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Architecture for Scalable, Self-human-centric, Intelligent, Secure, and Tactile next generation IoT

D8.1 - Evaluation plan

Deliverable No.	D8.1	**Due Date**	30-April-2022
Type	Report	**Dissemination Level**	Public
Version	1.0	**WP**	WP8
Description	Reference document concerning all evaluation activities within the action; describing in detail how/when/who will accomplish them (KPIs/data gathering methods/time-plan/partners).		

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Executive Summary

This Risk Management Plan is written within the context of WP8 – Evaluation and Assessment of **ASSIST-IoT** project, under Grant Agreement No. 957258. The Deliverable D8.1 aims to provide an evaluation plan for an assessment of ASSIST-IoT components considering the standpoint of its users, stakeholders, and developers.

ASSIST-IoT evaluation plan provides a way to conduct an assessment on technical functioning and interoperability of ASSIST-IoT components, as well as their performance, usability (including the stakeholders' assessment), general project's results, business design, impact creation and its final exploitation.

The methodological approach for the evaluation is introduced first, partitioning ASSIST-IoT into five different dimensions of assessment. These include exploitation, impact, pilots, technology as well as ethical, societal, gender and legal evaluation. Dimensions are then further subdivided into fields that group together related Key Performance Indicators.

Evaluation plan is subdivided into three separate plans. First is the technical evaluation plan, which assesses ASSIST-IoT from a technical standpoint. Aim of this evaluation is not only to assess ASSIST-IoT technical capabilities and performance, but also evaluate how much it improves the stakeholders' organisations performance (e.g., staff usage, time per task, financial gain). It evaluates all four main ASSIST-IoT development areas: Device and Edge plane, Smart Network and Control Plane, Data Management Plane and Application and Service Plane components. The second evaluation plan assesses ASSIST-IoT from the standpoint of the pilots, measuring impact of using ASSIST-IoT, including users' and stakeholders' satisfaction. Third evaluation plan is the process evaluation plan, which is the most encompassing of all three. Process evaluation plan considers project's stakeholders and users, their interest in the project and their potential gain from the project, as well as also project's legal, gender, societal and ethical aspects, etc. Process evaluation plan for ASSIST-IoT will deliver a comprehensive picture of the expectable benefits from implementing the system as well as of the modalities required for its successful implementation.

Evaluation plans are going to be executed in the Tasks T8.2, T8.3 and T8.4, and each task includes and evaluation plan.

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List of acronyms

Acronym	Explanation
AI	Artificial Intelligence
AIOTI	Alliance for Internet of Things Innovation
AP	Access Point
AR	Augmented Reality
BIM	Building Information Modelling
BLE	Bluetooth Low Energy
BS	Base Station
CAN	Controller Area Network
CCP	CAN Calibration Protocol
DLT	Distributed Ledger Technology
EDPB	European Data Protection Board
ETA	Estimated Time of Arrival
EU-OSHA	European Agency for Safety and Health at Work
FL	Federal Learning
GA	Grant Agreement
GDPR	General Data Protection Regulation
GUI	Graphical User Interface
GWEN	Gate Way / Edge Node
HiFi	High Fidelity
HW	Hardware
ICT	Information and Communications Technology
IoT	Internet of Things
ISC	In-Service Conformity
KPI	Key Performance Indicator
KVI	Key Validation Indicator
K8s	Kubernetes
LoRa	Long Range
MFT	Malta Freeport Terminal
MR	Mixed Reality
NFV	Network functions virtualization
NO_x	Nitrogen Oxides
NGI	Next Generation Internet
OCR	Optical Character Recognition

OBD	On-Board Diagnostic
OEM	Original Equipment Manufacturer
OGC	Open Geospatial Consortium
OSH	Occupational Safety and Health
OTA	Over-The-Air
PPE	Personal Protective Equipment
RDE	Real Driving Emissions
RFID	Radio-Frequency Identification
RTG	Rubber-Tired Gantry
SDO	Standards Developing Organizations
SDN	Software Defined Networking
SD-WAN	Software-Defined Wide Area Network
STS	Ship-To-Shore
SW	Software
T	Task
TEU	Twenty-foot Equivalent Unit
UV	Ultraviolet
VR	Virtual Reality
WP	Work Plan

1 About this document

The aim of deliverable D8.1 is to provide a basis for a quantitative assessment of ASSIST-IoT both from the standpoint of its users and stakeholders, as well as its developers. Its essential output is an evaluation plan, which is based upon an internally developed evaluation methodology that uses quantitative models. Most notable of these are the provisional KPIs, whose purpose is to measure the impact and success of the ASSIST-IoT project, as well as to provide the basis for internal assessment of ASSIST-IoT progress. The aim of the evaluation is not only to assess the ASSIST-IoT technical capabilities and performance, but also how much it improves the stakeholder organisation performance (e.g., staff usage, time per task, financial gain). Although we are concerned mainly with collecting quantitative data and defining a rigorous process of evaluating (calculating) KPIs, the number of covered evaluation areas and heterogeneity of evaluation data sources, will allow as to get some qualitative insights as well.

1.1 Deliverable context

Keywords	Lead Editor
Objectives	D8.1 contributes to all objectives set for ASSIST-IoT by: • Defining quantitative and qualitative KPIs, and • Developing a comprehensive evaluation plan for quantitative and qualitative assessment of each ASSIST-IoT object
Work plan	KPIs and plans defined in D8.1 will be used to form the actual evaluation and assessment reports in tasks T8.2, T8.3 and T8.4
Milestones	Deliverable D8.1 is indirectly linked to milestone MS8 Feedback at the end of the project as the definitions given in D8.1 will be used to measure the achievements of the project.
Deliverables	The KPIs defined in the deliverable D8.1 are derived from previous deliverables D2.3, D3.2, D3.3, D3.5, D4.1, D5.2, D6.1, D7.1 and D9.2. As the nature of the deliverable is to set fixed KPIs, their measurement processes and targets, there will be no future updates to D8.1. Actual achievements of the ASSIST-IoT project will be reported on D8.2 and D8.3 against the defined evaluation plans in this deliverable.

Main objective of the deliverable D8.1 is to define the evaluation methodology and use it to create evaluation plans for subsequent tasks in this work package. Definition of the evaluation methodology encompasses design of the evaluation framework and definitions of fields of measurement, which further build upon Key Performance Indicators (KPIs). D8.1 will thus provide methodology, approach to data collection and processing, evaluation targets and detailed plan for the following evaluation areas:

- technical evaluation of ASSIST-IoT,
- evaluation of the results of Pilots (thus including also open call projects),
- process evaluation, including assessment of ethical, societal, gender and legal aspects of the project.

These are going to be fed directly into other three tasks of WP8, where actual project's evaluation is going to be performed. Each of the subsequent tasks will perform this evaluation from a different standpoint and using a subset of the evaluation methodology and KPIs, as developed in this deliverable.

In task T8.2 "Technical Evaluation and Validation" a purely technical evaluation of specifications and developed technical components is performed: interoperability capabilities, framework usability (e.g., APIs), and system performance. Evaluation that requires user input and subjective feedback through surveys and interviews is part of T8.3 and T8.4.

Task T8.3, "Continuous Pilot Analysis, Evaluation and Assessment", will build upon KPIs and subsections of evaluation methodology connected with project's performance in Pilots of ASSIST-IoT. In this task the project team will perform data collection from both surveys (by questionnaire, interviews, focus group, etc.) and technical data sources (e.g., system logs). The obtained data will be used to define KPI metrics and assess the project success as what relates to application of ASSIST-IoT in real-world environments.

Final task T8.4 will be the most thorough one, as it will do a complete process evaluation of ASSIST-IoT, thus improving project's usability and ease of use beyond the pilots executed in the project. This task will also aid further ASSIST-IoT developments.

Tasks are going to be executed separately and independently from one another.

1.2 The rationale behind the structure

This deliverable is divided into five main sections. In the Introduction, objectives of the deliverable are presented. In the Methodology section, evaluation methodology, which forms the backbone of the whole evaluation process performed in WP8, is presented. In this section, the evaluation methodology is introduced and dimensions (main areas of measurement) that are further broken-down infields of measurement, are defined. Further, fields are collections of KPIs. In the same section data collection and management is explained, as well as how evaluation findings are going to be communicated internally and externally. In the Key Performance Indicators section, the notion of KPIs is introduced and portioned into dimensions, introduced in the previous section. The evaluation plan of ASSIT-IoT, consisting of three separate evaluation plans, is described in the Evaluation section. First, the technical evaluation of ASSIST-IoT itself, the second one is the evaluation of the results of the pilots (impacts while using ASSIST-IoT, including users' and stakeholders' satisfaction), and the third is the process evaluation, where the work done in ASSIST-IoT is considered both from the standpoint of its developers as well as users and stakeholders regarding its quality, how hard it is for other people to build upon it and other similar matters. The assessment of ethical, societal, gender and legal aspects section elaborates on ethical issues related to the execution of the evaluation. The final section is reserved for conclusions.

1.3 Version-specific notes

The document lays the framework of target setting and measuring and sets the KPIs used throughout the ASSIST-IoT project. These KPIs and their targets have been tentatively defined at this stage of the project, but potential refinement may be performed in D8.2 and D8.3. Following tasks will only report and assess against the defined KPIs and targets. However, if practice shows that two, or more, KPIs are very similar, a decision might be made during the reporting tasks to consolidate this kind of KPIs into one. Therefore, updating the KPIs and targets without updating D8.1.

2 Methodology

In this section, the methodology for evaluation of the ASSIST-IoT project and specification of guidelines to evaluate the impact of ASSIST-IoT are described. First, the groundwork is exposed in the form of dimensions and fields of measurement that are then used in the next section for introducing specific KPIs. These provide a better, more tangible assessment of the project's success factors, along with to information gained from questionnaires and other such means.

KPIs are derived mainly from the ASSIST-IoT Grant Agreement, and requirements gathered in WP3, as well as initial set of KPIs defined during the project review. This process allows to measure the project success with respect to the Grant Agreement; requirement coverage (accomplished, not accomplished, partially accomplished.), gap analysis, system potential bottlenecks, partners and stakeholders feedback and recommendations.

The evaluation methodology adopted has been inspired upon ideas derived from the Deliverable 01.04 of the H2020 CREATE-IoT Project. This decision was made since this deliverable addresses the analysis of large scale IoT pilots, spread through more focus areas and application domains. It is thus very similar to the structure of ASSIST-IoT, where three large scale pilots exist in addition to several Open Call projects, in various application domains and thus also focus areas. However, in WP7, in contrast to the above-mentioned deliverable, only Pilots and validation execution are performed, as testing takes place in WP6.

First, the methodology has been designed, followed by the definition of dimensions and fields of measurement, in accordance with project aspects presented above. Data collection management, use and communication of evaluation findings are considered at the end of this section. The actual evaluation procedure is based on ASSIST-IoT project requirements.

2.1 Dimensions and fields of measurement

Measurement of ASSIST-IoT performance and progress is done via the usage of KPIs. Technically, a KPI is a type of performance measurement, which is done against a predefined set of values, called indicators. In this deliverable, only quantitative indicators are used, meaning that each KPIs value is going to be a number (or a percentage over a baseline). For example, if defined a KPI for users' satisfaction with performance of ASSIST-IoT, we would choose a value for it from the set of numbers from 1 to 5, where 1 would represent complete dissatisfaction and 5 would represent complete satisfaction.

KPIs are grouped into fields. These join KPIs that are semantically similar, for example, KPIs that deal with system performance from the user's standpoint are grouped together, and in a different field we would have KPIs that deal with users' satisfaction with ASSIST-IoT.

Related fields are further coupled together into dimensions, which represent different aspects of progress measurement in the ASSIST-IoT project. It has been decided to define these five main dimensions, which are further worked upon in section 3:

- 1 Exploitation (see Table 2)
- 2 Pilots (see Table 3)
- 3 Impact (see Table 4)
- 4 Technology (see Table 5)
- 5 Ethical, societal, gender and legal evaluation (see Table 6)

Table 1 shows how each dimension maps with the different tasks of WP8 (where actual assessment will take place). Each of the dimensions is assigned to one or more evaluation areas, which also represent three different methodologies by which the overall impact of ASSIST-IoT will be measured. As an example, the interoperability will be part of all evaluation areas and thus there will be measured: interoperability capabilities in technical evaluation area, interoperability capabilities in pilot projects as well as in the process evaluation.

Table 1 Mapping dimensions with evaluation tasks

	Dimension Filed of evaluation	Technical evaluation (Task 8.2)	Pilot evaluation (Task 8.3)	Process evaluation (Task 8.4)
1	**Exploitation**			
	Field 1.1 Stakeholders' and third parties' engagement			X
	Field 1.2 Business models			X
	Field 1.3 Exploitation of products			X
2	**Pilots**			
	Field 2.1 Port automation Pilot		X	
	Field 2.2 Smart Safety of workers Pilot		X	
	Field 2.3 Advanced Powertrain monitoring and diagnostics Pilot		X	
	Field 2.4 Vehicle exterior condition inspection and documentation		X	
	Field 2.5 Overall pilots' implementation		X	
3	**Impact**			
	Field 3.1 Standardisation			X
	Field 3.2 Dissemination			X
	Field 3.3 Communication			X
4	**Technology**			
	Field 4.1 Device and Edge Plane	X		
	Field 4.2 Smart Network and Control Plane	X		
	Field 4.3 Data Management Plane	X		
	Field 4.4 Application and Services Plane	X		
	Field 4.5 Self-*	X		
	Field 4.6 FL	X		
	Field 4.7 Security, Privacy and Trust	X		
	Field 4.8 DTL	X		
	Field 4.9Manageability	X		
5	**Ethical, societal, gender and legal evaluation**			
	Field 5.1 Legal issues			X
	Field 5.2 Holistic innovation			X
	Field 5.3 User worktime/life impact			X
	Field 5.4 Targeted social groups			X
	Field 5.5 Trusted, safe, secure IoT environment promotion			X
	Field 5.6 Community engagement			X

Within each dimension, further partition of KPIs into the fields has been made as described in the following tables.

Fields within the first KPI dimension deal with the topic of exploitation of project results.

Table 2 Dimension 1 - Exploitation fields

Field id	Short description	Long description
Field 1.1	Stakeholders' and third parties' engagement	Ability to reach and engage different stakeholders, innovators, and external parties to participate on ASSIST-IoT project
Field 1.2	Business models	Ability to support diversified business models, including how to serve different feature needs, and adapt to their mechanisms
Field 1.3	Exploitation of products	The ability to effectively exploit the products and services of the project, as well as with which rights

Fields within the second KPI dimension deal with the topic of pilots.

