be connected to the internet.	M
SE_02_FR07	Electric vehicle must be connected to the internet.	M
SE_02_FR08	Charging station must provide energy data in real-time; data shall be stored	S
SE_02_FR09	Electric vehicle must provide energy data in real-time; data shall be stored.	S
SE_02_FR10	DSO shall be able to forecast electricity production/consumption and estimate flexibility need.	S
SE_02_FR11	DSO must be able to select the charging stations involved in a specific Demand-Response (DR) campaign.	M
SE_02_FR12	DSO and CPO platforms must be able to execute smart micro-contracts.	M
SE_02_FR13	DSO and CPO platforms must be able to process micro-payments.	M

4.2.2.4 Use Case Non Functional requirements

NFR ID	Description	MoSCoW
SE_02_NFR01	CPO platform shall be capable to manage multiple EV users without affecting its performance	S
SE_02_NFR02	CPO platform shall be portable. So, moving from one OS to other OS does not create any problem	S
SE_02_NFR03	CPO platform login shall be processed by 3 seconds	C
SE_02_NFR04	Charging station ping shall be under 200 ms	S
SE_02_NFR05	Electric vehicle ping shall be under 200 ms	S
SE_02_NFR06	Data shall be consistent, reliable, transparent and accessible only to authorized users	M

SE_02_NFR07	Store data in a safe and tamperproof manner	M

4.2.3 Technological alignment to NEMO

The goal of smart Energy/Mobility LL is to improve the performance of the electric distribution grid by leveraging the resources of NEMO platform in terms of ML tools and secure approach on data management and user privacy.

To optimize the operation of the electric distribution network, acquisition of a large amount of data is enabled which will then be processed by ML tools to achieve consumption and production forecasting and for identifying potential local energy grid discrepancies. For data and network management, 5G infrastructure will be tested which will allow more data transmission with higher reliability and with high speed. Decentralized Monetization Services and payments based on Distributed Ledger Technology and smart contracts will be tested in the smart mobility use case. The Smart Energy/Mobility LL will support third party development and validation activities.

The foreseen exploitation of NEMO developments within the Energy/Mobility trial is briefly presented in the table below.

NEMO functionalities	Foreseen exploitation
AIoT Architecture	Instantiation in the LL
Cybersecure Microservices' Digital Twin (CMDT)	Microservices' discovery and profiling
MLOps via CF-DRL	ML model training Model sharing Model serving
Monetization and Consensus-based Accountability	Decentralized IoT data transfer and monetization services
Micro-services Secure Execution Environment (SEE)	Secure deployment and execution of microservices
PRESS, Safety & Policy enforcement framework	Controlled data sharing/management and definition of strategy for resource management
Cybersecurity & Digital Identity attestation	Advanced access control to devices and microservices
meta-Orchestrator	Flexible allocation of services across IoT, edge, cloud resources
Plugin & Applications Life-Cycle Manager	Management of project platform

Table 6: NEMO technology alignment for the Energy/Mobility trial

4.3 Pilot Smart Manufacturing & Industry 4.0

4.3.1 Use Case 1: Fully automated indoor logistics/supply chain

4.3.1.1 Use Case description

USE CASE: Fully automated indoor logistics / supply chain	
ID	SM_01

USE CASE: Fully automated indoor logistics / supply chain	
Goal(s)	• Improve mass production and safety in factories with high levels of automation, enabling Collaborative Robot (Cobots) systems, Automated Guided Vehicles (AGVs) and humans co-work • High speed heterogeneous connectivity using 5G NR (5G New Radio access), TSN and WiFi and various types of AGVs • Analyse input from sensors, 3D cameras and RFID nodes and predict, identify and avoid collisions between humans and AGVs and between different types of AGVs
Narrative	Inefficient operation because the materials are removed from the AutoStore every 30 minutes manually by an operator. For this, employees have to interrupt other parts of their work. The process is not ergonomic and is very time consuming.
Risk / Challenges / Assumptions	• Automatic component recognition • Automated picking process • Automatic transfer to AGV
Actors	• Operator in logistics • Operator at production line • Persons/employees in the transport routes
Storyline / Features	This use case is focused on defining the Pilot requirements concerning the full automation of the manufacturing workflow. By using a 3D-Vision-Camera for the specific Bin Picking Application, integrated Barcode Scanners and collaboration between various types of robot systems, the solution implemented in NEMO is aiming to fully automate controlled material picking from Auto Store and autonomous transfer to the production line. This use case comprises the following features: • Correct component recognition • Correct gripping / removing of the components • Efficient and effective transfer to AGV • Required communication between robot and AGV
Preconditions	

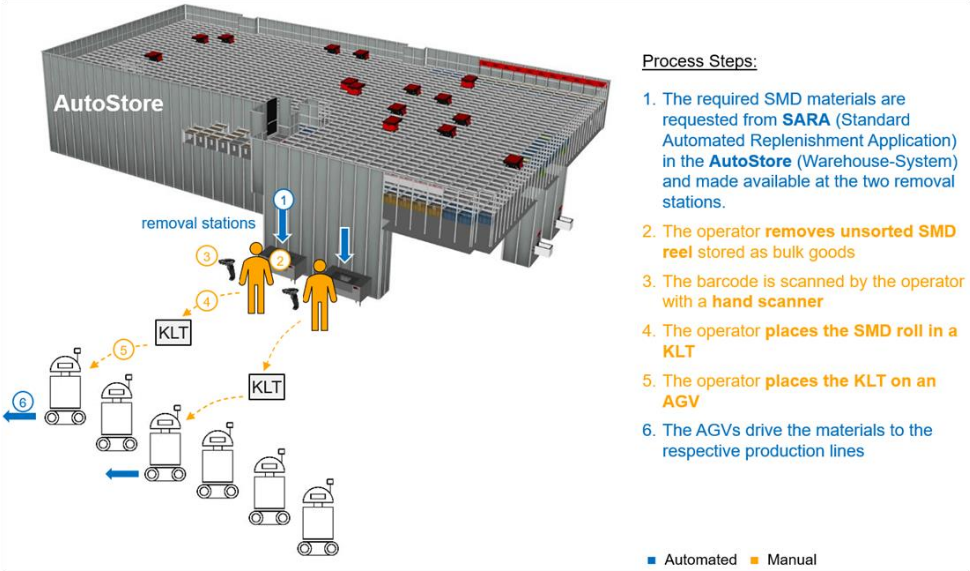
<table>
<tr><th colspan="2">USE CASE: Fully automated indoor logistics / supply chain</th></tr>
<tr><td></td><td>


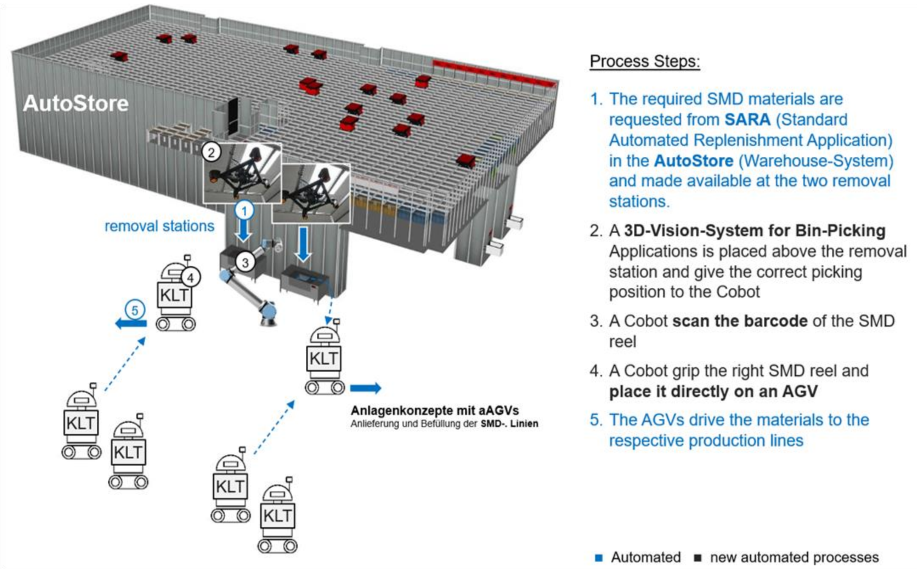
Figure 11: Current Situation: Material supply of SMD-Components, including both manual and automated tasks.
</td></tr>
<tr><td>Postconditions</td><td>


Figure 12: Future Situation: Direct interaction between Cobot and AGVs ensuring the full automated material supply
</td></tr>
<tr><td>Trigger events</td><td>
Need for automated material supply, ensuring the required SMD materials on the manufacturing stations
</td></tr>
</table>