Table 3 Dimension 2 - Fields connected with pilots

Name	Short description	Long description
Field 2.1	Port automation Pilot	The objective of the evaluation is to test the functionality of different ASSIST-IoT enablers over the Port Automation Pilot with the helping container terminal operators to improve operational efficiency. KPIs in this field are oriented to evaluate the success of such a pilot.
Field 2.2	Smart Safety of workers Pilot	The Smart safety of workers Pilot is focused on the improvement of health and safety at the construction site by providing human-centric modular solutions and enablers capable to effectively support the operations. KPIs in this field are oriented to evaluate the success of such a pilot.
Field 2.3	Advanced Powertrain monitoring and diagnostics Pilot	This pilot of ASSIST-IoT deals with the ability to understand a fleet's emissions level, respond to emission levels close to or above their legal thresholds, and add innovative diagnostic methods at the edge. KPIs in this field are oriented to evaluate the success of such a pilot.
Field 2.4	Vehicle exterior condition inspection and documentation	In this specific pilot for the ASSIST-IoT project, the focal point is on the vehicular exterior condition and the consequent support of human tasks. ASSIST-IoT is expected to support the accelerated results and efficient data management in a secure and decentralized way. KPIs in this field are oriented to evaluate the success of such a pilot.
Field 2.5	Overall pilots’ implementation	Overall evaluation with regards of the implementation of the 4 real-world pilots

Fields within the third KPI dimension deal with the topic of impact.

Table 4 Dimension 2 - Impact fields

Name	Short description	Long description
Field 3.1	Standardisation	Contribution to emerging or future standards and pre-normative activities.
Field 3.2	Dissemination	Long-term evolution of NGIoT infrastructures and service platforms technologies and contribution to scientific progress enabling novel, future semi-autonomous IoT applications.
Field 3.3	Communication	Contribution to impact creation and communication of project activities and results to the widest public.

Fields within the fourth KPI dimension deal with interoperability.

Table 5 Dimension 4 - Technology fields

Name	Short description	Long description
Field 4.1	Device and Edge Plane	KPIs related to Device/Edge plane, which includes physical and tangible components of the interconnected ecosystem, realized by smart devices, routers, switches, network hubs, physical controllers, and control units, including accompanying edge nodes, autonomous IoT platforms, etc.
Field 4.2	Smart Network and Control Plane	KPIs related to Smart Network and Control plane, which provides virtual connectivity functionality (e.g., 5G BS; Wi-Fi AP, or gateway of a LoRa network) in the form of SDN (SD-WAN) and NFV for network functions, to connect smart components directly and logically within communication infrastructure.

Field 4.3	Data Management Plane	KPIs related to Data Management plane, which virtualises the shared data ecosystem viewed as a combination of data acquisition, data processing, data availability and data interoperability capabilities.
Field 4.4	Application and Services Plane	KPIs related to Application and Services plane, which supports and provides human-centric enablers for administrative and end-user applications and services.
Field 4.5	Self-*	KPIs related to ASSIST-IoT, which will establish how various needs for self-* behaviour can be captured, processed, and applied in a working system (with only minimal interruption, e.g., no need for complete restart).
Field 4.6	FL	KPIs related to a set of AI/ML algorithms adapted to edge-cloud Continuum, detailed guidelines concerning data pre-processing, storing/sending of data when and how to apply AI/ML, and validated examples of advantages of joint use of semantics and AI/ML.
Field 4.7	Cybersecurity	KPIs related to the main aspects covered by the security enablers, identification, and authorization actions, and cybersecurity monitoring, including valid and invalid attempts, in order to measure managed activity, and assessment activity that reflects the visibility obtained from the field operations.
Field 4.8	DLT	KPIs related to ASSIST-IoT will establish data privacy, trust, interoperability, automated accountability of interactions/communications and support for data governance services with the help of DLT.
Field 4.9	Manageability	KPIs related to how to reduce complexity and improve configuration capabilities, providing cross-cutting coordination and orchestration between enablers.

Fields within the fifth KPI dimension that deal with ethical, societal, gender and legal evaluation.

Table 6 Dimension 5 - Fields connected with ethical, societal, gender and legal evaluation

Name	Short description	Long description
Field 5.1	Legal issues	KPIs pertaining to legislation.
Field 5.2	Holistic innovation	KPIs concerning the ability of ASSIST-IoT to conceive new products, services and processes that are human-centred.
Field 5.3	User work time/life impact	KPIs related to the extent to which ASSIST-IoT supports and improves the user's quality of life.
Field 5.4	Targeted social groups	ASSIST-IoT's ability to target the needs of more vulnerable social groups.
Field 5.5	Trusted, safe, secure IoT environment promotion	KPIs related to promoting the safety of the IoT environment.
Field 5.6	Community engagement	KPIs pertaining ASSIST-IoT's interaction directly with individuals through public community events and activities.

2.2 Data collection management

Evaluation method of ASSIST-IoT embeds the intention to ensure ease of use and maximization of stakeholders' and users' gains. Thus, the core of the ASSIST-IoT evaluation methodology is formed through direct contact with the stakeholders and users. One of the points of contact is going to be through one-to-one interviews. These will be conducted with coordinators of all pilots, as well as leaders of tasks pertaining to the specific pilot. Along with one-to-one interviews, desk research, secondary research and on-line questionnaires are also going to be employed.

Ways for obtaining the evaluation data for the ASSIST-IoT project are as follows:

1. desk research will be performed to investigate the existing material (documentation),
2. face-to-face interviews/online questionnaires with different stakeholders (open call projects, WP/Task leaders, end users, businesses, software developers and researchers) are going to be performed,
3. questionnaires will be organized and conducted to obtain feedback from wider IoT community if needed.

To be able to assess ASSIST-IoT progress in a more objective manner, obtained findings will be assigned a numerical value, a KPI.

To allow comparison of KPIs and calculation of overall scores for fields and dimensions of measurement, each KPI will be assigned a number, which will denote the percentage (completeness) of achievement of the target set for that KPI. Thus, 0% will mean that none of the ASSIST-IoT activities have managed to contribute to the KPI and 100% will mean that the target set in this evaluation plan has been reached. Moreover, values exceeding 100% mean that for that KPI, ASSIST-IoT has achieved more than initially planned.

The **KPI value** will be measured directly (for example messages/second, user satisfaction on the Likert scale). Then, the **KPI score**, expressed in percentages in relation to the KPI target, is going to be calculated for each KPI.

Thus, the steps in defining the KPI score are as follows:

1. Define the KPI unit of measure
2. Define the KPI target value
3. Define the function to transform the KPI value into the KPI score. The function must implement the following rules:
   a. KPI value = no achievement → KPI score = 0%
   b. no achievement < KPI value < target → 0% < KPI score < 100%
   c. KPI value = target → KPI score = 100%
   d. KPI value > target → KPI score > 100%

This approach allows us to, at the indicator level:

1. show the current value of an indicator,
2. define the performance function of an indicator where, for example, higher value means higher performance, lower value means lower performance and non-numerical values are transformed to a score,
3. interpret the value of an indicator against the original target set by ASSIST-IoT.

Then, KPI scores are used to calculate **Field scores**, which are calculated as average of all KPI scores for that field. These are expressed in percentages as well.

Formula for computation of the Field score is expressed in *Figure 1*. If all KPIs reach the target, which would manifest as all KPI scores being 100%, then Field score is also going to be 100%.

$$FieldScore = \frac{\sum_{i=1...N} KPIscore_i}{N}$$

Figure 1 Formula for computation of the Field score

Field scores are then further combined into a **Dimension score**, which is defined as the average of Field scores for that dimension.

On field and dimension level we thus calculate a score by considering the performance values of corresponding KPIs. This approach would provide an indication of achievements for specific indicators, as well as overall results obtained by ASSIST-IoT.

2.3 Use and communication of evaluation findings

It is important to consider how the evaluation findings can be further used and communicated to offer the maximum of their impact to ASSIST-IoT ecosystem, target audience and stakeholders.

Specifically, once the Consortium will obtain the results of the evaluation process, we will have a much deeper insight into where ASSIST-IoT stands both regarding its internal developments as well as regarding its connection to the outside world, IoT ecosystem, its users, its audience, and stakeholders. Through communication of evaluations results, we will ensure that ASSIST-IoT achievements are made well known in public and through this process they can be further elaborated, strengthened, adapted, or even corrected, if a proper two-way communication has been ensured.

As per ASSIST-IoT plan, evaluation findings will be initially assessed and used by all partners of the Consortium, each one from his own different perspective, based on the field of expertise and market activity of each partner. For instance, on the one hand, industrial partners will consider the evaluation results to confirm that their commercialisation plans are valid, and the technologies developed/tested are the ones requested by the markets/societies. On the other hand, the research institutions and academia will become aware of the exact technologies that have the potential, both technological and commercial wise, to be further developed and through R&D actions future developments to be planned to target certain scientific domains.

In more details, the Exploitation dimension will be communicated and used mainly by both marketing and technology departments of the commercial entities participating into the project, for the direct commercial exploitation of results. The evaluation results will be also used to drive more the overall exploitation of EU-funded projects, providing clear roadmaps through which the effectiveness of research projects' actions will be enhanced.

For the Pilots dimension, the evaluation will show the level of maturity and effectiveness of ASSIST-IoT proposed solution towards IoT markets as well as the readiness of those domains to the proposed IoT technologies in general but also to ASSIST-IoT solution. Similarly, these findings can be communicated and used by both research partners to further evaluate which scientific developments are most needed for specific domains, and by the commercial partners to focus on specific market segments and to specific actions to provide mature and commercially viable solutions to them.

The third dimension, the Impact, will have a similar use by both the participants of different EU-funded projects and project partners, as it will have an impact on more general issues such as dissemination, standards, market analysis, new business models to use and community engagement. It is the dimension that will exploit to its maximum the ASSIST-IoT communication channels and will drive the exploitation plans of different project actions and entities. The communication of evaluation results of the impact dimension will appeal also to a larger public and will show how societal issues are dealt with and how can the technology development respond to them.

The fourth dimension, Technology fields, will look more into technology issues' details, and will be communicated mainly to technology-related actors, therefore research, scientific, academic, technology and industrial partners, and will show how far our work did, and how much is left to develop a suitable solution for industry.

The fifth dimension, ethical, societal, gender and legal evaluation, is important for all involved parties, as it provides confidence that project results are compliant with legal and ethical standards, and accepted by the society as safe, ethical and legal.

To the efficient communication of the evaluation results of all dimensions, a vital role will play all the ASSIST-IoT communication channels and impact activities that have been well established and planned since the beginning of the project. Details on these channels, impact plans and strategy are provided in the WP9 deliverables.

3 Key Performance Indicators (KPI)

This section presents the Key Performance Indicators (KPIs), which are divided into five main dimensions of measurement: impact, exploitation, technology, pilots and ethical, societal, gender and legal aspects. For clarification, the Key Validation Indicator (KVI) as described in the Grand Agreement are also tagged with a KPI number for WP8. In this document the KPI numbering is used and, if it concerns a KVI (Key Validation Indicator – associated to objectives set out in the GA for the project as a whole), the KVI number is stated in brackets. Actual design of KPIs is based on the requirements of the ASSIST-IoT project, which are presented in section **¡Error! No se encuentra el origen de la referencia.**, while KPIs themselves are grouped into fields and thus dimensions in section 3.1.

3.1 KPIs grouped by dimension

This section details, for each KPI dimension, how KPIs are grouped into fields within this dimension and what are the properties of these KPIs. This is done via two consecutive tables per dimension – the first one specifying the grouping of KPIs into fields and the latter one specifying KPI properties.

The list has been compiled by ASSIST-IoT partners based on best-practises in similar domains and then further refined to reflect the specifics of this project.

The following KPI properties are provided:

- ***ID***: unique identifier of the KPI,
- ***Name***: short unique KPI name,
- ***Description***: description of the KPI,
- ***Metric***: a standard or dimension of measurement in which the KPI's value is expressed,
- ***Target***: a value against which to benchmark the KPI. It is obtained either from the commitments set out in the actions' Grant Agreement, from the literature or from ASSIST-Io partner's experience.

Further details about each KPI are provided in the annexes. They contain the following additional information about each KPI:

- ***Dimension***: into which of five ASSIST-IoT dimensions (Exploitation, Pilots, Impact, …) the KPI belongs,
- ***Fields***: into which field within the above selected dimension the KPI belongs,
- ***Target*** (T): target of the KPI, described above,
- ***KPI score calculation***: each KPI is assigned a score, which is computed from KPI value and target T in accordance with the rules set in Section 2.2. This column provides the function or the method, which is used to obtain this KPI score,
- ***Comments***: any additional comments about the KPI.

3.1.1 Exploitation

This section describes the KPIs designed to evaluate the success of the exploitation. These aim to ensure a high degree of participation and dissemination of the scope and objectives of the project.

KPIs presented below are partitioned into fields, as described in Section 2.2.

Table 7 Dimension 1 - Exploitation; distribution of KPIs

Field id	Field Name	KPI id	Name
Field 1.1	Stakeholders' and third parties' engagement	KPI.1.1.1 *(KVI-7.2)*	Stakeholders/innovators expressing interest of willing to join the project or to adopt ASSIST-IoT.
		KPI.1.1.2	External adopters
		KPI.1.1.3 *(KVI-5.1)*	Satisfaction of tactile applications
		KPI.1.1.4	IoT pillar institutions involved
		KPI.1.1.5	System usability scale

		KPI.1.1.6	Technology acceptance
Field 1.2	Business models	KPI.1.2.1 KPI.1.2.2 *(KVI-7.1)* KPI.1.2.3 KPI.1.2.4 *(KVI-8.2)* KPI.1.2.5 KPI.1.2.6	Target customers Business plans for exploitable assets Total addressable markets Innovative business models Technological advantage Diversification
Field 1.3	Exploitation of products	KPI.1.3.1 KPI.1.3.2 *(KVI-8.3.1)* KPI.1.3.3 *(KVI-8.3.2)* KPI.1.3.4 KPI.1.3.5 *(KVI-1.1)* KPI.1.3.6 KPI.1.3.7 *(KVI-6.2)* KPI.1.3.8	IPRs Revenue growth Market share Return of Investment (RoI) Architecture made available Conformance to new techs New verticals identified Collaborating IoT Security Projects

Table 8 Dimension 1 - Exploitation KPIs

KPI id	Name	Description	Metric	Target
KPI.1.1.1 *(KVI-7.2)*	Stakeholders/innovators expressing interest of willing to join the project or to adopt ASSIST-IoT.	Determine how many stakeholders/innovators expressed their interest on ASSIST-IoT project	number	>10
KPI.1.1.2	External adopters	Determine how many external adopters expressed their interest to adopt or participate on the project innovations (including open callers)	number	50
KPI.1.1.3 *(KVI-5.1)*	Satisfaction of tactile applications	Quantify/determine the level of acceptance and satisfaction of the solutions of tactile interned delivered by ASSIST-IoT.	TAM	85%
KPI.1.1.4	IoT pillar institutions involved	Determine the pervasiveness ability to engage external entities that could be representative of the various pillars of IoT (5G, AI, devices…)	# instituti ons	12
KPI.1.1.5	System usability scale	Determines the usability scale of the system based on a proposed measuring approach	Numbe r	70%
KPI.1.1.6	Technology acceptance	Determines the acceptance level of ASSIST-IoT as a whole based on a sound, reliable methodology	number	>5
KPI.1.2.1	Target customers	List of potential customers extracted from data market analyses	number	500
KPI.1.2.2 *(KVI-7.1)*	Business plans for exploitable assets	Business plans for a % of exploitable assets	%	100%
KPI.1.2.3	Addressable markets	Numbers of user to be addressed	% number	10k users
KPI.1.2.4 *(KVI-8.2)*	Innovative business models	Number of proposed viable business models with no presence in the industrial sector	number	>6
KPI.1.2.5	Technological advantage	Measured as % of operation (over total operational expenditures) supported by ASSIST-IoT technology	%	10-15%
KPI.1.2.6	Diversification	Number of new vertical markets where the proposed business models could be applied without significant changes (pivoting)	number	8
KPI.1.3.1	IPR	Number of partners and third parties who are planning to exploit the intellectual property from the results their own results	number	5

KPI.1.3.2 *(KVI-8.3.1)*	Revenue growth	Revenue growth increase for SMEs and industries	%	15-25%
KPI.1.3.3 *(KVI-8.3.2)*	Market share	Market share gained by ASSIST-IoT partners thanks to the developed innovations	%	15%
KPI.1.3.4	Return of Investment (RoI)	The RoI due to ASSIST-IoT adoption, helping companies to increase revenues, including profit margins and customer satisfaction	%	5-10%
KPI.1.3.5 *(KVI-1.1)*	Architecture made available	Reference architecture available, published and presented to relevant IoT and NGI related entities	Boolean	True
KPI.1.3.6	Conformance to new techs	Determine whether ASSIST-IoT is conforming to new techniques and technologies, analysing a list.	% Out of a list	100%
KPI.1.3.7 *(KVI-6.2)*	New verticals identified	Identification of different new verticals to deploy architecture reference implementations	Number	At least 3
KPI.1.3.8	Collaborating IoT Security Projects	Determine the quantity of cyber-security related projects (EC-funded and otherwise) that are being engaged to relevantly collaborate (anyhow) with ASSIST-IoT.	Number	10

3.1.2 Pilots

In this section the KPIs designed to assess the success of the pilot deployments are described. By using the ASSIST-IoT components, the efficiency and productivity is going to be improved. The defined KPIs analyse how much these parameters can be enhanced.