4.3.1.2 Use Case Target KPIs

KPI ID	Name	Description	Measurement / Assessment method	Target
KPI_SM_01_1	Automation indicator	Different types of AGV and cobots to be addressed	Number of robots involved in the manufacturing workflow	>4
KPI_SM_01_2	Communication indicator	Different types of sensors' data to be analysed	Measure the field data amount collected	> 10
KPI_SM_01_3	Responsiveness	System reaction in emergency cases	Measure time of reaction in emergency situations	<0.5 sec
KPI_SM_01_4	Accuracy	ADAS supply chain improvement: accuracy	Evaluate the accuracy of measurements	>30%
KPI_SM_01_5	Savings	Cost and time reduction	Measure the efficiency and productivity	>20%

4.3.1.3 Use Case Functional requirements

FR ID	Description	MoSCoW
SM_01_FR01	Bin Picking: The platform must ensure secure part recognition and handle position determination (no component destruction)	M
SM_01_FR02	Camera: Must ensure recognition of black parts in black trays	M
SM_01_FR03	Bin picking: The application should provide a sufficiently short cycle time	S
SM_01_FR04	Bin Picking: The application must ensure error-free component assignment / QR code read	M
SM_01_FR05	Robot Collaboration: The application must provide timely provision of the transport boxes by AGV	M
SM_01_FR06	The application should provide information about the localization of AGVs	S

4.3.1.4 Use Case Non Functional requirements

NFR ID	Description	MoSCoW
SM_01_NFR01	The platform must ensure the traceability for operator	M
SM_01_NFR02	The platform must have capabilities of a monitoring system	M
SM_01_NFR03	Possibility to switch to manual operation	S

4.3.2 Use Case 2: Human-centred indoor factory environment safety

4.3.2.1 Use Case description

USE CASE: Human-centred indoor factory environment safety	
ID	SM_02
Goal(s)	• Improve safety of operators working on the production processes • Smart detection of the position of each body and build a human-centred safety environment around it • Analyse input from sensors, 3D cameras and RFID nodes and identify, analyse, predict and avoid collisions between production operators and AGVs and between different types of AGVs
Narrative	This use case is focused on localizing the AGVs with high precision, using real-time localizations information obtained from smart sensors and devices (safety cameras, radar and Lidar). The private wireless network (TSN) will support great amount of data uploads to the edge cloud facilities, where AI algorithms will detect the position of each body and build a "safety shell" around, thus ensuring the human-centred safety. Federated CF-DRL will implement model transfer learning to the AGVs to enable autonomous avoidance of potential collision between AGVs, or between a worker and an AGV.
Risk / Challenges / Assumptions	• Automatic human body identification • Monitoring, detection and prediction • Using smart algorithms for training of AGVs' ML models
Actors	• Operator at production line • Persons/employees in the transport routes
Storyline / Features	This use case addresses the safety of production operators and comprises the following features: • Correct detection of human body • Correct localization of AGVs working with the operators on the factory line • Combine 3D Vision, heterogeneous networks, edge (remote) and semi-autonomous (on-device) CF-DRL/ Transfer Learning, ensuring the monitoring, identification and prediction functionalities • Ensuring collision protection for employees in highly automated production areas and enabling "smart" cooperation between people and machines
Preconditions	• NEMO is deployed and operational. Data are collected via AGVs and cobots and devices connected to the NEMO platform. • Existing organized workflows on the production line, involving both human staff and robots.
Postconditions	• Collect and analyze information from a specified area, ensure a smart detection of the position of each body and build a human-centred safety environment around any operator

USE CASE:	Human-centred indoor factory environment safety
Trigger events	• When an obstacle is detected by the robots, the robot automatically changes its trajectory.

4.3.2.2 Use Case Target KPIs

KPI ID	Name	Description	Measurement / Assessment method	Target
KPI_SM_02_1	Communication indicator	Different types of sensors' data to be analysed	Measure the field data amount collected	> 10
KPI_SM_02_2	Responsiveness	System reaction in emergency cases	Measure time of reaction in emergency situations	<0.5 sec
KPI_SM_02_3	Manufacturing safety	Improve human collision avoidance and manufacturing safety	Measure the degree of manufacturing safety	30%
KPI_SM_02_4	Savings	Cost and time reduction	Measure the efficiency and productivity	>20%

4.3.2.3 Use Case Functional requirements

FR ID	Description	MoSCoW
SM_02_FR01	The application must provide information about the localization of the AGVs	M
SM_02_FR02	The application must provide information about the localization of the human worker	M
SM_02_FR03	The application has the capability of detecting / identifying the human body	M
SM_02_FR04	The application will send alerts in case of potential collisions between human workers and AGVs	M
SM_02_FR05	The application has the capability to predict possible incidents depending on the identified trajectories	S

4.3.2.4 Use Case Non Functional requirements

NFR ID	Description	MoSCoW
SM_02_NFR01	The platform must have capabilities of a monitoring system	M
SM_02_NFR02	High accuracy of detection and identification	M

4.3.3 Technological alignment to NEMO

From a technological point of view, the Smart Manufacturing & Industry 4.0 Pilot (Trial 4) aims to implement and validate the innovative architectural solution proposed by NEMO in order to fully automate the production workflows. The solution developed within the Pilot will achieve two major objectives at the level of process automation, namely: *i) monitoring and detection on the manufacturing workflow (equipment, devices and smart algorithms)* and *ii) ensuring the manufacturing safety procedures (equipment and smart algorithms)*.

The NEMO platform will provide the functionalities of two monitoring systems through equipment and sensors, namely Bin Picking system (camera or laser) for the automation of the manufacturing process and Sensorik system (camera, radar, Lidar, etc.) [12] for assessing the working environment.

At the level of the communications infrastructure, an IoT/5G Time Sensitive Networking (TSN) network will be implemented, and the orchestration of services will be done through intelligent Open API algorithms. Within the trial, emphasis will be put on implementing next generation of IoT applications related to AGVs-AGVs and AGVs-human operators collision prediction, detection and avoidance through real-time positioning and federated ML hosted locally and in the 5G/WiFi edge.
The foreseen exploitation of NEMO developments within the Smart Manufacturing & Industry 4.0 trial is briefly presented in the following table.

NEMO functionalities	Foreseen exploitation
AIoT Architecture	Implement and validate the AIoT meta architecture solution
IoT/5G Time Sensitive Networking (TSN)	Used for bandwidth and data connection resource transmission
SEE and SLO meta-Orchestrator	Establish secure connection and data sharing and AI processing
Policy Enforcement and Cybersecurity Vertical	Implement policies and cybersecurity regulations specific to the field
Support 3rd Parties via Open Calls	Open Call for usage of infrastructure based on NEMO meta-OS

Table 7: NEMO technology alignment for the Smart Manufacturing & Industry 4.0 trial

4.4 Pilot Smart Media & XR

4.4.1 Use Case 1: Round of Athens Race

4.4.1.1 Use Case description

USE CASE: Smart Media/ City	
ID	SC_01
Goal(s)	Enhance the live sport event spectating experience by enriching the content through AI driven data and content analysis and XR capabilities.

USE CASE: Smart Media/ City	
Narrative	During the race, media content is captured by many spectators and selected runners along the running circuit using smartphones/tablets and GoPro cameras, a few professional cameras and drones. Incoming content is automatically processed, annotated and rendered (partially on the device using already trained AI/ML models and partially at the edge), and a selection is directly broadcasted (e.g. via social media) based on location info of the (top) runners and interesting events during the race (e.g. based on contributor annotation). The audience has the option to improve their contributions and can interact with contributors in case of specific race incidents
Risk / Challenges / Assumptions	• High computing resources • Low network latency • Low video latency (both for technical director and video delivery) • Synchronisation of events with media content • Right access to content with privacy preservation • Quality of Experience (QoE) optimisation
Actors	• Real spectators that are capturing the race: pictures, videos and/or annotations. • Application end users. • Runners with cameras if they participate. • Technical director.
Storyline / Features	Stamatia and Panagiotis are intending to go to the Athens race because they love running. Stamatia is placed 5 km from the finish line while Panagiotis is placed in the middle of the circuit. Both of them are taking videos from the race. Francesca is passionate about running events and she's following the race through the NEMO's race application from her house in Rome. Pablo is a sport journalist from Barcelona and he's following the race through the NEMO's race application. When the runners arrive at Panagiotis' position some of the top runners attack to the rest of the group. The application recognises the attack from the video and the position of the runner. Francesca's and Pablo's viewing applications start showing the attack moment. The race continues and when the top runners arrive at the position of Stamatia she begins to capture video of the runners. Francesca and Pablo are now viewing the race from the position of Stamatia. Suddenly Panagiotis notices that a runner is injured and presses the injury button in his application. The accidented runner is a famous Spanish runner. Francesca continues to visualise the race. The AI driven recommender system sends Pablo the content captured by Panagiotis. Pablo receives information from the position of the race in Athens, time and kms to the finish line.

Preconditions	• NEMO is deployed and operational. This includes:
	  o Edge processing available for
	    ▪ Media Production Engine, which includes: Virtualised video editing tool, Virtualised video coding, Virtualised video mixer, Virtualised video compressor.
	    ▪ Cognitive services, which includes: Data processing, Virtualised video annotation tool, AI engine, QoE optimiser, data fusion with external data.
	    ▪ Emission selector, which includes: XR engine, Virtualised CDN for delivery.
	    ▪ GoPro cameras on runners, smartphone cameras of spectators, professional and drones cameras are connected to platform and send real time data.

USE CASE: Smart Media/ City	
	▪ The platform users (professionals) are registered to the platform.
Postconditions	• The users have access to enriched content that includes: o GPS location of the cameras and runners. o AI driven image detection for running events. o AI object tracking. o XR City locations o XR maps o A program signal created by a professional technical director. o General overview of the event situation (classification, groups, time advantage, etc.).
Trigger events	• Change of situation on the run (automatically detected). • Injury of a runner (user annotated). • Run passing through (or near) key location (check point, city PoIs, etc).

4.4.1.2 Use Case Target KPIs

KPI ID	Name	Description	Measurement / Assessment method	Target
KPI_SC_01_1	Number of users	Number of users consuming the AV content	Users connected through NEMO viewing app	10 - 100
KPI_SC_01_2	QoE	QoE value of content delivered	MOS score provided by a Quality Probe deployed in the viewing App	Mean MOS>3
KPI_SC_01_3	Number of sources	Number of AV simultaneous sources used to create the final content	MPE/Production center inputs	>=5
KPI_SC_01_4	Number of VNFs	Number of AV VNFs deployed on the NEMO edge & cloud	Number of AV VNFs deployed and orchestrated on the NEMO edge & cloud	>5
KPI_SC_01_5	Enriched content	Number of non-media data sources included in the content enrichment	Number of non-media data sources included in the content enrichment	>3
KPI_SC_01_6	Multipath connectivity	Multipath connectivity to enable extreme high bandwidth	Log analysis	>=12K for 360o video & 3D textures
KPI_SC_01_7	Accurate positioning	Accuracy of positioning of events	Improvement of accurate positioning of events in terms of geolocation	>= 25%

4.4.1.3 Use Case Functional requirements

FR ID	Description	MoSCoW
SC_01_FR01	The contributors (real spectators) must be authenticated to access the tools and set up a transmission.	M
SC_01_FR02	The broadcaster must be able to define/adjust the media-specific requirements of the transmission.	M
SC_01_FR03	The broadcaster must be able to monitor the signal quality and QoE parameters of the transmission to ensure streaming quality.	M
SC_01_FR04	Several video streams are to be transferred through the cloud/network. Bandwidth requirements must be met accordingly.	M
SC_01_FR05	Control signals (voice and data) and audio/video return channels are to be transferred between the Technical director location and the venue via the cloud network.	M
SC_01_FR06	NEMO must provide the adequate resources to the service provider to map these requirements onto the cloud network and perform accordingly.	M
SC_01_FR07	The processing of the video streams is achieved automatically by the virtualised compression functions that are part of the Media Production Engine, which are deployed at the edge cloud near the venue.	S
SC_01_FR08	NEMO will be able to allocate and launch the required services/VNFs on a location basis.	M
SC_01_FR09	The service provider must be able to chain services/VNFs with the help of a service orchestrator.	M
SC_01_FR10	NEMO applies a central control unit (Cognitive Network Optimization) that is used by the service provider to adjust/adapt the network dynamically according to the specific requirements and conditions.	S
SC_01_FR11	NEMO must be able to monitor and control the network and ensure adherence to QoS levels (bandwidth, average bit rate, round trip delay).	M
SC_01_FR12	The production of a final stream on-site is realised with the help of the MPE module at the cloud edge. The technical director remotely controls the signal switching at the MPE.	M
SC_01_FR13	Cognitive Services module allows for enrichment of the audio/video stream with additional information like face recognition, image recognition, data fusion, etc.	M
SC_01_FR14	A media app on a smartphone can be used (by journalists and/or the audience) for acquisition and streaming of audio-visual content into the cloud and make it available for the selection from technical director.	S
SC_01_FR15	Max. end-to-end network latency (RTT) - It comprises the latency of the whole network path excluding end devices on-site (like the network gateway or HW video coder) <= 50 ms	S
SC_01_FR16	Minimum end-to-end connection bandwidth (per stream). Listed here are pure video data rates, for resulting data rates on the network layer add 10 % overhead. • Uncompressed HD (1080i and 1080p): 1.5 Gbit/s and 3.0 Gbit/s	M

FR ID	Description	MoSCoW
	• JPEG2000: 100 Mbit/s • H.264/AVC-Intra: 25 Mbit/s • H265/HEVC: 15 Mbit/s	
SC_01_FR17	Error-free/lossless transport of signals with max. packet-loss rate: <10^(-12)	S
SC_01_FR18	Max. network jitter/packet delay variation (PDV) < 10 ms	S
SC_01_FR19	Classification and prioritisation of audio-video-streams. Due to the high requirements on latency, jitter and bandwidth media streams have to be prioritised in the network.	S
SC_01_FR20	Max latency of end-to-end signal transport (video, audio and control data) - it comprises the latency of the whole signal path including converting of end devices on-site and media-specific VNFs). • Maximum E2E latency one way for video and audio: <= 500 ms • Max. E2E latency for return video (one way): <= 500 ms (Typically uses less bandwidth because of low-resolution proxy transfer) • Max. end-to-end latency for intercom (if needed): <= 100 ms (according to ITU G.114)	S
SC_01_FR21	Synchronisation of video and audio signals. GPS Synchronisation of end devices (using black burst, tri-level sync and/or PTP).	M
SC_01_FR22	The MEC platform and underlying NFVI is required to deploy and run all the needed VNFs. The estimated use of resources is: • High CPU power, preferably new processor generation (>= 96 cores). • 128 GB RAM • 1 TB Storage SSD • Multiple 10 Gbit/s and 1 Gbit/s interfaces. • GPU processing capability.	M

4.4.1.4 Use Case Non Functional requirements

NFR ID	Description	MoSCoW
SC_01_NFR01	The platform must provide mechanisms for security and data privacy	S
SC_01_NFR02	The platform should support high availability deployments	S
SC_01_NFR03	Live migration should be done using microservices.	S
SC_01_NFR04	The platform should detect of network faults or malfunctions before those have any drastic impact on its performance	S
SC_01_NFR06	The use cases depend on 5G network availability at level of five-nines for all communications	S

4.4.2 Use Case 2: XR Time Machine

4.4.2.1 Use Case description

USE CASE: XR Use Case 01	
ID	XR_01
Goal(s)	XR_01: VR Experience about ancient Workshop of sculptor Phidias • Learn and participate in actions and activities of ancient workshop • Usage of heterogeneous IoT devices (Wearables, AR/VR headsets etc.) • Collect/Analyse biometric data during experience • Evaluate emotional/physical status and alter experience • Applying ML algorithms trained and executed in IoT-Edge to Cloud Continuum • Implement a VR/AR application which receives status and adapts the experience.
Narrative	The visitors of the premises of the FHW participate to a VR application that presents everyday life in the workshop of a famous sculptor; the users are able to live the experience of participating in several actions and activities as they are executed in the workshop. The XR application will be based on heterogeneous IoT devices (i.e. wearables, AR/VR headsets etc) and is going to collect and analyse biometric data from the users in order to estimate their emotional and physical status during the VR experience. The specific use case is going to use state-of-the-art machine learning algorithms that are going to be trained and executed in the IoT-to-Edge-to-Cloud continuum.
Risk / Challenges / Assumptions	Challenges will be associated with: • Low latency and accurate biometric data analysis • Filter and remove false positives for the subscription service • Validate XR case with heterogeneous IoT to provide and enhance cultural product. The quantitative evaluation will consider various workload values, to assess the sensitivity and robustness, along with end-user behaviour.
Actors	The actors involved in the use cases include: • The volunteers users of the FHW cultural venue • Administrators/presenters of FHW.
Storyline / Features	The XR use case will be executed in FHW premises and its main goal is to enhance users' VR/AR/XR experience. The new application will use NEMO platform to manage, collect, and analyze data from multiple heterogeneous smart devices, 3D applications, advanced AR/VR/XR headsets, and low-cost devices (i.e. smartphones, tablets, wearables, etc.) in a automated and energy efficient way.