KPIs presented below are partitioned into fields related with pilots.

Table 9 Dimension 2 - Pilots; distribution of KPIs/KVIs

Field id	Field Name	KPI/KVI id	Name
Field 2.1	Port automation Pilot	KPI.2.1.1 KPI.2.1.2 KPI.2.1.3 KPI.2.1.4 KPI.2.1.5 KPI.2.1.6 KPI.2.1.7 KPI.2.1.8 KPI.2.1.9	Decrease of Quay to stack and gate to stack turnaround time CHE fleet dispatching Yard equipment workforce Yard accidents Remote wireless bandwidth Remote wireless latency Proximity range Redundant access networks New human-to-machine interfaces
Field 2.2	Smart Safety of workers Pilot	KPI.2.2.1 KPI.2.2.2 KPI.2.2.3 KPI.2.2.4 KPI.2.2.5 KPI.2.2.6 KPI.2.2.7 KPI.2.2.8 KPI.2.2.9 KPI.2.2.10	Workers alerts OSH hazards detected Hazard detection time User acceptance Notification and alerting Reporting BIM manipulation Near-miss fall from a height Worker alert latency OSH manager notification latency
Field 2.3	Vehicle in-service emission diagnostics	KPI.2.3.1 KPI.2.3.2 KPI.2.3.3 KPI.2.3.4 KPI.2.3.5	Series recall reduction Development time for diagnostic software updates Number of data channels measured in parallel Available connectivity channels provided by ASSIST-IoT Time to update a PCM calibration on the Edge, after a vehicle was offline

		KPI.2.3.6 KPI.2.3.7	Number of Drivelets, which can be stored on a GWEN for later download Server capacity to manage and monitor vehicle fleet
Field 2.4 s	Vehicle exterior condition inspection and documentation	KPI.2.4.1 KPI.2.4.2 KPI.2.4.3 KPI.2.4.4	Detected defects Vehicle inspection elapsed time Revenues for repairing services Minimised dataset to be uploaded
Field 2.5	Overall pilots' implementation	KPI.2.5.1 *(KVI-1.2)* KPI.2.5.2 *(KVI-4.1)* KPI.2.5.3 *(KVI-6.1)*	Architecture integrated in lab and real conditions AI-driven pilots Successful pilots' implementation

Table 10 Dimension 2 – Pilots

KPI id	Name	Description	Metric	Target
KPI.2.1.1	Trucks turnaround time	Decrease of quay to stack and gate to stack truck turnaround time due to real-time and correct data	%	5%
KPI.2.1.2	CHE fleet dispatching	Increase of yard CHE fleet dispatching dynamics due to remote operation	%	30%
KPI.2.1.3	Yard equipment workforce	Increase of yard equipment workforce due to remote operability from office environment	%	20%
KPI.2.1.4	Yard accidents	Decrease of accidents due to automation and less persons at quay and yard	%	80%
KPI.2.1.5	Remote wireless bandwidth	Bandwidth required to support remote operation of CHEs via wireless access	number	>60 Mbps
KPI.2.1.6	Remote wireless latency	L2 network latency required to support remote operation of CHEs via wireless access	number	20ms
KPI.2.1.7	Proximity range	Coverage area (in m) for starting M2M authentication process to avoid unauthorised accesses	number	15m
KPI.2.1.8	Redundant access networks	Number of supported wireless access networks for the remote operation of CHEs	number	2
KPI.2.1.9	New human-to-machine interfaces	Human-to-machine interfaces provided for CHE drivers	number	3
KPI.2.2.1	Workers alerts	Percentage false positives or negatives out of total when alarming a worker of a risk nearby	%	< 5%
KPI.2.2.2	OSH hazards detected	Types of OSH hazards to be detected and prevented	number	10
KPI.2.2.3	Hazard detection time	Reduction of detection time of hazard/risk situation	%	50%
KPI.2.2.4	User acceptance	User acceptance of technology applied	%	> 75%
KPI.2.2.5	Notification and alerting	The OHS shall be informed about hazardous events within the construction area (success rate)	%	>90%
KPI.2.2.6	Reporting	The OHS shall report context-based media reports (photo and information) through the MR device (success rate).	%	>90%
KPI.2.2.7	BIM manipulation	Users can manipulate the BIM models through the MR devices:	number (6DOF)	≥ 6 degrees of freedom
KPI.2.2.8	Near-miss fall from a height	Success rate of the method for detecting near-miss fall from a height situation	%	>85%
KPI.2.2.9	Worker alert latency	Latency between worker entering a dangerous zone and them being warned	time	<1.5s
KPI.2.2.10	OSH manager notification latency	Latency between worker entering a dangerous zone and the OSH manager being notified	time	<5s
KPI.2.3.1	Series recall reduction	Reduce number of potential recalls based on emission outliers in a set of fleet emission distributions, with the help of ASSIST-IoT tools	%	50%

KPI.2.3.2	Development time for diagnostic software updates	Reduce time to understand and fix a field issue in a released diagnostic software, with the help of ASSIST-IoT tools	%	> 50%
KPI.2.3.3	Number of data channels measured in parallel	Number of high frequency data channels which can be measured in parallel from various vehicle sources	number	≥ 200
KPI.2.3.4	Available connectivity channels provided by ASSIST-IoT	Availability of different connectivity channels, to allow the best compromise between low-latency transmissions of small data packages and cost-efficient, yet timely uncritical data transfer of large data packages, such as for 2G, 3G, 4G, 5G, Wi-Fi, Ethernet	boolean	TRUE or FALSE (for each option)
KPI.2.3.5	Time to update a PCM calibration on the Edge, after a vehicle was offline	Time needed, until an outdated calibration level on the edge is detected and the update process is triggered, after a vehicle is online again	Time	<1h
KPI.2.3.6	Number of Drivelets, which can be store don a GWEN for later download	Number of Drivelets which can be stored on a GWEN in parallel, until oldest Drivelets must be deleted because of exhausted memory space	number	≥ 100
KPI.2.3.7	Server capacity to manage and monitor vehicle fleet	Number of vehicles (= edge nodes), which can be managed within an ASSIST-IoT network in parallel (Smart queuing mechanism allowed)	number	≥ 200
KPI.2.4.1	Detected defects	Increase on detected defects on the outer body of vehicles that would otherwise be unnoticed	%	> 40%
KPI.2.4.2	Vehicle inspection elapsed time	Faster vehicle inspection compared to current manual practices	%	> 30%
KPI.2.4.3	Revenues for repairing services	New revenue through additional repair services	%	> 10%
KPI.2.4.4	Data transfer minimisation	Minimisation of data transfer in the pilot thanks to FL in case of FL-AI-based, automated inspection with edge computing	%	50%
KPI.2.5.1 *(KVI-1.2)*	Architecture integrated in lab and real conditions	Reference implementation of the architecture available and working in laboratory and real conditions	Boolea n	TRUE
KPI.2.5.2 *(KVI-4.1)*	AI-driven pilots	Pilots that are AI-driven, getting historic and online data from IoT deployments	%	> 20%
KPI.2.5.3 *(KVI-6.1)*	Successful pilots' implementation	Successful implementation of the 3 real-world pilots fulfilling a high % of use cases established initially in the GA	%	95%

During the execution of pilot trials lots of information will be produced. These data will be analysed in the evaluation process. The result of the evaluation will be compared with the estimated target, to measure the effectiveness of the ASSIST-IOT products.

3.1.3 Impact

The fundamental element of the ASSIST-IoT impact strategy is the constant operation and update with project activities of all impact channels to make the project more visible and impactful. Website, social media, publications, events, presentations, contribution to SDOs, exploitation of results, market and business development are in the frontline of the "impacting" image of the project.

During the development of the project and, moreover, at last stages of this period, the repercussion of the tasks carried out inside the ASSIST-IoT framework will be measured and analysed. ASSIST-IoT will spread its knowledge and results, by means of standardization, information, support, or product, to reach all groups of the scientific, academic, and industrial community involved in IoT. This will benefit the community helping to improve the current situation of non-interoperability in the IoT systems and platforms. For that reason, with the aim of contribute positively the community and future activities based on ASSIST-IoT; we will accomplish a series of tasks that will provide the desired impact of the project. To define and quantify this 'desired impact' a series of KPIs activity-related have been defined with a minimum effect to be fulfilled. Achieving these objectives can be understood that ASSIST-IoT have reached the desired impact on the IoT environment for the scientific, academic, and industrial areas.

To measure the progress and the impact of the project, specific KPIs have been established (analysed in detail in D9.1 and D9.2) starting from the GA. KPIs are specific metrics that help us control, monitor and evaluate the progress of the project and the impact created. During the timeline of the project, we may diversify the proposed impact approach, under specific circumstances, but it is very important to closely follow and support the defined course of action for impact creation (refer to D9.2).

The following table, present all the identified KPIs that are immediately related to the impact creation. To be more accurate, it is important to mention that the activities referred to the tables have a dual nature:

- The **non-interactive activities** include communication of any related activity and information through website articles, press releases and technical and non-technical articles, magazines, and books.
- The **interactive activities** include human interaction and aim to establish more trusted relationships between the Consortium members and potential stakeholders, thus strengthening the target audience involvement. Such activities include the use of communication and dissemination material at important international venues such as posters, leaflets, presentations, workshops, special sessions, and panels.

To ensure that the KPIs will be met, WP9 partners have established a dedicated plan, as thoroughly described in D9.2, which will facilitate the knowledge diffusion of ASSIST-IoT project. This impact approach consists of a comprehensive and well-structured, set of activities, to facilitate the broad promotion and effective communication of the developed concepts, technologies, pilots/trials, and overall results.

Briefly the main objectives that will achieved by fulfilling the impact KPIs are summarized below:

- To raise awareness of the project to the relevant industries and stakeholders,
- To communicate project activities, innovations, findings, and recommendations,
- To attain high project visibility and increased awareness to the broadest audience,
- To contribute to SDOs through ASSIST-IoT architecture, trials, and results
- To build communication interconnection and to enhance collaboration with other research initiatives, such as the H2020 program and the NGIoT community, ensuring alignment with ongoing projects, and influence other research EU working groups and associations such as the AIOTI, and 5G-PPP.

The KPI id's as shown in tables 11 and 12 below are subdivided into Impact fields and then further elaborated in clear descriptions with measurable or validated objectives (based on qualitative or quantitative aspects), as depicted in D9.2 Section 2.2.1.

Table 11 Dimension 3 - Impact; distribution of KPIs

Field id	Field Name	KPI id	Name
Field 3.1	Standardisation	KPI.3.1. 1	Internationally recognized standards supported in ASSIST-IoT solutions
		KPI.3.1.2	Communications to modify/improve existing standards used in ASSIST-IoT
		KPI.3.1.3	Recommendations in relevant SDO's and initiatives
		KPI.3.1.4	SDOs and pre-normative initiatives engaged.
		KPI.3.1.5	Identified standards related to ASSIST-IoT activities
Field 3.2	Dissemination	KPI.3.2.1	Number of scientific publications
		KPI.3.2.2	European IoT Platforms compatible and connected to ASSIST-IoT modules
		KPI.3.2.3	Letters of interest to adopt ASSIST-IoT technologies
		KPI.3.2.4	Research actions including one or several modules developed on ASSIST-IoT
		KPI.3.2.5	Industrial actions including one or several modules developed on ASSIST-IoT
		KPI.3.2.6	Cybersecurity fairs/congresses attended

Field 3.3	Communication	KPI.3.3.1 KPI.3.3.2 KPI.3.3.3 KPI.3.3.4 KPI.3.3.5 KPI.3.3.6 *(KVI-8.1.3)* KPI.3.3.7 *(KVI-8.1.2)* KPI.3.3.8 *(KVI-8.1.1)* KPI.3.3.9	Communication and community building activities organised Subscribers to ASSIST-IoT communication channels and related activities Online communications (news, posts, articles) Online traffic attracted (website, social media) Participation in external IoT Communities IoT related organisations Joining communities Professionals engaged for impact External Professionals involved

Table 12 Dimension 3 – Impact

KPI id	Name	Description	Metric	Target month(18)/36
KPI.3.1.1	Internationally recognized standards supported in ASSIST-IoT solutions.	Number of standards supported in ASSIST-IoT solutions from different SDO's and initiatives	Number	(15)/40
KPI.3.1.2	Communications to modify / improve existing standards used in ASSIST-IoT.	Number of identified required modifications or improvements of existing standards	Number	(2)/6
KPI.3.1.3	Recommendations in relevant SDO'S and initiatives	Number of activities/contributions to relevant recommendations regarding ASSIST-IoT technologies	Number	(4)/10
KPI.3.1.4	SDOs and pre-normative initiatives engaged.	Number of engagements in different SDO's and initiatives	Number	(6)/40
KPI.3.1.5	Identified standards related to ASSIST-IoT activities	Number of identified standards related to ASSIST-IoT solutions	Number	(50)/120
KPI.3.2.1	Number of scientific publications.	Determines the number of publications in Conference Proceedings, Journals as well as technical reports	Number	38
KPI.3.2.2	European IoT Platforms compatible and connected to ASSIST-IoT modules	Determines the number of IoT platforms developed in research projects or otherwise (in Europe) that have been connected/integrated with any of ASSIST-IoT enablers	Number	4
KPI.3.2.3	Letters of interest to adopt ASSIST-IoT technologies	Determines the interest of external parties (potential customers or not) on the ASSIST-IoT technology (expressed via letter	Number	4
KPI.3.2.4	Research actions including one or several modules developed on ASSIST-IoT	Determines the pervasiveness of ASSIST-IoT products as baseline for further research projects	Number	2
KPI.3.2.5	Industrial actions including one or several modules developed on ASSIST-IoT	Determines the pervasiveness of ASSIST-IoT products as baseline for further Industrial implementations	Number	2
KPI.3.2.6	Cybersecurity fairs/congresses attended	Determines the number of fairs/congresses attended by partners related to cybersecurity	Number	8
KPI.3.3.1	Communication and community building activities organised/co-organised	Determines the number of events organised/co-organised by ASSIST-IoT such as workshops, webinars, events, open trials etc.	Number	12

KPI.3.3.2	Subscribers to ASSIST-IoT communication channels and related activities	Number of visitors, subscribers, and followers in ASSIST-IoT communication channels	Number	2000
KPI.3.3.3	Online communications (news, posts, articles)	Number of posts and news communicated through the website and social media	Number	>600
KPI.3.3.4	Online traffic attracted (website, social media)	Number of visitors and persons reached by the online communication activities	Number	50.000
KPI.3.3.5	Participation in external IoT Communities	Determines the level of participation of ASSIST-IoT in external IoT Communities (e.g., AIOTI)	number	25
KPI.3.3.6 *(KVI-8.1.3)*	IoT related organisations	Determines the capacity of ASSIST-IoT of involving external organisations (related to IoT) to participate/collaborate/follow with the project	number	12
KPI.3.3.7 *(KVI-8.1.2)*	Joining communities	Refers to the tentative (and achievement) of ASSIST-IoT to join external communities (e.g., ALICE ETP).	number	>20
KPI.3.3.8 *(KVI-8.1.1)*	Professionals engaged for impact	Professionals attracted to enhance impact.	number	>2000
KPI.3.3.9	External Professionals involved	External professionals involved (open-source developers contributions and hackathons participants)	number	80

Having listed and explained the KPIs Impact-related, an evaluation of completion status will be done to determine how far ASSIST-IoT is to reach the success threshold. Based on this, future activities will be defined to complete the minimum values required per KPI.