USE CASE: XR Use Case 01	
	The platform can make smart decisions regarding the deployment/scaling/migration of specific microservices in order to minimise CO2 emissions (i.e. by choosing devices powered from renewable resources) and ensure the QoS. The identified user groups are: • Users of VR headsets and visitors of the Dome • Museum educators/presenters and technicians in FHW venue
Preconditions	• NEMO is deployed and operational. • IoT smart devices are connected to the platform and send real time data. • The platform users (professionals) are registered to the platform.
Postconditions	• The professionals and users have enhanced experience based on ML analysis that provides positioning, emotional/physical status detection, gesture recognition, and multi-sensorial stimuli
Trigger events	• Real-time evaluation of the biometric signals

4.4.2.2 Use Case Target KPIs

KPI ID	Name	Description	Measurement / Assessment method	Target
KPI_ XR_01.1	User status detection	Get biometry and analyze status in realtime from the IoT-Edge-Cloud system.	Log analysis	<20 ms
KPI_XR_01.2	VR application improvement	Service trigger events on subscribed VR devices. Percent of event triggered.	Log analysis	100%
KPI_XR_01.3	Micro-service migration	Conditional tasks/Micro-service migration. Success rate.	Log analysis	100%
KPI_XR_01.4	Network low latency	End to end low latency migration to avoid dizziness and	Log analysis	<20ms

KPI ID	Name	Description	Measurement / Assessment method	Target
		motion-sickness		
KPI_XR_01.5	User validation	Does the user get better experience	Qualitative analysis	>=25% improvement compared to traditional presentation
KPI_XR_01.6	Multipath connectivity	Multipath connectivity to enable extreme high bandwidth	Log analysis	>=12K for video and textures

4.4.2.3 Use Case Functional requirements

FR ID	Description	MoSCoW
XR_01.FR01	Collect user's biometric data	M
XR_01.FR02	ML model for physical and emotional status detection	M
XR_01.FR03	The solution must have an Application server (REST API) Service for communication between system admin and AR/VR application and UI interface for specifying what events and data to send depending on the state.	S
XR_01.FR04	Enhance VR app to subscribe and handle events	M
XR_01.FR05	Network will support diverse devices (wearables, AR/VR headsets) with different performance (e.g., high throughput, low latency and massive connection densities)	M
XR_01_FR06	Interoperability with external systems (i.e. multi sensorial stimuli system)	M
XR_01_FR07	The platform components involving direct interaction with the end-users should be quick to respond to the users' actions	S

4.4.2.4 Use Case Non Functional requirements

NFR ID	Description	MoSCoW
XR_01_NFR01	The platform must provide mechanisms for security and data privacy	S
XR_01_NFR02	The platform should support high availability deployments	S
XR_01_NFR03	Live migration should be done using microservices live migration	S
XR_01_NFR04	The platform should detect of network faults or malfunctions before those have any drastic impact on its performance	S

NFR ID	Description	MoSCoW
XR_01_NFR06	The use cases depend on 5G network availability at level of five-nines for all communications	S

4.4.2.5 Use Case description

USE CASE: XR Use Case 02	
ID	XR_02
Goal(s)	• XR_02: Enhance AV experience in the Tholos Dome VR Theatre Analyse speech and position of museum-educator presenter. Voice and Gesture based recognition by using ML in IoT-to-Edge-to-Cloud continuum • Trigger events in real time that are going to be consumed by multi-sensorial stimuli systems, AR/VR glasses, wearables, and smart displays outside the Tholos • Create a proof-of-concept REST API based framework for testing multi-sensorial stimuli (wind, heat, etc.) and actions based on external devices
Narrative	This use case is going to further enhance the user's audiovisual (AV) experience in Tholos by providing the appropriate software and tools to support multi-sensorial stimuli via effects such as wind, heat, and vibration, or movement and sound in addition to AV. This use case will analyse the physical position of the presenter as well as his/her speech and it will perform gesture and voice recognition based on state-of-the-art machine learning algorithms. The system trains and executes ML models in the IoT-to-Edge-to-Cloud continuum and it will trigger events in real time that are going to be consumed by multi-sensorial stimuli systems, AR/VR glasses, wearables, and smart displays outside the Tholos.
Risk / Challenges / Assumptions	Challenges will be associated with: • Low latency and accurate real-time voice and gesture recognition • Filter and remove false positives for the subscription service • Validate XR case with heterogeneous IoT to provide and enhance cultural product. The quantitative evaluation will consider various workload values, to assess the sensitivity and robustness, along with end-user behaviour.
Actors	The actors involved in the use cases include: • The volunteers users of the FHW cultural venue • Administrators/presenters of FHW.
Storyline / Features	The XR use case will be executed in FHW premises and its main goal is to enhance users' VR/AR/XR experience. The new application will use NEMO platform to manage, collect, and analyze data from multiple heterogeneous smart devices, 3D applications, advanced AR/VR/XR headsets, and low-cost devices (i.e. smartphones, tablets, wearables, etc.) in a automated and energy efficient way. The platform can make smart decisions regarding the deployment/scaling/migration of specific microservices in order to minimise CO2 emissions (i.e. by choosing devices powered from renewable resources) and ensure the QoS. The identified user groups are: • Users of VR headsets and visitors of the Dome • Museum educators/presenters and technicians in FHW venue
Preconditions	• NEMO is deployed and operational. • IoT smart devices are connected to the platform and send real time data.

USE CASE: XR Use Case 02	
	• The platform users (professionals) are registered to the platform.
Postconditions	• The professionals and users have enhanced experience based on ML analysis that provides positioning, emotional/physical status detection, gesture recognition, and multi-sensorial stimuli
Trigger events	• Real-time voice and gesture recognition

4.4.2.6 Use Case Target KPIs

KPI ID	Name	Description	Measurement / Assessment method	Target
KPI_XR_02.1	Micro-service migration	Conditional tasks/Micro-service migration. Success rate.	Log analysis	100%
KPI_XR_02.2	Network low latency	End to end low latency migration to avoid dizziness and motion-sickness	Log analysis	<20ms
KPI_XR_02.3	Voice recognition	Service recognizes presenter's voice	Log analysis	>90% success, no false positives
KPI_XR_02.4	Gesture recognition	Does the IoT-Edge-Cloud system recognize gesture and position	Log analysis	>= 80% success and at least 25% improvement
KPI_XR_02.5	User validation	Does the user get better experience	Qualitative analysis	>=25% improvement compared to traditional presentation
KPI_XR_02.6	Multipath connectivity	Multipath connectivity to enable extreme high bandwidth	Log analysis	>=12K for video and textures

4.4.2.7 Use Case Functional requirements

FR ID	Description	MoSCoW
XR_02.FR01	Enhance VR app to subscribe and handle events	M
XR_02.FR02	Capture Presenter Voice and Video feed	M
XR_02.FR03	Identify key phrases and gestures	M
XR_02.FR04	Application Server (REST API) for communication between system devices and applications	S
XR_02.FR05	UI tool for specifying key phrases to detect	C
XR_02.FR06	UI tool for specifying what to send to subscribers	C
XR_02.FR07	Network must support diverse devices (wearables, AR/VR headsets) with different performance (e.g., high throughput, low latency and massive connection densities)	M
XR_02_FR08	Interoperability with external systems (i.e. multi sensorial stimuli system)	M
XR_02_FR09	The platform components involving direct interaction with the end-users should be quick to respond to the users' actions	S

4.4.2.8 Use Case Non Functional requirements

NFR ID	Description	MoSCoW
XR_02_NFR01	The platform must provide mechanisms for security and data privacy.	S
XR_02_NFR02	The platform should support high availability deployments.	S
XR_02_NFR03	Live migration should be done using microservices live migration.	S
XR_02_NFR04	The platform should detect of network faults or malfunctions before those have any drastic impact on its performance.	S
XR_02_NFR06	The use cases depend on 5G network availability at level of five-nines for all communications.	S

4.4.3 Technological alignment to NEMO

The trial 5 use cases will make full use of the NEMO meta-architecture. Tasks that were previously executed on on-site servers are going to be pushed to the edge, far-edge and cloud depending on the implementation KPIs. In particular the use cases in this trial will use on-device federated Machine Learning to analyze video and biodata, perform gesture recognition and recognize actions. All this data will need a federated secure network adaptation ensured by a SEE, PRESS and Policy Enforcement framework and the meta orchestrator. Furthermore, in order to be flexible, MOCA and the plugin life cycle management solution will be validated based on the intent-based migration SDK which will be provided NEMO. The policy enforcement on the data will be vertical across all sections needed and will ensure anonymization and safety for the data collected. The services will be factored in such a way that it will be possible to open the usage on the NEMO infrastructure to 3rd parties either by open calls or by invitation.

The foreseen exploitation of NEMO developments within the Smart Media/City and XR trial is briefly presented in the following table.

NEMO functionalities	Foreseen exploitation
AIoT Architecture	Modular and secure use of the AIoT meta architecture for the underlying implementation
On-device federated MLOps and TL via CF-DRL	Used to analyse video inputs and recognize actions and persons, gestures and analyse user biodata, based on AI processing
Federated mNCC and Network Adapters	Used for bandwidth and data connection resource transmission.
SEE and meta-Orchestrator	Flexible allocation and secure deployment of services
Plugins' Life-Cycle Manager and MOCA	Launching, lifecycle management and accounting of apps
Intent-based migration SDK	Easy deployment and migration for services
Policy Enforcement and Cybersecurity Vertical	Implement policy and press enforcement on new posts
Support 3rd Parties via Open Calls	Open Call for usage of infrastructure based on NEMO meta OS

Table 8: NEMO technology alignment for the Smart Media/City and XR trial

5 List of Functional and Non-functional requirements

This section presents the consolidated list of the identified Functional Requirements (FR) and Non-Functional Requirements (NFR) of the NEMO solution.

Considering the specificity of the various business domains we address, where technical innovation has a major role, the functional requirements have been ranged in three categories like: ***technological*** (addressing the technology, architectural vision, infrastructure and smart algorithms), ***end-user requirement*** (addressing the end-user perspective and need) and ***operational*** (direct impact on activity / practicality).

The functional requirements are related to the use of a software system in the real-world facts, implied by the end-user needs and expectations. The non-functional requirements are those features which describe how the software system should behave and the potential constraints upon the system behaviour. While functional requirements define what a system should do, non-functional requirements specify how the system must work.

Within the requirements analysis stage, each Pilot provided details of the specific FRs for Use cases as presented below.

Functional requirement ID	Description	MoSCoW
Unique identifier of the functional requirement like FR1	*Description of functional requirement, correlated with the use case and reflecting a real need / demand of the end-user*	*Priority to implement the FR:* *M - "Must have"* *S - "Should have"* *C - "Could have"* *W - "Won't have"*

The MoSCoW (Must Have; Should Have; Could Have; Won't Have) method was considered as suitable for prioritizing the development of requirements.
By applying MoSCoW method, the functional requirements will be gathered in four major categories, as follows:

1. **Must have** (**M**o): The requirements that are critical and must be applied to a product as a matter of priority.
2. **Should have** (**S**): Requirements that are important but not critical for the release. Such requirements are not very sensitive to time.
3. **Could have** (**C**o): The requirements are desirable but not mandatory for the release.
4. **Won't have** (**W**): These requirements are considered the least critical or may not correspond to the product strategy at all. They can be ignored and be revised for future releases.

Similar to FRs, the approach for the non-functional requirements assumes that NFRs are associated to particular use cases and are formalized like the functional requirements.

Functional requirement ID	Description	MoSCoW
Unique identifier of the functional requirement like NFR1	*Description of non-functional requirement, correlated with the use case and reflecting the operational capability and performance of the system*	*Priority to implement the NFR:* *M - "Must have"* *S - "Should have"* *C - "Could have"* *W - "Won't have"*

Considering all aspects presented above, the final lists of collected FRs and NFRs are the following:

5.1 NEMO Functional requirements

FR ID	Description	MoSCoW	Category
NEMO_FR01	The platform must provide access to measurements.	M	Technological
NEMO_FR02	The platform must provide options to manage/view sensors/devices.	M	Technological
NEMO_FR03	The platform must provide options to manage users.	M	Technological
NEMO_FR04	The platform should support ML/FL training and ML model sharing/serving.	M	Technological
NEMO_FR05	The platform should provide ML classification accuracy probability.	S	Technological
NEMO_FR06	The platform should support automated aerial spraying.	S	Operational
NEMO_FR07	The platform should support monitoring of SLOs, e.g. related to energy consumption or CO2 emissions.	S	Technological
NEMO_FR08	The platform must respect data sovereignty and privacy requirements.	M	Technological
NEMO_FR09	The platform must support collection of monitoring data, such as the weather and plant conditions.	M	Technological
NEMO_FR10	The platform must support collection of monitoring data, such as the weather and plant conditions.	M	Technological
NEMO_FR11	The platform must support retrieving photos via drones.	M	Technological
NEMO_FR12	The monitoring devices must support network connectivity.	M	Technological
NEMO_FR13	The monitoring devices must be able to communicate data to and receive control commands from the NEMO platform.	M	Technological

FR ID	Description	MoSCoW	Category
NEMO_FR14	The platform should be able to perform alternative scheduling or geographical distribution of smart farming services based on user goals.	S	Technological
NEMO_FR15	The Smart Farmer should be able to define strategies for the use of available resources.	S	End-user
NEMO_FR16	Mobile robots must support autonomous operation.	M	Technological
NEMO_FR17	Mobile robots must be able to understand the weeds they should spray.	M	Technological
NEMO_FR18	Mobile robots must be able to follow a route or reach a destination.	M	Technological
NEMO_FR19	Mobile robots must support network connectivity, such as Wi-Fi or cellular.	M	Technological
NEMO_FR20	The platform must be able to calculate mobile robots routes in real-time.	M	Technological
NEMO_FR21	The platform must be able to identify and avoid obstacles such as humans and trees in real-time.	M	Technological
NEMO_FR22	Mobile robots must be able to provide data to and receive control commands from the NEMO platform.	M	Technological
NEMO_FR23	The platform must provide access to collected data.	M	Technological
NEMO_FR24	The platform must provide access to the devices.	M	Technological
NEMO_FR25	The platform must provide options to manage users.	M	Technological
NEMO_FR26	The Smart Farmer should be able to define strategies for the use of available resources.	S	End-user
NEMO_FR27	The platform has the capability to monitor the real time data from the sensors deployed in the grid.	M	Technological
NEMO_FR28	DSO must be able to forecast electricity production/consumption and estimate flexibility need.	M	Technological
NEMO_FR29	High-tech power sensors should be useful to elaborate on new strategies, in order to improve the power quality in a secure way.	S	Technological
NEMO_FR30	Based on sampled data, phasors are calculated with high precision and the synchronization process must be very fast. Indeed, innovative reconfiguration and self-healing schemas should rely on appropriate measurements.	M	Technological
NEMO_FR31	DSO must have access to a grid monitoring platform.	M	Technological

FR ID	Description	MoSCoW	Category
NEMO_FR31	CPO must have an electric mobility platform.	M	Technological
NEMO_FR32	Electric mobility platform shall be enabled for EV user registrations.	S	Technological
NEMO_FR33	As there will be more than one charging station involved in the trial, each individual charging station must have its own unique identifier.	S	Technological
NEMO_FR34	As there will be more than one electric vehicle involved in the trial, each individual electric vehicle must have its own unique identifier.	S	Technological
NEMO_FR35	Charging station must be connected to the internet.	M	Technological
NEMO_FR36	Electric vehicle must be connected to the internet.	M	Technological
NEMO_FR37	Charging station must provide energy data in real-time; data shall be stored.	S	Technological
NEMO_FR38	Electric vehicle must provide energy data in real-time; data shall be stored.	S	Technological
NEMO_FR39	DSO shall be able to forecast electricity production/consumption and estimate flexibility need.	S	Technological
NEMO_FR40	DSO must be able to select the charging stations involved in a specific Demand-Response (DR) campaign.	M	Technological
NEMO_FR41	DSO and CPO platforms must be able to execute smart micro-contracts.	M	End-user
NEMO_FR42	DSO and CPO platforms must be able to process micro-payments.	M	End-user
NEMO_FR43	The platform must ensure secure part recognition and handle position determination (no component destruction). (Bin Picking)	M	Technological
NEMO_FR44	The application should provide a sufficiently short cycle time. (Bin Picking)	S	Operational
NEMO_FR45	The application must ensure error-free component assignment / QR code read. (Bin Picking)	M	Operational
NEMO_FR 46	The application must provide timely provision of the transport boxes by robots (AGV).	M	Operational
NEMO_FR47	The application must provide information about the localization of robots (AGV).	M	Operational
NEMO_FR48	The camera must ensure recognition of black parts in black trays.	M	Technological