In addition to above mentioned Impact-related KPIs, impact creation is achieved through a well-balanced mix of communication, dissemination, standardisation, and business/market activities which take place throughout the project lifetime. The content and targeted audience of these activities may vary based on the channel to be used and the time (compared to the project lifetime) that this activity takes place. Those activities are closely monitored under WP9 and their success status in impact creation is evaluated against certain WP9 set KPIs and timeline, that is worth presenting in brief below, supplementing the KPIs presented in the table 12 above. More details are also available in D9.2.

In addition, irreplaceable part of the impact plan, and strategy, is also the control and monitoring mechanisms established within WP9. More details about the plan and functionality of such control, monitoring and evaluation mechanisms are presented in D9.2 (Section 2.3).

3.1.4 Technology

The KPIs defined within the Technology dimension should allow to measure to what extent solutions proposed in ASSIST-IoT project reached one of project's goals i.e., to propose mechanisms to achieve interoperability between heterogeneous IoT artefacts. This dimension addresses both functional aspects related to development, deployment, and architecture of ASSIST-IoT components, and alignment to existing standards and open technologies. KPIs defined here, should allow to evaluate technologies used, their maturity and readiness level. Moreover, they should allow to assess how this technology has been integrated and is performing.

KPIs presented below are partitioned into fields (connected with interoperability) as follows.

Table 13 Dimension 4 - Technology; distribution of KPIs

Field id	Field Name	KPI id	Name
Field 4.1	Device and Edge Plane	KPI.4.1.1 KPI.4.1.2	CPU load of GWEN processes Memory usage of GWEN processes

Field 4.2	Smart Network and Control Plane	KPI.4.2.1 *(KVI-2.1.1)* KPI.4.2.2 *(KVI-2.1.2)* KPI.4.2.3 *(KVI-2.2)* KPI.4.2.4. KPI.4.2.5	VNFs achieved for improving network AI models achieved for improving network Percentage of network connections being improved Hosts connected to VPN k8s clusters Messages classified
Field 4.3	Data Management Plane	KPI.4.3.1 KPI.4.3.2 KPI.4.3.3 KPI.4.3.4 KPI.4.3.5	Streaming Annotation Latency Streaming Translation Latency Streaming Annotation Clients Number Semantic Repository File Size Support Semantic Repository File Size Support
Field 4.4	Application and Services Plane	KPI.4.4.1 KPI.4.4.2 KPI.4.4.3	Human-centric components Human-centric UCs per pilot UX usability
Field 4.5	Self-*	KPI.4.5.1 KPI.4.5.2	Number of autonomous decisions taken while executing pilots. Number of components/resources involved in self-* process
Field 4.6	FL	KPI.4.6.1 KPI.4.6.2 KPI.4.6.3 KPI.4.6.4	Distributed AI costs FL users FL models FL use cases
Field 4.7	Cybersecurity	KPI.4.7.1 KPI.4.7.2 KPI.4.7.3 KPI.4.7.4 KPI.4.7.5	Users covered by ASSIST-IoT security Pervasiveness of user coverage by security enablers Correct identification attempt ratio Validated authorization request ratio Detected alerts per hour
Field 4.8	DLT	KPI.4.8.1 *(KVI-3.1)* KPI.4.8.2 *(KVI-3.2)* KPI.4.8.3 KPI.4.8.4 KPI.4.8.5 KPI.4.8.6	Automated accountability of interactions /communications performed (defining responsible) Data governance services supported by IoT-enabled DLT. Availability of FL ML local models' collection. Decrease in training dataset biases. Number of use cases successfully tested with the DLT registry enabler Number of use cases successfully tested with the DLT integrity verification enabler
Field 4.9	Manageability	KPI.4.9.1 KPI.4.9.2 KPI.4.9.3	Enablers deployed through interface Service topologies and enablers Configuration parameters

Table 14 Dimension 4 - Technology

KPI id	Name	Description	Metric	Target
KPI.4.1.1	CPU load of GWEN processes	This KPI measures the CPU load of the gateway and the edge node process or processes through a monitoring agent installed on the GWEN.	% Of average CPU load	<75%
KPI.4.1.2	Memory usage of GWEN processes	This KPI measures the memory usage of the GWEN process or processes through a monitoring agent installed on the GWEN.	% Of average memory usages	<75%
KPI.4.2.1 *(KVI-2.1.1)*	VNFs achieved for improving network	VNFs (CNFs) achieved for improving performance and network reconfiguration and other network tasks.	# of CNFs	6
KPI.4.2.2 *(KVI-2.1.2)*	AI models achieved for improving network	AI models achieved for improving performance and network reconfiguration and other network tasks.	# of AI models	3

KPI.4.2.3 *(KVI-2.2)*	Percentage of network connections being improved	Network transmissions execute one of the routines and get an improvement from the baseline.	From baseline TBE	20%
KPI.4.2.4	Hosts connected to VPN k8s clusters	Number of hosts clusters connected to remote k8s clusters thanks to VPN enabler (in total of all pilots)	# of hosts	8
KPI.4.2.5	Messages classified	Messages classified in all pilots by the traffic classificatory	# of messages	>500
KPI.4.3.1	Streaming Annotation Latency	Processing Latency - duration between reception of a message at input topic, and processed message arriving at the output topic. Measured as average over 1 minute of constant message output aimed at saturating the processing capacity with high frequency messages of small or medium size.	time	<10ms
KPI.4.3.2	Streaming Translation Latency	Processing Latency - duration between reception of a message at input topic, and processed message arriving at the output topic. Measured as average over 1 minute of constant message output aimed at saturating the processing capacity with high frequency messages of small or medium size.	time	<10ms
KPI.4.3.3	Streaming Annotation Clients Number	Supported number of concurrent clients measured as number of annotation channels being used at the same time (not number of clients sending or receiving messages), with at least one producer and consumer (clients sending and receiving messages) per channel.	number	>9
KPI.4.3.4	Streaming Translation Clients Number	Supported number of concurrent clients measured as number of translation channels being used at the same time (not number of clients sending or receiving messages), with at least one producer and consumer (clients sending and receiving messages) per channel.	number	>9
KPI.4.3.5	Semantic Repository File Size Support	Maximal supported size of a versioned data model stored in the repository, measured per versioned file i.e., a single version of a model, not all versions together. Latency of basic operations (retrieval, upload, retrieval of metadata) should not be significantly different (<20% time difference), than average for smaller files. In this context, latency excludes network speed, and counts only processing time after upload, or before download.	file size	>5GB
KPI.4.4.1 *(KVI-5.2)*	Human-centric components	Human-centric components with traceable and quantifiable impact in the quality of work/life	number	9
KPI.4.4.2 *(KVI-6.3)*	Human-centric UCs per pilot	Number of Human-centric UCs per pilot with NGI technologies performing meaningful tasks	number	3
KPI.4.4.3	UX usability	End-users level of satisfaction after testing GUIs of the project by performing a SUS assessment	number	70
KPI.4.5.1	Number of autonomous decisions	Number of autonomous decisions taken by self-* enablers in the same field of action in a pilot.	number	>5
KPI.4.5.2	Number of resources involved in self-* process	Resource is a “thing” in IoT deployment	number	>5
KPI.4.6.1	Distributed AI costs	Reduction of processing needs/costs of distributed AI regarding equivalent performing algorithms	%	50%

KPI.4.6.2	FL users	Number of simultaneous FL users/parties participating in the federated training	number	10
KPI.4.6.3	ML models	Number of ML models supported by the ASSIST-IoT FL system	number	2
KPI.4.6.4	FL use cases	Number of use cases in the pilots that has been made use and successfully tested with ASSIST-IoT FL system	number	2
KPI.4.7.1	Users covered	Potential number of users that could be covered by implementing ASSIST-IoT security / privacy methods	# of users	20k
KPI.4.7.2	Pervasiveness of users coverage	Percentage of users implementing the security and privacy methods in the ASSIST-IoT use cases, including the identity, authorization, and cybersecurity monitoring services.	%	75%
KPI.4.7.3	Correct identification attempt ratio	Correct identification attempt ratio Percentage of correctly identified accesses in the system. % over total requests.	%	75%
KPI.4.7.4	Validated authorization request ratio	Validated authorization request ratio Percentage of correctly validated authorized requests in the system. % over total requests.	%	40%
KPI.4.7.5	Detected alerts per hour	Number of alerts raised in a certain time	number	10
KPI.4.8.1 *(KVI-3.1)*	Automated accountability of interactions/communications performed (defining responsible)	This KPI identifies the accountability of the involved actors when they communicate with ASSIST-IoT.	% out of total interactions	>85%
KPI.4.8.2 *(KVI-3.2)*	Data governance services supported by IoT-enabled DLT.	Data governance services, e.g., management (extraction, curation); protection (anonymization, pseudonymization); processing (data in motion, data brokers) supported by IoT-enabled DLT	% out of total interactions	10
KPI.4.8.3	Availability of FL ML local models' collection	This KPI identifies how available are the collected local FL models. We compare this availability to the baseline availability which is the availability of the local FL models when they are collected on a centralised server.	From baseline TBD	75%
KPI.4.8.4	Decrease in training dataset biases	This KPI identifies the decrease in the training datasets biases (e.g., the data skewness) when using a DLT-based local FL model verification mechanism.	From baseline TBD	50%
KPI.4.8.5	Number of use cases successfully tested with the DLT registry enabler	This KPI is about the use cases that will contain interaction with the distributed broker enabler. More specifically, the number of these use cases that the distributed broker enabler was successfully tested.	# Of use cases	2
KPI.4.8.6	Number of use cases successfully tested with the DLT integrity verification enabler	This KPI is about the use cases that will contain interaction with the integrity verification enabler. More specifically, the number of these use cases that the integrity verification enabler was successfully tested.	# of use cases	2
KPI.4.9.1	Enablers deployed through interface	Number of enablers deployed using the manageability interface	Number	60
KPI.4.9.2	Service topologies and enablers	Different topologies managed by the service flow enabler / enablers per deployment handled in each topology	# / #	4/40
KPI.4.9.3	Configuration parameters	Configurable parameters that can be tuned in the manageability interface	Number	50

3.1.5 Ethical, societal, gender and legal evaluation

This dimension measures the societal impacts of developed technologies that may affect quality of working and personal life. The measurements are mainly obtained through online questionnaires. Other legal or ethical issues are exposed here, like security, privacy, safety, efficiency.

KPIs presented below are partitioned into fields (connected with ethical, societal, gender and legal evaluation), as depicted in Section 2.2.1.

Table 15 Dimension 5 - Ethical, societal, gender and legal evaluation; distribution of KPIs

Field id	Field Name	KPI id	Name
Field 5.1	Legal issues	KPI.5.1.1 KPI.5.1.2	Regulation adherence Legalisation assessment
Field 5.2	Holistic innovation	KPI.5.2.1 KPI.5.2.2	Worktime - Time Saving Human-centred innovations
Field 5.3	User work time/life impact	KPI.5.3.1	Threat on the labour demand
Field 5.4	Targeted social groups	KPI.5.4.1 KPI.5.4.2	Life - Social inclusion Gender equality
Field 5.5	Trusted, safe, secure IoT environment promotion	KPI.5.5.1 KPI.5.5.2	Security and privacy institutions engaged Security, privacy, trust and accountability specific publications
Field 5.6	Community engagement	KPI.5.6.1 KPI.5.6.2	Minority groups inclusion Accessibility

Table 16 Dimension 5 - Ethical, societal, gender and legal evaluation

KPI id	Name	Description	Metric	Target
KPI.5.1.1	Regulation adherence	The number of legislation (regulations and public policies) relevant to the project and hailing from at least 2 countries that ASSIST-IoT is compliant with.	Positive results (100 answers)	>75%
KPI.5.1.2	Legalisation assessment	Do you feel comfortable with the data collection process? Do you feel that you had sufficient time to read and think about any document and process? Do you think that Intellectual Property is properly managed?	Positive results (100 answers)	>75%
KPI.5.2.1	Worktime - Time Saving	Will the ASSIST-IoT platform save work time and renovate business?	Positive results (100 answers)	>75%
KPI.5.2.2	Human-centred innovations	Do the ASSIST-IoT have an impact people lives?	Positive results (100 answers)	>75%
KPI.5.3.1	Threat on the labour demand	Do you believe that the ASSIST-IoT platform can be considered a threat to the labour market by superseding people in some tasks?	Positive results (100 answers)	>75%
KPI.5.4.1	Life - Social inclusion	Will the ASSIST-IoT platform influence your personal or professional life? Will the ASSIST-IoT platform contribute to social inclusion?	Positive results (100 answers)	>75%
KPI.5.4.2	Gender equality	Presence of gender equality policies in the ASSIST-IoT to improve the gender balance ratio and increase women participation?	Positive results (100 answers)	>75%
KPI.5.5.1	Security and privacy institutions engaged	Has the project plan raised awareness and drawn institutions? Has the project established a network on security and privacy?	# of institutions	20
KPI.5.5.2	Security, privacy, trust and	Has the project produced a social impact and helped the community with its material?	# of publications	12

	accountability specific publications			
KPI.5.6.1	Minority groups inclusion	Do you think that such a platform will support people's well-being and does not discriminate or exclude any group of users (e.g., among the elderly and disabled)?	Positive results (100 answers)	>75%
KPI.5.6.2	Accessibility	Do you think the ASSIST-IoT platform will benefit people from all social backgrounds?	Positive results (100 answers)	>75%

4 Evaluation Plan

In this section the actual ASSIST-IoT evaluation plan is presented. It consists of three separate evaluations, each presented in its own subsection. First one considers ASSIST-IoT from a technical perspective, including interoperability capabilities, framework usability (e.g., APIs), system performance (KPIs) and usability. The second one considers ASSIST-IoT from the viewpoint of its pilots, while the third one presents the ASSIST-IoT process evaluation.