FR ID	Description	MoSCoW	Category
NEMO_FR49	The application must provide information about the localization of the human worker.	M	Operational
NEMO_FR50	The application must have the capability of detecting / identifying the human body.	M	Technological
NEMO_FR51	The application will send alerts in case of potential collisions between human workers and AGVs.	M	End-user
NEMO_FR52	The application should have the capability to predict possible incidents depending on the identified trajectories.	S	Technological
NEMO_FR53	The contributors (real spectators) must be authenticated to access the tools and set up a transmission.	M	Technological
NEMO_FR54	The broadcaster must be able to define/adjust the media-specific requirements of the transmission.	M	Technological
NEMO_FR55	The broadcaster must be able to monitor the signal quality and QoE parameters of the transmission to ensure streaming quality.	M	Technological
NEMO_FR56	Several video streams are to be transferred through the cloud/network. Bandwidth requirements must be met accordingly.	M	Technological
NEMO_FR57	Control signals (voice and data) and audio/video return channels are to be transferred between the Technical director location and the venue via the cloud network.	M	Technological
NEMO_FR58	NEMO must provide the adequate resources to the service provider to map these requirements onto the cloud network and perform accordingly.	M	Technological
NEMO_FR59	The processing of the video streams is achieved automatically by the virtualised compression functions that are part of the Media Production Engine, which are deployed at the edge cloud near the venue.	S	Technological
NEMO_FR60	NEMO will be able to allocate and launch the required services/VNFs on a location basis.	M	Technological
NEMO_FR61	The service provider must be able to chain services/VNFs with the help of a service orchestrator.	M	Technological
NEMO_FR62	NEMO applies a central control unit (Cognitive Network Optimization) that is used by the service provider to	S	Technological

FR ID	Description	MoSCoW	Category
	adjust/adapt the network dynamically according to the specific requirements and conditions.		
NEMO_FR63	NEMO must be able to monitor and control the network and ensure adherence to QoS levels (bandwidth, average bit rate, round trip delay).	M	Technological
NEMO_FR64	The production of a final stream on-site is realised with the help of the MPE module at the cloud edge. The technical director remotely controls the signal switching at the MPE.	M	Technological
NEMO_FR65	Cognitive Services module must allow for enrichment of the audio/video stream with additional information like face recognition, image recognition, data fusion, etc.	M	Technological
NEMO_FR66	A media app on a smartphone can be used (by journalist and/or the audience) for acquisition and streaming of audio-visual content into the cloud and make it available for the selection from Technical director.	S	End-user
NEMO_FR67	Max. end-to-end network latency (RTT) - It comprises the latency of the whole network path excluding end devices on-site (like the network gateway or HW video coder) <= 50 ms.	S	Technological
NEMO_FR68	Max latency of end-to-end signal transport (video, audio and control data) - it comprises the latency of the whole signal path including converting of end devices on-site and media-specific VNFs). • Maximum E2E latency one way for video and audio: <= 500 ms • Max. E2E latency for return video (one way): <= 500 ms (Typically uses less bandwidth because of low-resolution proxy transfer) • Max. end-to-end latency for intercom (if needed): <= 100 ms (according to ITU G.114).	S	Technological
NEMO_FR69	Synchronisation of video and audio signals. GPS Synchronisation of end devices (using black burst, tri-level sync and/or PTP).	M	Technological

FR ID	Description	MoSCoW	Category
NEMO_FR70	The MEC platform and underlying NFVI is required to deploy and run all the needed VNFs. The estimated use of resources is: • High CPU power, preferably new processor generation (>= 96 cores). • 128 GB RAM • 1 TB Storage SSD • Multiple 10 Gbit/s and 1 Gbit/s interfaces. • GPU processing capability.	M	Technological
NEMO_FR71	The platform must collect user's biometric data.	M	Technological
NEMO_FR72	The solution must have a ML model for physical and emotional status detection.	M	Technological
NEMO_FR73	The solution must have an Application server (Rest API) Service for communication between system admin and AR/VR application and UI interface for specifying what events and data to send depending on the state.	S	Technological
NEMO_FR74	The solution must enhance VR app to subscribe and handle events.	M	Technological
NEMO_FR75	Network will support diverse devices (wearables, AR/VR headsets) with different performance (e.g., high throughput, low latency and massive connection densities).	M	Technological
NEMO_FR76	The platform must ensure the interoperability with external systems (i.e. multi sensorial stimuli system).	M	Technological
NEMO_FR 77	The platform components involving direct interaction with the end-users should be quick to respond to the users' actions	S	End-user
NEMO_FR78	The solution must capture Presenter Voice and Video feed.	M	Technological
NEMO_FR79	The solution must identify phrases and gestures.	M	Technological
NEMO_FR80	The solution should have an Application Server (Rest API) for communication between system devices and applications.	S	Technological
NEMO_FR81	The solution could provide a UI tool for specifying key phrases to detect.	C	End-user
NEMO_FR82	The solution could provide a UI tool for specifying what to send to subscribers.	C	End-user

FR ID	Description	MoSCoW	Category
NEMO_FR83	Network must support diverse devices (wearables, AR/VR headsets) with different performance (e.g., high throughput, low latency and massive connection densities).	M	Technological

5.2 NEMO Non-functional requirements

NFR ID	Description	MoSCoW
NEMO_NFR01	The NEMO platform must respect security and privacy requirements.	M
NEMO_NFR02	NEMO should support High Availability features.	S
NEMO_NFR03	The Smart Agriculture Application of NEMO should be vendor-independent.	S
NEMO_NFR04	The NEMO platform should be flexible and scalable in the sense of exploiting available resources according to set goals.should be scalable in the sense of providing additional resources when computationally heavy tasks are initiated.	S
NEMO_NFR05	Secure communication of sensitive data related to the infrastructure should be provided.	M
NEMO_NFR06	The 5G availability should allow achieving better performances in data transmission.	C
NEMO_NFR07	CPO platform shall be capable to manage multiple EV users without affecting its performance.	S
NEMO_NFR08	CPO platform shall be portable. So, moving from one OS to other OS does not create any problem.	S
NEMO_NFR09	CPO platform login shall be processed by 3 seconds.	C
NEMO_NFR10	Charging station ping shall be under 200 ms.	S
NEMO_NFR11	Electric vehicle ping shall be under 200 ms.	S
NEMO_NFR12	Data shall be consistent, reliable, transparent and accessible only to authorized users.	M
NEMO_NFR13	Store data in a safe and tamperproof manner.	M
NEMO_NFR14	The platform must ensure the traceability for the operator.	SM
NEMO_NFR15	The platform must have capabilities of a monitoring system.	SM

NFR ID	Description	MoSCoW
NEMO_NFR16	The platform should offer the possibility to switch from the automated operation to manual operation.	S
NEMO_NFR17	High accuracy of detection and identification.	M
NEMO_NFR18	The platform must provide mechanisms for security and data privacy.	S
NEMO_NFR19	The platform should support high availability deployments.	S
NEMO_NFR20	Live migration should be done using specific microservices.	S
NEMO_NFR21	The platform should detect of network faults or malfunctions before those have any drastic impact on its performance.	S
NEMO_NFR22	The use cases depend on 5G network availability at level of five-nines for all communications.	S

6 GDPR Compliance

The NEMO project is performing research towards a meta-OS that realises integration across the IoT-Edge-Cloud continuum. To achieve this vision, the project consortium partners recognise the importance and significance of indirectly involving adult humans/citizens. The overall implementation of the NEMO project is fully compliant with the “do no significant harm” principle as per Article 17 of Regulation (EU) No 2020/852, since it is designed in a way that it is not harming any of the 6 environmental objectives of the EU Taxonomy Regulation. The NEMO Consortium also confirm that the ethical standards and guidelines of European Projects [6] 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, NEMO 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 and provides an overview of the compliance management activities regarding ethical issues. Therefore, in order to avoid repetition, this chapter of D1.1 focuses on the identification of the guidelines ensuring the ethical compliance. In terms of management of the research information as well as the processing of personal data, more information can be found in deliverable D5.1 "Data Management Plan".