4.1 Technical evaluation of ASSIST-IoT

The technical evaluation of ASSIST-IoT encompasses the analysis (based on demonstrations in previous WPs) of whether the technical features that the different products of the project committed to provide have been actually delivered. ASSIST-IoT developments are divided in four main core components: Device & Edge plane, Smart Network & Control Plane, Data Management Plane, and Application & Service Plane. Furthermore, these four components can be subdivided in smaller pieces of software (namely, enablers) that will be tested and evaluated from a technical point of view in WP6 and WP7. Also, each component follows a different development methodology that has been described in previous deliverables of the project and that will be analysed in this one by providing information on methods and timelines for accomplishing them.

4.1.1 Introduction

4.1.1.1 Evaluation purpose

The purpose of this evaluation is to address the existence, functionality and availability of the technical components and features defined by the requirements in the ASSIST-IoT products. We document the methodology to evaluate these components and describe the results of this evaluation that will be summarized in future deliverables of this WP. The actions that will be included in this evaluation involve: validation of functionality, performance assessment and validation of KPIs.

The technical objectives proposed at the beginning of the project will be reviewed to assess the degree of compliance. To analyse the technical parameters, the assessment will use the results and outcomes from integration, testing and pilot activities. Concretely, the following will be evaluated:

1. requirement coverage (accomplished, not accomplished, partially accomplished) and gap analysis.
2. system performance (via KPIs and associated success criteria).
3. overall interoperability methodology and identification of potential bottlenecks.
4. partners and stakeholders' feedback and recommendations.

These technical aspects will be analysed over all modules that compose ASSIST-IoT. The main software modules that are being developed; to be evaluated, are the following:

1. Device and Edge Plane results
2. Smart Network enablers
3. Data Management Plane enablers
4. Application & Services Plane enablers
5. Self-* enablers
6. Cross-context Federated Machine Learning enablers
7. Cybersecurity components
8. DLT decentralized infrastructure for privacy, trust, and interoperability
9. Manageability and control enablers

Each of these modules is going to be evaluated separately. Furthermore, the integration between some of the modules will be also evaluated and finally, some of the modules will be tested altogether, as in case of the pilots.

The findings from the evaluation will be used for measuring the level of maturity of the system and identifying its strong and weak points. Furthermore, fulfilment of the original requirements, set at the begging of the project is going to be verified.

4.1.1.2 Stakeholders

In this concrete evaluation our aim is to objectively measure the technical parameters and characteristics of the ASSIST-IoT proposal. Furthermore, usability and conformance testing for the obtained products is also going to be performed (in WP6, out of the scope of this work package), and the opinion and feedback from the stakeholders will be added in future deliverables. Direct beneficiaries of ASSIST-IoT are the following:

1 Future users of ASSIST-IoT (Pilot section),
2 Administrations of systems that use ASSIST-IoT
3 Developers of ASSIST-IoT modules/solutions.

Moreover, the outcomes of this evaluation might be used for future users of ASSIST-IoT to decide if the system meets their expectations.

Depending on the users' role, their interests in different parameters will vary. For example, interests of final users with non-technical knowledge will be oriented to cost-effective trade-offs, ease-of-use, and performance. For administrators and integrators of ASSIST-IoT systems, their main interest will be oriented towards scalability, ease of integration and the existence of documentation, APIs, and Interfaces. And finally, for developers who are going to extend the capabilities of the current system, their interests will be close to the ones of the administrators but with more focus on development helper tools, internal interfaces, modularity of the software and understanding of the code.

Any in the lists of stakeholders presented in the subsequent subsections, who will benefit from the system, are not directly involved in the evaluation part.

4.1.1.3 Description of evaluation approach/system setup and timeline

The main need for ASSIST-IoT solutions is to cover the design, implementation, and validation of a next generation IoT reference architecture (more concretely: distributed smart networking components, decentralized security and privacy exploiting DLT, smart distributed AI enablers, human-centric tools, and interfaces). Usually, IoT technology experiences the so called "silo effect", delivering solutions to different markets or areas with specific requirements, complicating reusability to other application domains different from the original one for which they were created. ASSIST-IoT aims at breaking this rigidity rooting on modularity and adaptability at each level between heterogeneous components.

ASSIST-IoT main functional components are Device and Edge plane, Smart Network and Control Plane, Data Management Plane and Application and Service Plane. Each of them is going to be evaluated separately in the scope of the Evaluation plan set out in this document.

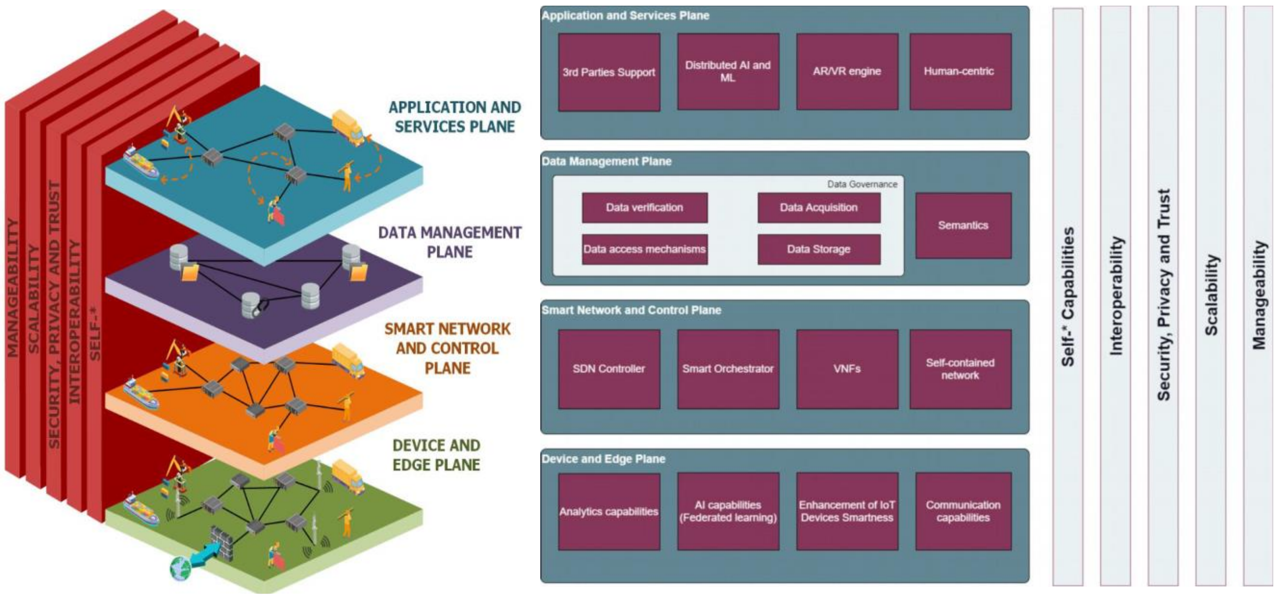

Figure 2 ASSIST-IoT Conceptional and functional architecture

To evaluate them we select a list of KPIs, mainly the interoperability ones that will compose the evaluation of Device and Edge plane, Smart Network and Control Plane, Data Management Plane and Application and Service Plane components. Furthermore, the evaluation of **¡Error! No se encuentra el origen de la referencia.** w ill be based on questionnaires and usability test for users to define the quality of the component.

To achieve the stated stakeholders and the stated goals, the technical evaluation and validation results (described in T8.2) will be monitored and delivered by the involved partners (in fact most partners are part of this task) to cover the agreed scope.

This task will assess ASSIST-IoT from technical perspective, including interoperability capabilities (all levels), functionality, usability (e.g., APIs), performance (including application of KPIs) and acceptance (by partners and stakeholders). It will use results and outcomes of integration, testing and pilot activities.

Evaluated will be: requirement coverage (accomplished, not accomplished, and partially accomplished) and gap analysis; system performance (via KPIs and associated success criteria); overall methodology and identification of potential bottlenecks; partners and stakeholders' feedback and recommendations.

Moreover, T8.2 will use outputs from WP3, where requirements and technical specification were formulated, and from technical work packages WP4-6.

With regards to timing, the following T8.2 timeline has been designed. Sufficient and structured participation of all necessary partners is planned accordingly.

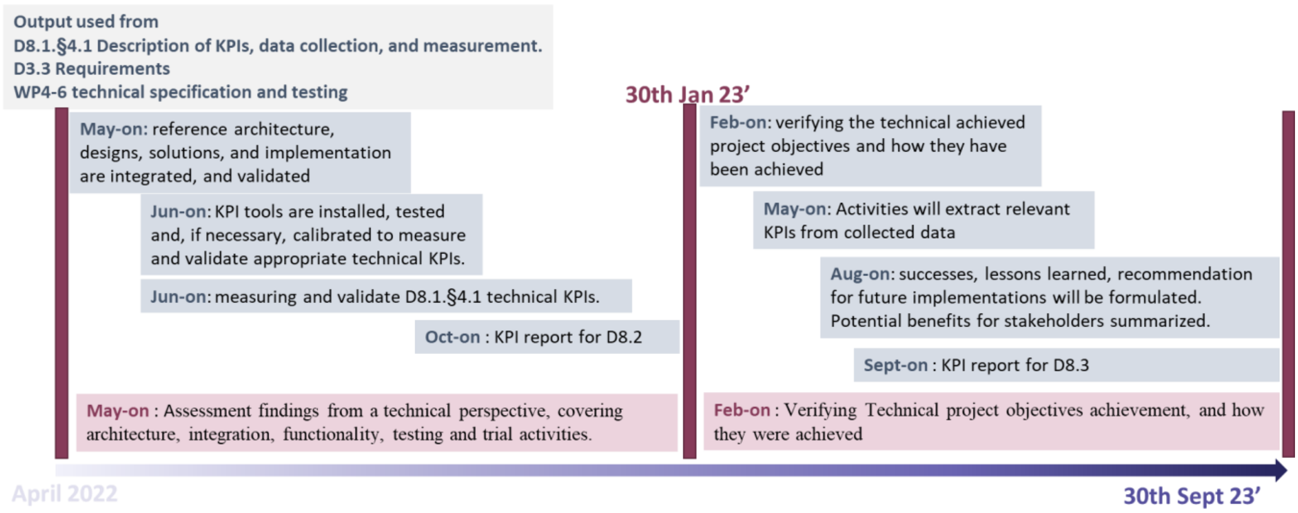

Figure 3 T8.2 timeline plan

In the first phase of the T8.2 project task, the ASSIST-IoT reference architecture, designs, solutions, and any implementation available will be analysed to assess results from a technical perspective, including integration, testing and pilot activities. Different types of tools are installed, tested and, if necessary, calibrated to measure and validate appropriate technical KPIs. This requires all parties to ensure that all technical solutions work well together, adapted, and aligned where necessary to ultimately make relevant technical data visible and validated. In some cases: Trial activities will also be set up to achieve more specific and targeted measurable results. From a global project vision, sufficient attention will be required to ensure that the main technological developments of ASSIST-IoT aim to break through the rigidity and make better use of specific functionalities and greater potential for modularity and adaptability at every level between heterogeneous components, making them visible, possible, and measurable.

The second phase focuses on verifying the technical achieved project objectives and how they have been achieved. Activities will extract relevant KPIs from collected data e.g., system logs, verifications of the enablers, the number of supported use cases by the enablers, and project team observations (qualitatively via questionnaire, interviews, etc.). The successes, lessons learned and recommendation for future implementations will be formulated. Potential benefits for stakeholders will be summarised.

4.1.2 Selected KPIs (by all KPI Owners)

For the Technical Evaluation the KPIs selected are directly related with technical features of the modules. Hence, these KPIs belong mainly to the area of Technology. As defined in Table 2, the selected KPIs are from the following fields of dimension "4. Technology":

- Field 4.1 Device and Edge Plane
- Field 4.2 Smart Network and Control Plane
- Field 4.3 Data Management Plane
- Field 4.4 Application and Services Plane
- Field 4.5 Self-*
- Field 4.6 FL
- Field 4.7 Security, Privacy and Trust
- Field 4.8 DTL
- Field 4.9 Manageability

As Technology is the main technical objective of the project, the KPIs selected for the evaluation mainly address the area of Technology. However, other technical KPIs can be derived from this basis.

4.1.3 Data collection and measurement

KPI.4.1.1 CPU load of GWEN

This KPI measures the CPU usage of the gateway and the edge node process or processes through a Monitoring agent installed on the GWEN. CPU resources are finite. If the GWEN process has the maximum CPU, the gateway may not be able to handle all events. As a result, the events may be delayed in reaching the target system.

Considered the achievement of this KPI, the average CPU load for the number of pilot use cases supported by GWEN remains below 75%.

KPI.4.1.2 Memory usage of GWEN processes

This KPI measures the memory usage of the GWEN process or processes through a Monitoring agent installed on the GWEN. Memory resources are finite. Unlimited memory growth may cause the abnormal termination of the process or processes. It can be expected the memory usage of a GWEN process to be relatively stable. However, some increase is expected as the caches build.

Given the fulfilment of this KPI, the average memory usage for the number of pilot use cases supported by GWEN remains below 75%.

KPI.4.2.1 (KVI-2.1.1) VNFs achieved for improving network

This KPI aims at recording how many VNFs/CNFs have been achieved in the project for improving performance and network reconfiguration and other network tasks. This is an automatic result of the outcomes of T4.2, especially the smart orchestrator that will be able to deploy NFs in diverse ecosystems. The goal of this KPI is to illustrate that the orchestrator is actually functional in the network area, improving the network performance in different ways (bandwidth, availability, speed, etc.). The usage of these functions is rather specific (in contrast with application functions). They can only be applied to particular environments and setups, overseen by specialised, skilful teams.

ASSIST-IoT aims at deploying 6 NFs in the project with the orchestrator. This KPI will be measured at the end of the project and will be validated against the results of the pilots.

KPI.4.2.2 (KVI-2.1.2) AI models achieved for improving network

ASSIST-IoT has committed to deliver a "smart orchestrator". Naturally, for an orchestrator to be called "smart", it needs to rely on certain intelligence to deploy the functions in the edge-cloud ecosystem. One of the goals of ASSIST-IoT is to realise such "intelligence" by leveraging some AI models (e.g., linear regression, decision tree, etc.) to allow the orchestrator to select the most optimal spot in the deployment (in the available clusters) in such a way that both the network and the function's purposes are maximised.

The goal is to test and use (in pilots), at least 3 different AI models to convert T4.2 output in a "smart orchestrator".

KPI.4.2.3 (KVI-2.2) Percentage of network connections being improved

The description of this KPI is. "*Network transmissions execute one of the routines and get an improvement from the baseline*". Concerning to data collection and measurement, this KPI aims at representing that the actual NFs (network functions) described in KPI.4.2.1 have real results in terms of improving network parameters from a baseline. It is expected that the enablers associated to KPI.4.2.4 will also contribute.

The idea is to perform an A/B exercise, measuring network parameters before applying the NFs provided by ASSIST-IoT and afterwards, applying them and re-probing. A target improvement has been set to 20%.

KPI.4.2.4 Hosts connected to VPN k8s clusters

One of the enablers to be delivered by task T4.2 is the VPN enabler. This software (encapsulated as an ASSIST-IoT enabler following the packaging and releasing methodology set out in deliverable D6.4) allows the access to a node or device (in the case of ASSIST-IoT, to a Kubernetes (K8s) -or equivalent- cluster) from a different network to the site's private network using a public network (e.g., the Internet) or a non-trusted private network. In practical terms, this enabler allows an external host (device, computer, server…) to join ASSIST-IoT deployment's network via the connection using a VPN that is served by a k8s cluster that is part of the environment of the site.

The goal with this KPI is to illustrate the functionality (and that it actually meets its objective, and it is used in real life) in the pilots of the project, considering 8 hosts connecting to k8s clusters of ASSIST-IoT as the target KPI. This will be measured transversally across all pilots and will be reported by the end of WP7 and WP8.

KPI.4.2.5 Messages classified

The traffic classification enabler automatically drills down network traffic into a number of application classes (video streaming, VoIP, Network control, best effort, OAM, etc.), making use of an AI/ML framework and dedicated algorithms. This functionality could be considered the baseline for allowing further innovations to build on, for instance re-routing traffic or selecting deployment spots in a dynamic fashion depending on the analysis performed by this software. Being delivered as an ASSIST-IoT enabler, it is expected that traffic classification will be used in the pilots of the project.

This KPI will have a target value of 500 relevant messages analysed and classified, distributed among the pilots, and only taking into account those whose classification has had an impact and has been properly stored.

KPI.4.3.1 Streaming Annotation Latency

Streaming annotation is a process that depends on many factors, including network throughput, message size, and annotation configuration file size. The annotation core is a component that connects to a broker, which interfaces with clients, and passes messages to the core. To isolate the performance of the annotator itself, the message processing latency will be measured. This latency is defined as the amount of time it takes to process a single message (averaged over a period of time) at the core component, without taking into account broker throughput. Even though the annotator is designed to support high volume of small messages, the latency will be tested with messages of small and medium size, to stretch the limits of the simulation. Measurements will be taken over 1 minute of constant message output from the broker, with the target of average processing latency less than 10ms per message.

KPI.4.3.2 Streaming Translation Latency

Just like in the case of streaming annotation (see KPI.4.3.1 above), measurement of streaming translation latency will be performed at the core component to isolate it from networking conditions and broker performance. Latency, defined as time needed to process a single message will be measured as average over 1 minute of constant small and medium message streaming with target of less than 10 ms per message.

KPI.4.3.3 Streaming Annotation Clients Number

A single streaming annotator is designed to support multiple streaming channels, each with possibly many sub-channels. Performance of supported client parallelism will be measured by creating a number of annotation channels, and scaling the number up, until resources on the test machine are saturated. Because the number of clients per channel is scaled on the level of the broker, each channel will have just one sender and receiver.

Adding more clients per channel is supported but would make the simulation more dependent on performance of the broker, and not the streaming annotation core. A conservative target is placed at 10 parallel channels, as that is the expected maximum number of channels in a single real-world deployment, that will be realistically required.

KPI.4.3.4 Streaming Translation Clients Number

Just like the streaming annotator (see KPI.4.3.3 above), streaming semantic translator can support a number of channels in parallel, with performance concerns dependent on the same factors, as in the case of streaming annotation. Despite similar dependency on streaming brokers, the core components and internal processing infrastructure of the streaming translator and annotator are very different, so KPIs have to be measured separately. Supported client parallelism of the streaming translator will be measured as maximum number of channels with one consumer and one producer per channel, before saturation of resources.

KPI.4.3.5 Semantic Repository File Size Support

Testing the capacity of the Semantic Repository will be relatively straightforward, by simply uploading files of increasing size. The files will be selected to represent a real use case, from one of the pilots or a different potential application. For example, Pilot 2's BIM files are of significant size and can be used as part of the testing.

KPI.4.4.1 (KVI-5.2) Human-centric components

This KPI is focused on quantifying the different ASSIST-IoT human-centric enablers that the project will develop, which will provide a quantifiable impact in the quality of work/life of end-users of project pilots, including e.g., human-centric GUIs, VR/MR services, Computer vision capabilities, fall-detection algorithms, etc.

KPI.4.4.2 (KVI-6.3) Human-centric UCs per pilot

This KPI will identify the number of ASSIST-IoT use cases that make full or partial use of some of the human-centric NGI technologies developed in the project (listed in the previous KPI.4.4.1), providing meaningful tasks that cannot be done without them, or leading to significant features changes in performance.

KPI.4.4.3 UX usability

This KPI indicates how difficult it will be to operate with the ASSIST-IoT GUIs. A System Usability Scale (SUS) questionnaire, which offers a quick and effective way to evaluate the usability of products and/or designs, will be used for the evaluation of this KPI. Interviews with end-users will be held, in which they must answer to 10 questions with a value between 1 (strongly disagree) and 5 (strongly agree). Scoring above or below the average gives insights about the overall usability of the solution. The KPI will be successful if at least half of the GUIs developed in ASSIST-IoT receive a SUS score greater than 70 among the users interviewed during the demonstrations of the project.

KPI.4.5.1 (KVI-4.2) Number of autonomous decisions taken while executing pilots

Self-* Enablers can take autonomous decisions. Such decisions do not involve human operators. This KPI will track several such actions taken. It will be measured at the end of the pilots.

KPI.4.5.2 Number of resources involved in self-* processes

Resource is a "Thing" in Internet of Things. It may vary from physical device to a software component. This KPI will track how many such Things (excluding Self-* Enabler's internal components) will participate in autonomous decision taking or be influenced by such decisions.

KPI.4.6.1 Distributed AI costs

Different factors have to be considered in order to create working AI software solutions. One of these factors (if not the most relevant) is the cost of AI infrastructure. To make Artificial Intelligence (AI) more affordable, its needs may be decentralized. In particular, Distributed AI is the computing paradigm that aims at removing the need to manage vast amounts of data in the cloud, providing the ability to analyse this data at the source. This KPI will evaluate the reduction of AI processing/infrastructure costs from traditional cloud-based systems versus custom-edge distributed AI solutions. To do so, the project partners will carry out a market analysis of the different AI for IoT solutions available in the market and their prices and compare them with the cost of deploying a solution in their edge premises.

KPI.4.6.2 FL users

The ASSIST-IoT FL system is being built to enable the emulation of real-world systems which require a large number of clients involved in the federated training. This KPI aims at demonstrating the scalability capabilities of the ASSIST-IoT FL system. Different performance tests of the FL system with a large number of FL Local Operations instances running in parallel will be evaluated. If the system is capable of supporting at least 10 simultaneous users, the KPI will be considered fulfilled.

KPI.4.6.3 ML models

Like the previous KPI, another pillar of ASSIST-IoT FL system is to be able to support several ML models. Therefore, this KPI will evaluate the compatibility of future ASSIST-IoT FL system with several of the existing open-source ML frameworks (e.g., Keras, Tensorflow, or scikit-learn).

KPI.4.6.4 FL use cases

The principal motivation for the implementation of the ASSIST-IoT FL system in the project comes from the real-needs of some of the project's pilots. This KPI will evaluate the number of use cases of ASSIST-IoT pilots that has been made use and successfully tested with ASSIST-IoT FL system (either with simulations in laboratory or with real-time demonstrations on their industrial premises).

KPI.4.7.1 Users covered by security of ASSIST-IoT

This KPI will measure the potential number of users that could be covered by implementing ASSIST-IoT security / privacy methods. In particular, it will consider the number of "users" that will be "protected" thanks to the implementation of ASSIST-IoT security enablers supposing a full deployment of the ASSIST-IoT solution in a real production scenario on the project end users' partners.

The KPI is not very representative of the project due to ASSIST-IoT is based on use cases and the products developed at the end of the project are not expected to be completely ready for production deployment, and the TRL expected for this is associated to RIA. A suggested way of assessing and measure this KPI could be obtained from the project stakeholders on the use of security and privacy in the use cases to extrapolate to a real production scenario

KPI.4.7.2 Pervasiveness of user coverage by security enablers

This KPI will measure the coverage of users implementing the security and privacy methods in the use cases, including the identity, authorization, and cybersecurity monitoring services. It is considered that a 75% should indicate a correct functioning of the mechanism.

KPI.4.7.3 Correct identification attempt ratio

This KPI measures the flow of identification requests as they are being processed by the system. It is considered that a 75% should signal a correct functioning of the mechanism. Higher rate could indicate excessive lightness of the control. Lower rate could be a signal of incorrect activity with a possible attack attempt being performed.

KPI.4.7.4 Validated authorization request ratio

This KPI measures the flow of decision-making requests processed by the system. It is considered that a 40% correct may indicate a correct functioning, but it is very dependent on the use case definition.

KPI.4.7.5 Detected alerts per hour

This KPI measures the number of incorrect situations that require visibility detected on the network. It is considered that 10 events in an hour can be a correct measure. Higher may indicate a problem in the network. Lower indicator may be the result of an inefficient observation. This KPI is very dependent on the use case and may have to be redefined.

KPI.4.8.1 (KVI-3.1) Automated accountability of interactions/communications performed (defining responsible)

This KPI identifies the accountability of the involved actors when they communicate with ASSIST-IoT. To measure this KPI, we measure the number of critical interactions that are logged in the DLT in an immutable way. We consider that we comply with this KPI when the number of critical interactions that are logged in the DLT are > 75 %.

KPI.4.8.2 (KVI-3.2) Data governance services supported by IoT-enabled DLT.

This KPI identifies how the DLT enablers will increase the security, integrity, availability of data and the accountability of actors. In particular, this KPI (and KVI) will count how many data governance services delivered in the project that could be understood as endorsed by DLT enablers or the consequences of them. We consider that we comply with this KPI when the number of interactions with DLT enablers, out of total interactions, is 10.

KPI.4.8.3 Availability of FL ML local models' collection

This KPI identifies how available are the collected local FL models. To measure this KPI, we compare this availability to the baseline availability which is the availability of the local FL models when they are collected on a centralised server. We consider that we comply with this KPI when the availability compared to baseline increases over 75 %

KPI.4.8.4 Decrease in training dataset biases

This KPI identifies the decrease in the training datasets biases (e.g. the data skewness) when using a DLT-based local FL model verification mechanism. To measure this KPI, we compare the identified biased in training dataset in the absence and in the presence of the aforementioned verification mechanism. We consider that we comply with this KPI when the decrease in training dataset biases compared to baseline is over 50 %.

KPI.4.8.5 Number of use cases successfully tested with the DLT registry enabler

This KPI is about the use cases that will contain interaction with the distributed broker enabler. We consider that we comply with this KPI when the number of these use cases, that the distributed broker enabler was successfully tested, is 1.

KPI.4.8.6 Number of use cases successfully tested with the DLT integrity verification enabler

This KPI is about the use cases that will contain interaction with the integrity verification enabler. We consider that we comply with this KPI when the number of these use cases, that the integrity verification enabler was successfully tested, is 2.

KPI.4.9.1 Enablers deployed through interface

One of the enablers to be delivered by the manageability task (although most likely condensed and packaged as one with various functionalities) is the capacity to order the deployment of an enabler in the IoT ecosystem managed by the solution. While the actual deployment will be orchestrated by the enhanced-OSM orchestrator (from T4.2), the selection of the enabler, the indication of additional parameters, and other information, including "executing" the deployment order, will be done through the user interface controlled by the manageability enabler.

This KPI aims at validating the functioning in real (pilot) conditions of this enabler, that will be installed in the four pilots of the project and that will let managers, app developers and stakeholders to deploy software over the equipment that is included in ASSIST-IoT network. A number of 60 enablers (~15 per pilot) has been established as an ambitious target.

KPI.4.9.2 Service topologies and enablers

This KPI measures the scale to which one of the most complex enablers of the project will reach to. The service flow enabler aims at allowing a user (via the manageability interface – a UI) to configure, select, obtain information and (most importantly) connect among and interact with enablers that are deployed at specific parts of the deployment's topology. It will need to interact with the APIs of all enablers, will need to be aware of the network and k8s clusters topology, as well as the data pipelines that are established.

It is considered a very ambitious KPI, that has been set to 4 topologies (4 deployments that are visible through this enabler) with a total of 40 enablers that can be interacted with using this enabler. This KPI will be measured at the end of WP7 and WP8.

KPI.4.9.3 Configuration parameters

Apart from managing enablers, clusters, topology, etc., one of the goals of the manageability task in ASSIST-IoT is to allow enabler owners to configure parameters related to those enablers so that changes can be applied either on-the-fly or during the deployment of those enablers (e.g., storage options). The manageability interface has some reserved spaces in the Menu to include entries for specific enablers where specific parameters can be configured (via web).

This KPI measures the quantity of parameters that, at the end of the project, could be fine-tuned and/or configured through the manageability interface with effect on the deployment of associated enablers, Target number is 50.

4.2 Evaluation of pilot results

The main enablers as well as specific pilot developments throughout the project will be evaluated and assessed over the pilot testbeds. Thus, the results of the evaluation process will be paramount for the continuous improvement of the different developments. This section describes how the evaluation will be managed and implemented during the pilot's trials execution. The objectives, status of the developments, list of KPIs, etc. of each pilot are described next.

4.2.1 Introduction

4.2.1.1 Evaluation purpose

Port Automation Pilot 1
The Port Automation Pilot of ASSIST-IoT aims at helping container terminal operators to improve operational efficiency by means of including smarter devices that will improve the availability of information over which the operators can interact with. These features envisioned in ASSIST-IoT will help on making better decisions. To do so, ASSIST-IoT Port automation pilot identified 3 business scenarios: (i) BS-P1-1: Tracking assets in terminal yard; (ii) BS-P1-2: Automated CHE cooperation; and (iii) RTG remote control with AR support. Therefore, the objective of the evaluation is to test the functionality of different ASSIST-IoT enablers, with the aim of improving efficiency, network capabilities, and improving workers safety.

Smart Safety of workers Pilot 2
The Smart safety of workers Pilot is focused on the improvement of health and safety on the construction site by providing modular human-centric solutions and enablers capable to effectively support the operations. To achieve it, this pilot identified 3 business scenarios: (i) BS-P2-1: Occupational safety and health monitoring; (ii) BS-P2-2: Safe navigation; and (iii) BS-P2-3: Health and safety inspection support. Hence, the objective of the evaluation is to test the functionality of different ASSIST-IoT enablers for environmental parameters monitoring, workers' health issues identification, prevention from overheating, identification of dangerous and suspicious behaviours (e.g. falls, slips, immobility), prevention from collisions and unauthorised entrance, as well as for information support in relation to evacuation route and OSH management in general with the overall aim to improve safety and comfort of the workers on the construction site.