6.1 Our methodology

NEMO will adopt the Guideline of the EU High-Level Expert Group on AI (AI HLEG) to design and implement trustworthy AI/ML ecosystems. NEMO ethics will be applied (a) to ensure the compliance of the project with ethics codes and legislations, and (b) to align its research results with the most advanced outcomes of the international scientific community on ethics, engineering, and emerging technologies. The project policy implementation will be extremely vigilant in handling data and strictly collect and use only the one necessary to carry out the project activities considering all the processes and actions. In case of indirectly collecting personal data (e.g. as a part of Living Labs in Terni), they will be anonymised before use. During the project, an internal monitoring process will be carried out which will review ethics issues as a standing item in regular management meetings. NEMO 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. In this way, the ethical issues that might be raised by NEMO will be continuously addressed during the project’s lifecycle. So, Task 1.3: Benchmarking definition and GDPR/Ethical compliance and Task 5.1: Open Data Management Plan & Living Labs Set-up, will monitor the project Legal, Ethical and Regulatory compliance and provide for the Data Management activities, ensuring that fundamental rights (privacy and personal data protection in particular) and ethical principles are respected.

6.2 Ethics and Privacy rights

The collection and processing of same type of data, during the NEMO pilots, might affect the fundamental rights of the research participants, such as the right to privacy and their right to data protection. Therefore, NEMO consortium will take note of the requirements of these fundamental rights and comply with the relevant rules and regulations including those related to the processing of personal data under the GDPR.

6.2.1 Universal Declaration of Human Rights

The Universal Declaration of Human Rights (UDHR) is a milestone document in the history of human rights. It sets out, for the first time, fundamental human rights to be universally protected. One of those fundamental rights is the right to privacy. Article 12 of the UDHR to respect for private and family life marked the first time an international instrument laid down an individual’s right to protection of their private sphere against intrusion from others, especially from the state.

6.2.2 European Convention of Human Rights

The Council of Europe adopted the European Conversion of Human Rights (ECHR) in 1950, the Council of Europe comprises 47 Contracting Parties, 28 of which are also EU Member States. Contracting Parties must respect the rights stipulated in the convention when exercising any activity or power.

Article 8 of the ECHR protects the right to respect for one's private and family life, one's home and correspondence. In accordance with the second paragraph of this article, the right to privacy can be limited i) in accordance with the law, ii) necessary in a democratic society, and iii) pursuing legitimate and important public interests. It is worth mentioning, that respect for private life and the right to privacy in some cases may affect other rights, such as freedom of expression and access to information and vice versa. So, the Court strives to find a balance between the different rights at stake.

With respect to the NEMO project, it is not expected to raise that kind of issue. However, the NEMO consortium will continuously conduct this balancing exercise between different fundamental rights in order to ensure that the right to privacy of all the humans involved in pilots will be respected.

6.2.3 Chapter of fundamental rights of the European Union

"The Charter of Fundamental Rights brings together all the personal, civic, political, economic and social rights enjoyed by people within the EU in a single text. It entered into force in December 2009 with the Treaty of Lisbon."[7]

Article 7 of the Charter is almost identical to article 8 of the ECHR with only minor changes. It is complemented by article 52 of the Charter which specifies limitations of the right to privacy. These limitations are also similar to those provided in the ECHR. Therefore, the balancing exercise similar to the required under the ECHR shall be applied with respect to all research activities, including NEMO. So, the aim here is, on one hand, to fully respect the privacy rights of the involved people in NEMO activities and on another hand to collect and analyze all the necessary data in order to maximize the research outputs. Therefore, the Charter provides a basis for EU legislation, including GDPR, as explained further.

6.3 Protection of personal data

The General Data Protection Regulation (GDPR) is intended to harmonise the rules related to data protection across Europe, it is important to note that the Regulation leaves room for derogations by Member States in certain areas, including the processing of special categories of personal data, which can be subject to stricter rules in national law.

6.3.1 GDPR principles

In the context of the NEMO project, it is important to consider a number of important definitions. This is because their application will often determine which and how data protection provisions will be applied. The main definitions (see Articles 4, 9, 22 and recitals 26 and 52) relevant for the NEMO project are provided in Table 9

"Personal data"	Any information relating to an identified or identifiable natural person (data subject).
"Identifiable natural person"	Anyone who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier (e.g. IP addresses) or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.
"Data processor"	A natural or legal person who processes personal data on behalf of the controller.
"Data controller	" A natural or legal person who, alone or jointly, determines the purposes and means of processing.
"Data subject"	Any natural person whose personal data is being processed.

"Biometric data"	Personal data resulting from specific technical processing relating to the physical, physiological or behavioural characteristics of a natural person, which allow or confirm the unique identification of that natural person, such as facial images or dactyloscopic data (finger print identification).
"Data concerning health"	Personal data related to the physical or mental health of a natural person, including the provision of health care services, which reveal information about his or her health status.
"Sensitive data"	Personal data which are, by their nature, particularly sensitive as the context of their processing could create significant risks to the fundamental rights and freedoms. It may include personal data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, trade union membership, processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person's sex life or sexual orientation.
"Processing"	Any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction.
"Pseudonymisation"	Processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organisational measures to ensure that the personal data are not attributed to an identified or identifiable natural person.
"Anonymous data"	Information which does not relate to an identified or identifiable natural person or personal data which is rendered anonymous in such a manner that the data subject is not or no longer identifiable.

Table 9: GDPR definitions

It is crucial to understand and define for NEMO's partners if the data processed by them within the project falls under the definition of 'personal data'. If it does, all the requirements under the GDPR shall be fulfilled by the project's partners. While assessing this issue, it should be taken into account that the definitions of personal data and processing are very wide, therefore, any activity with the data about identified or identifiable persons might be recognized as personal data and fall under the GDPR scope. Moreover, the processed data (i.e. biometric data, localization data, images, video etc.) are considered as sensitive data under the GDPR and should be processed under more restrictive requirements as explained further

While assessing if the processed data falls under the scope of GDPR, it is necessary to take into consideration the concept of anonymous data. Anonymous information is the information which does not relate to an identified or identifiable natural person or to personal data rendered anonymous in such a manner that the data subject is not or no longer identifiable. However, in reality, this option is far from simple and may be difficult or even unachievable in many research contexts. This is because in some cases data that is truly anonymous may often offer little potential in terms of research or practical value.

Another important concept that shall be taken into consideration and correlates to anonymous data is 'pseudonymisation'. Considering difficulties in meaningful processing full anonymized datasets (especially in light of big data and machine learning analysis that allows to find unexpected correlations in data), pseudonymisation may be often applicable. This approach reduces risks for data subjects and helps data controllers and processors to meet their data protection obligations. It is also one of the measures included in data protection by design concept. However, unlike anonymization, pseudonymisation does not exclude data processing activities from the GDPR's scope. Thus, the difference between anonymization and pseudonymisation shall be recognized by project partners and defined in advance.

The GDPR has two main objectives: the protection of natural persons with regard to the processing of personal data and ensuring the free movement of personal data within the EU. These objectives are above all other principles specified in the GDPR and should be always taken into consideration during the processing of personal data.

Besides objectives, the GDPR provides seven principles of personal data processing: 1) lawfulness, fairness and transparency; 2) purpose limitation; 3) data minimization; 4) accuracy; 5) storage limitation; 6) integrity and confidentiality; 7) accountability. These principles must be observed in most instances of processing. More importantly, it shall be done before the start of data processing at the stage of developing technical solutions and planning pilots. This would enable NEMO partners to implement data protection by design and by default procedures. Each of the principles is briefly explained further in relation to NEMO activities.

The lawfulness principle means that personal data shall be processed under legal grounds established by the GDPR. (i.e. consent request).

The transparency principle basically means that the data controller has to be open about processing activities and enable data subjects to be properly informed, using clear and plain language, about how their data are being used.

The purpose limitation principle means that personal data shall be collected for specified, explicit and legitimate purposes defined before the processing is started. For example, if the data initially collected in NEMO, for conducting initial research, will be used for different research activities than that outlined in the original consent materials, new consent should be obtained.

Data minimization means that personal data shall be limited to what is necessary in relation to the purposes for which they are processed.

According to the accuracy principle, NEMO partners have to ensure that data is accurate, kept up-to-date and inaccurate data is erased or rectified without delay.

The storage limitation principle means that personal data shall be kept for no longer than is necessary for the purposes for which it is processed. The exception relevant for the NEMO project states that personal data may be stored for longer if it is processed solely for scientific or historical or statistical purposes.

The integrity and confidentiality principle requires to ensure appropriate security of the personal data through the use of appropriate technical or organisational measures.

The accountability principle means that the controller shall be responsible for, and be able to demonstrate compliance with, all the previously mentioned principles.