Advanced Powertrain monitoring and diagnostics Pilot 3A
This Pilot of ASSIST-IoT orbits around the monitoring of vehicle and fleet emission levels during real-life operation, and the deployment of corrective actions when critical levels are reached. Those actions can be done at fleet level, by modifying the Powertrain Control Module (PCM) calibration of a subset of the fleet (for example, for coping with sensor bias) or by detecting non-conformant vehicles and routing them to technical service. ASSIST-IoT is expected to provide an architecture able to ease the many challenges of the pilot: varying sensor sets and driving conditions, coexistent software versions, etc. The pilot has identified two business

scenarios: (i) BS-P3A-1: Fleet in-service emission verification; and (ii) BS-P3A-2: Vehicle diagnostics. The objective of the evaluation, thus, is to test the functionality of different ASSIST-IoT enablers.

Cohesive vehicle diagnostics Pilot 3B

In this specific pilot for the ASSIST-IoT project, the focal point is on the vehicular exterior condition and the consequent support of human tasks. Specifically, the pilot focuses on the documentation and monitoring of the vehicles' exterior conditions with advanced digitalisation technologies, ergonomic visualisation techniques, and AI-based automated inspection of surface damages. The vehicles' condition is a subject for any vehicle owner regardless of being a single person or an entity. The vehicle's exterior condition is a factor with a range of implications. A human can perform manual vehicle inspection, but the latest advances in the computer vision field are encouraging the adoption of an automated procedure that can be faster and more precise. ASSIST-IoT is expected to support the accelerated results and efficient data management in a secure and decentralized way with its suggested architecture. As the business uses are varying, a single and general business scenario has been identified: BS-P3B-1: Vehicle exterior condition inspection and documentation.

4.2.1.2 Stakeholders

Port Automation Pilot 1

There are different companies in the logistic and transport business in a port, and most of them are nearly not sharing information. Thus, there are many opportunities for improvement and new business models that could occur if these companies allow to exchange data, so that most of them are interested in a common system to share data in a controlled way. For instance, a **container terminal** could improve the operational efficiency in the yard if they had real time information of the arrival of the external trucks in advance. Nowadays, the **haulier companies** are customers of the terminals, and they have the information, but they don't have a procedure to send the data. On the contrary, if the **truck drivers** of those hauliers do also have access to the specific location where assets to be picked/discharged, they will be able to carry out their daily routines in a faster and safer way.

Figure 4 Port Automation Pilot Picture

Smart Safety of workers Pilot 2

There is currently a quite limited number of ICT-based solutions supporting occupational health and safety with wearable smart devices. The main group of stakeholders interested in the ASSIST-IoT results in terms of preventing accidents and injuries in the work environment will be construction companies which are directly targeted by pilot 2. However, most of the solutions that will be deployed within the Smart Safety of Workers pilot, **can also be transferred to other sectors** with multi-hazard work environments (e.g., logistics, agriculture, maintenance). Providing monitoring, relevant actuation and information support to improve OSH will benefit the **employees** (i.e., better health and higher comfort at work), **OSH managers** (i.e., easier supervision of safety compliance), as well as the **employers** (i.e., lower financial costs to compensate for e.g., accidents, breaks, absences, as well as decreased risk of reputational losses due to accidents).

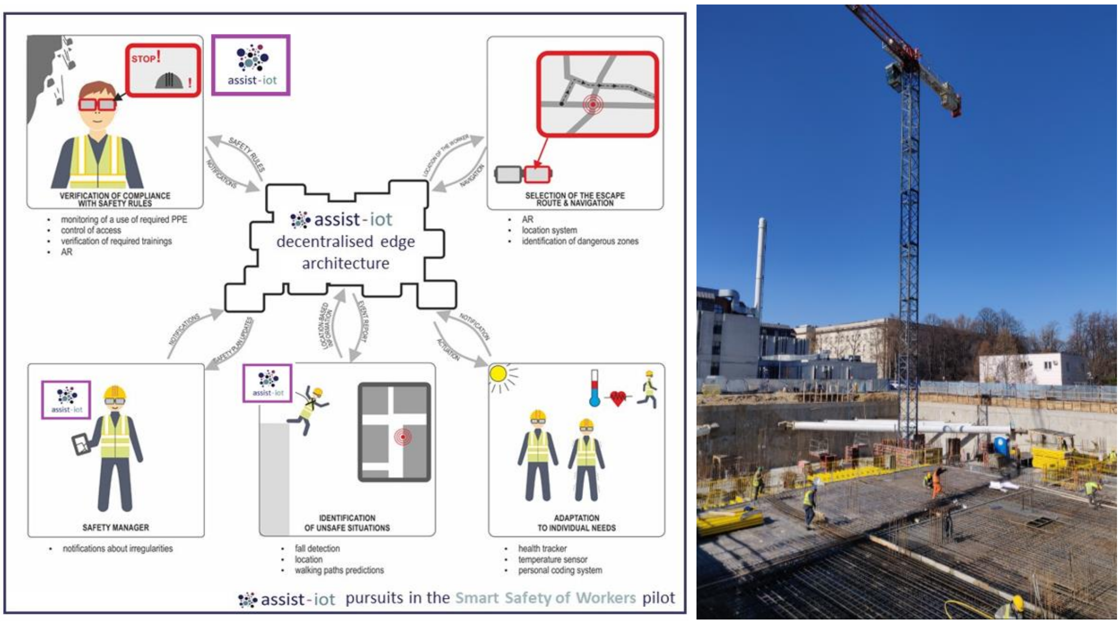

Figure 5 Smart Safety of workers setup

Advanced Powertrain monitoring and diagnostics Pilot 3A

The main group of stakeholders for the results of ASSIST-IoT are **vehicle manufactures** of passenger cars or commercial vehicles with Internal Combustion Engines (ICE). The results of this ASSIST-IoT Pilot can be directly transferred **for any interested OEM**. However, with few adjustments the results of Pilot 3A can also be utilised outside of the propulsion system perimeter, making ASSIST-IoT an interesting solution for all OEMs and **vehicle fleet operators in general** like rental car or cab companies.

Figure 6 Open PCM module (left) and NOx sensors (middle) installed in the Ford Kuga test vehicle

Vehicle exterior condition inspection and documentation Pilot 3B

Pilot 3b focuses on the exterior condition of vehicles, and numerous different stakeholders can benefit from ASSIST-IoT's pipeline. In detail, vehicles are produced in foreign countries and are transported to the consuming county. Stakeholders in the supply chain like **customs authorities**, **transporters**, and more are interested in proving the condition of the transported vehicles at each phase of the chain. Other stakeholders with vested interest on the exterior condition inspection range from **private vehicle owners** to **fleet managers** and **garages**. Fleet managers have to monitor the exterior condition of multiple vehicles including cars and vans. The exterior condition is a requirement of the employability of the vehicles as the existence of serious defects. The garages require to document the condition of vehicles and track defects quickly to suggest fixes and provide an accurate cost estimation. Finally, there are stakeholders with services related to a vehicle's condition. Essentially, this group of stakeholders base their services on documentation and involves insurance, car dealerships, and even researchers that require data. Groups like that require clean and potentially annotated data for their services built to support vehicle owners.

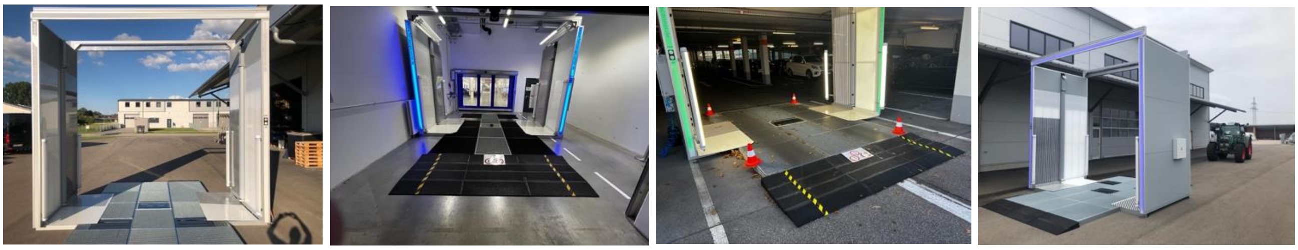

Figure 7 Vehicle exterior condition inspection and documentation Pilot setup

4.2.1.3 Description of the evaluation approach and timeline

To reach the mentioned stakeholders and to meet the described goals, the Continuous Pilot Analysis, Evaluation and Assessment has been organised in ASSIST-IoT as follows: a single task has been created (T8.3) that will oversee the participation of several partners (actually, most partners are part of this task) to cover the previous scope. This task will be focused on analysis of pilot results, with active involvement of stakeholders (e.g., partners, end-users: stakeholders and citizens). Expected impacts, to be evaluated during pilot execution, were described in Section 2.

Activities will extract relevant KPIs from collected data (e.g., system logs), project team's observations, and surveys (qualitative by questionnaire, interviews, focus group, etc.). Recommendation for future implementations will be formulated.

Potential stakeholders gains will be summarised (e.g., truck turnaround time, accidents reduction, financial gains). Components of services will be evaluated, by conducting experts, end-users and stakeholder surveys, during the trial phases in WP7, and analysed in T8.3.

With regard to timing, the following T8.3 timeline has been designed. Sufficient and structured participation of all necessary partners is planned accordingly.

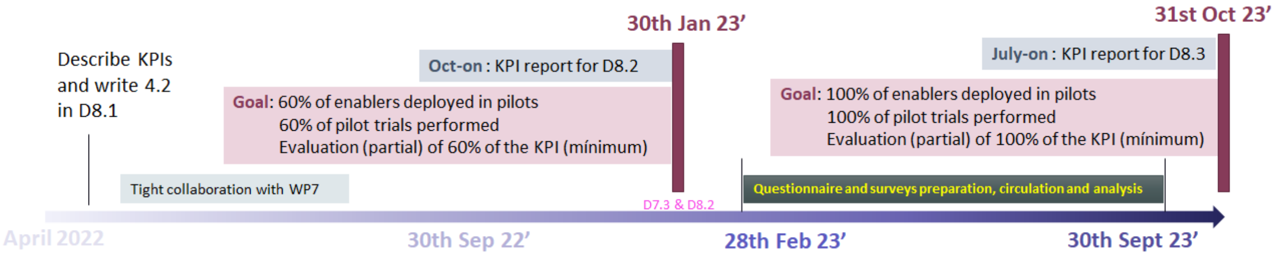

Figure 8 T8.3 timeline plan

4.2.2 Selected KPIs

For the Pilot evaluation we select fields from the dimension "1. Exploitation" and "2. Pilots", as they are directly related to the technical execution of the pilots and engaged stakeholders:

- Field 2.1 Port automation pilot
- Field 2.2 Smart safety of worker's pilot
- Field 2.3 Vehicle in-service emission diagnostics pilot
- Field 2.4 Vehicle exterior condition inspection and documentation pilot
- Field 2.5 Overall pilot implementation

4.2.3 Data collection and measurement

In the previous subsections the KPIs that will be measured to guarantee the success of the pilots were identified. This section aims at describing how these KPIs are going to be measured and presented.

KPI.2.1.1 Trucks turnaround time

This KPI will evaluate the truck turnaround time from quay to stack and from gate to stack. According to internal (confidential) reports, the average truck turnaround time in a container terminal is around 26 minutes. For evaluating this KPI, the elapsed time to perform the assigned working instructions to the truck drivers performing the trials of the project will be recorded and compared to that general value. If the experienced truck turnaround time is reduced 5% with respect to the global average value, the KPI will be considered as fulfilled.

KPI.2.1.2 CHE fleet dispatching

This KPI will evaluate the number of CHEs involved in the ASSIST-IoT remote operation business scenario for fleet dispatching dynamics. Currently, there is not any remote-capable crane in the port terminal (i.e., 0% of remote cranes), so this will identify those cranes that are remotely capable after the project ends. If there is one crane with remote capabilities successfully tested, this KPI will be fulfilled.

KPI.2.1.3 Yard equipment workforce

This KPI will evaluate the increased number of crane drivers working from an office environment thanks to the support of ASSIST-IoT remote operation services. As in the previous KPI, currently, there is not any remote-capable crane in the port terminal (i.e., 0% of terminal stuff manages cranes from terminal offices). Therefore, this KPI will be fulfilled if there is at least one fully operative crane with remote capabilities available before the project ends.

KPI.2.1.4 Yard accidents

This KPI will evaluate the decreased number of yard accidents due to automation and less persons moving around quay and yard. In last years, around 60 yard accidents (either from Collisions with vehicles, Collisions with structures, or related to RTG operators) were notified in MFT terminal. For evaluating this KPI, the number of accidents (even low) will be registered during the last six months of the project, or once at least one of the pilot 1 business scenario is successfully tested. If the average number of accidents during the monitored period is reduced up to an 80% with respect to the global average value, the KPI will be considered as fulfilled.

KPI.2.1.5 Remote wireless bandwidth

The remote operation use of the RTG cranes to be deployed in Pilot 1 requires of enough bandwidth to support the different audio-video streams sent over the cameras and loudspeakers to the remote operator working from the remote desktop in terminal offices. To evaluate this KPI a network sniffer tool will be retrieving L2-packets from the IP network transceivers connected to the cameras and AV servers to obtain a throughput value in Mbps.

KPI.2.1.6 Remote wireless latency

The remote operation use of the RTG cranes to be deployed in Pilot 1 requires of ultra-low latencies to support the tactile internet capabilities needed to provide a successful user experience for those crane drivers that are remotely managing the crane. To evaluate this KPI a network sniffer tool will be sending IP ping messages from the transceiver on the remote desktop side over the transceiver connected to the ROS PLCs of the crane.

KPI.2.1.7 Proximity range

The CHEs that will perform the trials for the business scenario BS-P1-2 will have to precisely perform the alignment process, but before starting this M2M communication, for security purposes, they should be jointly authenticated within a limited area. This KPI will be analysed by evaluating up to how coverage extent the short-range wireless systems to be installed on the cranes for triggering the authentication detects the incoming trucks.

KPI.2.1.8 Redundant access networks

The BS-P1-3 demands very constraint wireless access network reliability. Specifically, high bandwidth as well as ultra-low latency requirements should be met. However, due to the harsh conditions affecting to wireless networks in container terminals (e.g., containers walls blockages and the faraday cage effect of the RTG cranes), additional access networks should be supported. To evaluate this KPI, the ASSIST-IoT multilink software to be used in the pilot should be capable of supporting at least two different redundant networks.

KPI.2.1.9 New human-to-machine interfaces

External truck drivers that do not belong to the terminal company are only informed of their working instruction when accessing the port gates with some printed papers, leaving them outside of the workflow. This lack of additional contextual information leads to lower operational efficiencies. ASSIST-IoT aims at providing additional information via human-to-machine interfaces for alleviating these inefficiencies. This KPI will be fulfilled if at least 3 graphical interfaces are provided to them for (i) location of the crane over which they should cooperate, (ii) alignment graphical notifications, and (iii) container loading/unloading process complete.