6.3.2 Data Controllers and Processors

If a NEMO partner processes personal data, the scope of its obligations and responsibilities will greatly depend on its status under the GDPR – data controller or data processor. The main entity responsible for compliance with data protection rules is the data controller while it defines the purposes and means of processing. In other words, the first and foremost role of the concept of controller is to allocate responsibility. The data processor processes the personal data on behalf of the controller and on the basis of the controller's instructions. While data processor acts on behalf of data controller, the lawfulness of the processor's data processing activity is determined by the mandate given by the controller. "A processor that goes beyond its mandate and acquires a relevant role in determining the purposes or the essential means of processing is a (joint) controller rather than a processor."[8] Therefore, in case that different NEMO's partners will be involved in the processing of personal data in one process (for example, with the use of one technology), their respective roles must be defined prior to processing.

6.3.3 Data transferring in EU

The GDPR provides different procedures and requirements for personal data transfer within and outside the EU respectively. Most of NEMO's partners are from the countries – Member States of the European Union and one is based in Switzerland. Although GDPR a European regulation, it also applies to Swiss companies under certain conditions [8]. All NEMO pilot activities will take place only in EU countries, while monitoring of humans is clearly outside the project scope. Though no human related information is expected to be exported or imported from non-EU countries, in the unlikely event that such action is partially needed for the proper project execution, it will be performed in a way that remains legal at all EU Member State and comply with the Horizon Europe ethical standards.

6.3.4 Data Processing

In NEMO pilots volunteers will be involved, mainly for the collection of their opinion/feedback on the NEMO platform efficiency and will process it fully anonymized. It should be underlined that all humans will be adults, and if possible, equally representing different educational levels, professions, nationality and gender. Moreover, the cultural diversity and gender equality principles will also be taken into account to evaluate the impact of project outcomes across different communities. NEMO activities involve human participants only for the evaluation of the technologies to be established and human participants are expected to take part in surveys, workshops as well as scenario exercises.

6.3.4.1 Personal data proceeding with Artificial Intelligent

Regarding data processing and profiling based on personal data, GDPR identifies three types of processing that can be based on AI algorithms: profiling, automated decision-making, and solely automated decision-making. Profiling includes three elements: it has to be an automated form of processing; it has been carried out on personal data and the objective of the profiling must be to evaluate the personal aspects of a natural person.

Automated decision-making has a different scope and may partially overlap with or result from profiling. Automated decisions can be made with or without profiling; profiling can take place without making automated decisions. Solely automated decision-making is the ability to make decisions by technological means without human involvement.

The GDPR specifies the general requirements for automated decision-making and profiling. Under this perspective any type of processing shall be compliant with the principles of data processing and respect the rights of data subjects. Also, Article 22 of the GDPR provides specific requirements with respect to solely automated decision-making producing legal or other substantial effects on the data subject. Generally, this type of processing is prohibited unless one of the exceptions applies:

- is necessary for entering into, or performance of, a contract between the data subject and a data controller.
- is authorised by Union or Member State law to which the controller is subject and which also lays down suitable measures to safeguard the data subject's rights and freedoms and legitimate interests;
- is based on the data subject's explicit consent.

When the processing is based on a contract or consent of data subject, "the data controller shall implement suitable measures to safeguard the data subject's rights and freedoms and legitimate interests, at least the right to obtain human intervention on the part of the controller, to express his or her point of view and to contest the decision". (Article 22 of the GDPR). In the NEMO project, we have not identified yet any action that requires this kind of data processing, and in case of such activity occurred in the future the consortium will comply with the GDPR guidelines.

6.3.4.2 Personal data processing in NEMO

While realization of the NEMO project will include collecting and processing of different types of data, including within the scope of individualized bio-monitoring of some users and camera recording, it might affect the fundamental rights of people involved.

First, the right to privacy of people involved into the living labs can be affected, for example, by the use of UAVs/cameras. In this case, the right balance between the fundamental rights of those people and other interests shall be found.

Second, collecting and processing some types of data in NEMO might fall under the scope of GDPR. This would require that NEMO's partners carefully and anticipatory define the types of data, means and purposes of processing, and the roles of every partner applied in the project. Based on that, the legal grounds of processing and respective obligations of NEMO's partners will be established. It is important to take into consideration, that under the purpose limitation principle the data can be processed only for purposes it was collected, therefore. Moreover, only the data necessary for achieving the goals shall be collected and stored under the data minimization principle. Therefore, prior assessment of all the data and processing activities is crucial for NEMO's legal compliance.

While the project involves the use of different innovative technologies, a Data Protection Plan is required. The DMP can be carried out with respect to one technology used by different entities. Moreover, DMP may concern a single data processing operation or could be used to assess multiple processing operations that are similar in terms of nature, scope, context, purpose, and risks.

6.4 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.

6.4.1 Data Management Plan

One of the most important requirements within NEMO is the correct management of acquired data and produced data across the different technical outcomes of the project. DMP describes 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, and part of Task 5.1 "Open Data Management Plan & Living Labs Set-up". This will ensure compliance with 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

6.4.2 Integration legal and ethics compliance in 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.

6.5 NEMO ethical guidelines

NEMO research activities will be compliant with the ethical principles and the applicable EU regulations, laws for the ethics. More specifically, NEMO partners ensure that any personal data (a) will be properly anonymized/pseudo-anonymized and processed legally and fairly. (b) will be collected for explicit and legitimate purposes and used accordingly, (c) will be relevant and not excessive in relation to the purposes for which it is collected and/or further processed, (d) will be accurate, and updated where necessary, (e) will not be kept any longer than strictly necessary and always in an encrypted format. Moreover, each pilot will assign a Pilot Data Controller, who must ensure that data subjects can rectify, remove or block incorrect data about themselves and protect personal data against accidental or unlawful destruction, loss, alteration and disclosure, particularly when processing involves data transmission over networks.

7 Conclusions

The deliverable depicts the most relevant aspects of the particular stage of requirements analysis within the project implementation, addressing the Pilots description, representative Use Cases and the definition of functional and non-functional requirements specific to NEMO solution.

A uniform methodological approach has been applied for collecting detailed information about Pilots, refining the use cases specific to Pilots and analysing the requirements.

Significant effort has been put on defining and formalizing fine-grained Use case scenarios driven by the real needs and requirements of end-users and establishing the KPIs specific to each Use case.

The deliverable provides a unitary vision of the Pilots and their particularities, from methodological, technological and operational perspectives, using specific methods and common terminology applicable in business analysis. Relevant aspects regarding the GDPR/Ethical compliance and Data Management Plan have been also addressed within the document, in line with the requirements of Task 1.3.

A complete and comprehensive list of functional requirements has been defined in Chapter 5, based on the Use case requirements identified within each Use Case. Moreover, the requirements for performance and operation of the NEMO platform can be found in the list of non-functional requirements.

The terminology utilised within the document, as well as the identification of technologies, tools and services in each scenario and use case, provide a common understanding for all the partners with regards to each technology's, tool's and service' scope.

The relevant technical aspects and outcomes of this particular stage of analysis will be taken into consideration when drafting the deliverables D1.2 and D1.3 from WP1.

8 References

[1] M. S. Neuenschwander P, "The infestation of Dacus oleae (Gmel.)(Diptera, Tephritidae) at harvest time and its influence on yield and quality of olive oil in Crete.," *Zeitschrift für angewandte Entomologie,* pp. 420-433, Jan 1978 .

[2] C. Vasilopoulos, "In Greece, Olive Trees Suffer From Fruit Fly Infection Ahead of Harvest," 2018. [Online]. Available: https://www.oliveoiltimes.com/production/in-greece-olive-trees-suffer-from-fruit-fly-infection-ahead-of-harvest/64380.

[3] P. Skouras, M. JT, N. Seraphides, I. Ioannides, E. Kakani, K. Mathiopoulos and J. Tsitsipis, "Organophosphate resistance in olive fruit fly, Bactrocera oleae, populations in Greece and Cyprus," *Pest Management Science: formerly Pesticide Science,* pp. 42-48, 2007.

[4] E. Kakani, N. Zygouridis, K. Tsoumani, N. Seraphides, F. Zalom and K. Mathiopoulos, "Spinosad resistance development in wild olive fruit fly Bactrocera oleae (Diptera: Tephritidae) populations in California," *Pest Management Science: formerly Pesticide Science,* pp. 447-453, 2010.

[5] Synelixis, "SynField," Synelixis, 2022. [Online]. Available: https://www.synfield.gr/.

[6] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/guidance/how-to-complete-your-ethics-self-assessment_en.pdf

[7] https://ec.europa.eu/info/aid-development-cooperation-fundamental-rights/your-rights-eu/eu-charter-fundamental-rights/why-do-we-need-charter_en

[8] https://www.s-ge.com/en/european-data-protection-regulation

[9] https://www.agilebusiness.org

[10] http://agilemodeling.com

[11] https://cvw.cac.cornell.edu/usecases

[12] https://www. sensorikaustria.com