KPI.2.2.1 Workers alerts

ASSIST-IoT will provide two levels of notifications (alerts) to increase workers' safety on the construction site. The first (lower) level will be provided directly to the worker, when only a recommendation to undertake a specific action is needed (e.g., take a break, your heart rate is too high). The second (higher) level will be provided to the OSH manager, when their intervention is needed (e.g., no heartbeat and immobility of one of the workers). Considering the amount of data to be transferred and analysed, this KPI will focus on notification reliability. This KPI will be met when less than 5 % of the notifications provided by ASSIST-IoT is false.

KPI.2.2.2 OSH hazards detected

As a construction site is a multi-hazard work environment, ASSIST-IoT will improve workers' health and safety by detecting these hazards and preventing potential accidents and health issues. At least 10 OSH-related hazards should be detected by ASSIST-IoT on the construction site to achieve the assumed KPI. Detection of the following hazards will confirm reaching the goal: (1) heart disruptions, (2) overheating, (3) immobility, (3) slips and falls on the ground, (4) fall from heights, (5) collision with machines, (6) entrance to a dangerous zone, (7) UV radiation, (8) lack of PPE, (9) unauthorised entrance, (10) too high air velocity in relation to crane work.

KPI.2.2.3 Hazard detection time

To confirm the improvement of safety and health at work by means of ASSIST-IoT solutions, a starting point of hazard detection time will be established according to current methods used at the construction site. This time will also be evaluated for the selected hazards after deployment of ASSIST-IoT in Smart Safety of Workers pilot. The KPI will be met when the time of hazards detection after deployment of ASSIST-IoT will be reduced by at least 50 % compared to the values from the starting point (i.e., current state).

KPI.2.2.4 User acceptance

To confirm the appropriately addressed human-centric approach in ASSIST-IoT solutions, after deployment of ASSIST-IoT solutions at the construction site within the Smart Safety of Workers pilot, the acceptance of technology by workers will be evaluated in the survey research based on the five-point Likert scale. To achieve this KPI, the ASSIST-IoT should obtain more than 75% of at least grade '4' on to technology acceptance from the construction workers.

KPI.2.2.5 Notification and alerting

Alerts and notifications are used to notify the OSH inspector for incidents such as falling and other accidents, exceedance of permitted physiological and environmental parameters, unauthorized access, or when a worker is approaching of dangerous zones. To confirm that the OSH is aware about the majority of the danger event within the worksite through the MR device, a series of tests will be performed to measure the reliability of the mixed reality device. The tests should ensure that the above-mentioned notifications reach the MR enabler and thereafter the OSH inspector. During the pilot test phase, the alerts that will be generated from the other systems and components and will be transmitted to the MR device via the edge data broker, achieving more than 90% success rate to deliver the message.

KPI.2.2.6 Reporting

During inspection, one of the primary responsibilities of the OSH inspector is to report unusual or dangerous situations to the stakeholders (for example, when a construction worker, is not equipped with their appropriate personal protective equipment, or when a construction element requires attention, should be reported as an incident). To confirm the reporting functionality, the inspector will generate different reports that include photo and relevant information, and the system will save it to the LTSE. To achieve this KPI, more than 90% of the reports should successfully be saved to the ASSIST-IoT databases.

KPI.2.2.7 BIM manipulation

The OSH manager needs access to the BIM model to assess all needed information for the access points, such as the location of dangerous zones, and authorized areas. Object visualization and manipulation capabilities of the MR enabler ensure that the operator of the device has a full overview of the IFC model components. This KPI will be fulfilled by manipulating the 3D object in six degrees of freedom (6DOF) which include 3DOF for object positioning (x, y, and z-axes) and 3DOF for object rotation (x, y, and z-axes). Scaling will also be supported.

KPI.2.2.8 Near-miss fall from a height

To measure the success rate of the fall-from a height detection method, a series of tests will be performed involving simulated drops of an OSH mannequin. The drop scenarios will be varied to reflect a variety of hazardous situations that may occur on the worksite. The KPI will be achieved, if the system correctly recognizes the near-miss situation in at least 85% of test cases.

KPI.2.2.9 Worker alert latency

To ensure the provided solution can alert the workers of dangerous zones in time, the latency between the worker entering the zone and them being alerted will be measured. The scenario can be simulated by instructing a worker to enter a temporarily set dangerous zone and then measuring the time between the incursion and the triggering of the worker's alarm system. There will be no actual risk to the worker during the test, to ensure their safety. The test can be supported by, e.g., additional painted lines, to delimit the dangerous zone set in the BIM. The latency should not be higher than 1.5 seconds.

KPI.2.2.10 OSH manager notification latency

To ensure the OSH manager is able to react in time to a worker that has entered a dangerous zone, the latency between the incursion and the manager's notification should be minimized. The test setup will be similar to the worker alert latency scenario. However, here, the moment at which an appropriate notification appears on the manager's screen will be measured. The latency should not be higher than 5 seconds.

KPI.2.3.1 Reduce emission related series recalls by fleet monitoring and fleet maintenance

As described before, compliance for this KPI is given, if potential series recalls can be reduced by 50%, based on a comparison between original emission distribution and the same emission distribution, after Pilot 3A ASSIST-IoT tools have been applied. For this purpose, random yet realistic emission distributions are selected, which include a high amount of emission outliers. This high number of outliers would in a real-world scenario trigger a series recall addressing a potential conflict with emission regulations. By utilising the ASSIST-IoT tools developed in Pilot 3A, the number of outliers and therefore the amount of example distributions, which would usually trigger a recall, must be reduced by 50% or more.

KPI.2.3.2 Reduce development time for diagnostic software updates

As described before, compliance for this KPI is given, if the development time for a diagnostic software update can be reduced by 50% or more. To identify the compliance with this KPI, an average time for a standard release process of identifying diagnostic field issues, updating software diagnostics, testing and the final releasing of software will be calculated, based on numerous existing real-world examples. This average base line time will be compared to the time reduced significantly by the envisioned and innovative processes, with the help of the tools developed in ASSIST-IoT Pilot 3A.

KPI.2.3.3 Number of data channels measured in parallel

As described before, ASSIST-IoT Pilot 3A is built upon measuring many high frequency data channels in parallel. To allow this key characteristic of Pilot 3A, the minimum number of 200 data channels will be measured, and the resulting logfiles will be analysed afterwards. Compliance with this KPI is given, if 100 random logfiles include all measured signals, compared to professional high frequency measurement equipment.

KPI.2.3.4 Available connectivity channels provided by ASSIST-IoT

As described before, ASSIST-IoT Pilot 3A depends on a compromise between low-latency distribution of small data packages and timely uncritical distribution of large data packages. Therefore, a variety of connectivity channels will be applied in Pilot 3A and a compliance with this KPI is given, if 2G, 3G, 4G, 5G, Wi-Fi and

Ethernet connections are possible, depending on the Use Case. To verify compliance, the various connection channels need to allow activation and a transfer of 100 test data packages of different formats and sizes is completed without any issues.

KPI.2.3.5 Time to update a PCM calibration on the edge, after a vehicle was offline

As described above, vehicles can be offline for a significant amount of time. During this time a mandatory calibration update might have been distributed, which was not received by the offline vehicle. Therefore, it is a key element, that offline vehicles will receive the mandatory calibration updates shortly after they have network connectivity again. To determine the compliance with the KPI, a GWEN will be switched offline, and the time will be measured, until an update is triggered, after the GWEN was switched online again. To comply with this KPI, the time to trigger a calibration upload must be less than 1h.

KPI.2.3.6 Number of Drivelets, which can be stored on a GWEN for later download

To analyse interesting Drivelets, these data files must be stored on the GWEN for a later download, ideally after a Wi-Fi connection has been established. As the memory space on the GWEN is limited, the oldest Drivelets will be deleted once the memory space is filled up by newer Drivelets. To allow the access to a helpful amount of driving situations, at least 100 Drivelets should fit on the GWEN, until a newer Drivelet triggers the deletion of the oldest one. To determine the compliance with the KPI, 100+1Drivelets will be stored on the GWEN and only one (the oldest) Drivelet shall be deleted in this process.

KPI.2.3.7 Sever capacity to manage and monitor vehicle fleet

As described before, an ASSIST-IoT network in the car manufacturer or car rental perimeter consists of a large amount of far edge nodes, ranging from several thousand to several million vehicles. Therefore, it is essential for ASSIST-IoT Pilot 3A, that the server capacity can handle an according number of requests in parallel. As described above, a smart and resource friendly queuing mechanism can be used, to manage load-peaks efficiently. To determine the compliance with this KPI, a parallel access of at least 200 simulated vehicles with an additional database of at least 10.000 vehicles is targeted. This number seems reasonable for a valuable KPI evaluation, given the scalability options provided by ASSIST-IoT. Compliance is given, if no data is lost after 200 simulated vehicles are handled within the Pilot 3A ASSIST-IoT network simultaneously for 100 trials. .

KPI.2.4.1 Detected defects

Defect detection as base for the evaluation of the vehicle's exterior condition is a cornerstone of the pilot to assist the optimisation of the task. This happens either by the human operator reviewing the scanned vehicle images using the ergonomic support of the digitalisation methods of ASSIST-IoT or additionally by the optional configuration of AI-techniques, which automatically inspect the vehicle's condition based on the scanned images. The results will be a minimal 40% recognition detection of the various damage categories without the need of physical presence to inspect the vehicle.

KPI.2.4.2 Vehicle inspection elapsed time

Another aspect of defect detection closely relates to the time required to output a verdict on the captured data. ASSIST-IoT's architecture could accelerate the established pipeline as it can push tasks towards the edge. For this reason, it is crucial to measure the elapsed time between the current situation of contemporary tools and technologies to the one with ASSIST-IoT's solution. A significant difference will be to decrease the present time by 30% for a vehicle inspection, which today is performed almost manually.

KPI.2.4.3 Revenues for repairing services

The applied technologies should profoundly impact the revenue stream of the stakeholders adopting the solution. The impact could be depicted in the growth of their operations. For example, garages and their service advisors can streamline their operations to promote solutions tailored to their customers. They benefit of the advanced solutions by getting upselling business opportunities for their everyday operations. E.g., when the service consultant of the garage detects a damaged rim on the scanned vehicle he can ask the customer, whether he would be interested to buy a smart repair service for his rim as an unexpected revenue for his organisation. The indicative revenue increase of the industry partners can be around 10% of the current revenues.

KPI.2.4.4 Decrease in the transfer of data to preserve network bandwidth and adhere data privacy

This KPI is about indication of the issue of data traffic in the network. Federated learning should be applied to minimise the data transfer, while the network's enablers can enhance the bandwidth. We consider that we comply with this KPI when there is discretion in data traffic. Naturally this KPI is only valid for the case, where FL-AI-based automated inspection has been configured as operational option, not for the pure documentation operational mode (use case).

KPI.2.5.1 Architecture integrated in lab conditions

This KPI is about readiness of laboratory for implementation of most advanced elements of pilot's realizations (TRL6). This KPI is Boolean type. Fulfilment of this KPI is considered when there is a readiness for testing and evaluation in a high-fidelity laboratory environment or in a simulated operational environment. To identify the compliance of this KPI, WP6 will monitors that all work are in line with the plan of Testing and integration (D6.2-6.3).

KPI.2.5.2 AI-driven pilots

The project of ASSIST-IoT is formed by 3 pilots, each with different use cases. Although not all the use cases to be trialled will be AI-driven, several have considered any kind of intelligence within its purposes. This KPI will account the number of all AI-driven use cases that have been successfully tested in the final pilot operations, either coming from the ASSIST-IoT pilot partners, or from external open calls. To consider that this KPI is fulfilled, at least 20% of the demos should contain some AI/ML ASSIST-IoT functionality. The range of functionalities that are available in the project ranges from e.g., a computer vision solution with the video augmentation enabler, an intent-based network orchestration by making use of the network orchestrator enabler, or the self-healing / self-geolocation functionalities provided to ASSIST-IoT smart devices by the corresponding enablers, respectively.

KPI.2.5.3 Successful pilots' implementation

During the first stage of the project, several business scenarios, which were in turn split into different use cases were defined to test the different developments. Some of these use cases have been analysed in depth to be later deployed in the four ASSIST-IoT pilots. After the Open Call rounds 1 and 2, additional use cases will arise. This KPI will contain the number of all use cases successfully tested in the final pilot operations.

4.3 Process evaluation

4.3.1 Introduction

The case of the process evaluation is a bit different from the technical and pilot ones. While the latter aims at evaluating tangible software and hardware results and their performance (technical – associated to task T8.2) and the outcomes and impact of the application of such technology into the selected trials (pilots – associated to task T8.3), the process evaluation goes wider in its scope.

In particular, it aims at gathering those KPIs not falling under neither technical nor pilot-wise domains, but that are, notwithstanding, relevant to understand the impact of the project: towards future deployments, towards the community, in terms of scalability, in terms of sticking to the trends and standardisation, relation with the outside world, etc.

4.3.1.1 Evaluation Purpose

The baseline understanding of ASSIST-IoT process is the following (sticking to the widespread standard development approach according the 'V-model'): (i) definition of use cases and requirements (see D3.2 and D3.3), delivering and architecture (T3.5) upon which technical components (WP4&WP5) are first, developed, and, later (WP6), integrated, moving to their actual usage in real/relevant environments (WP7) ending with an all-encompassing evaluation (WP8).

The original goal of a process evaluation task would be that of the verification that the process used was the applied correctly in the project, guaranteeing that all project targets were achieved, and no gaps were left in the project and that the use project process approach was indeed a good method to be used in similar projects.

However, the purpose of task T8.3, as well as the overall process evaluation is to understand whether the previous methodology has achieved its goals, by measuring related KPIs that could illustrate it. In particular, it is the intention to carefully look both into project's outcomes and into outside perspective/acceptance/adoption of ASSIST-IoT propositions.

Last but not least, the process evaluation will help synchronise the project flow in terms of outcomes/deliveries, used approach and way of working to achieve, within time and budget, long term impact and sustainability of project results.

4.3.1.2 Stakeholders

During the process evaluation, the transferability and future adoption of ASSIST-IoT technology, as well as the impact that is being generated (and that it could have in the future) are measured. Therefore, the methodology (DevSecOps), the technology (appropriateness, usability, quality, etc.) and the validation in relevant environments will form the cornerstone around which the success of this task will be built. In addition, evaluating ASSIST-IoT process would help future projects to re-use it, specifically whenever tackling NG-IoT innovative actions.

Direct beneficiaries of the results of this evaluation will be:

- Stakeholders of ASSIST-IoT, to realise the impact of the process of the project and to decide the direction which continue them over afterwards.
- Future users of ASSIST-IoT, specially having in mind potential customers/adopters stakeholders with similar needs to the ones expressed by the ASSIST-IoT pilot stakeholders.
- IoT open source community eager to use and/or advance ASSIST-IoT results.
- Further projects arising after the finalisation of ASSIST-IoT by the partners of the Consortium.
- Open Call applicants/participants, in order to align their products that interact with ASSIST-IoT or in order to adjust their lines in accordance.

Finally, the works in this part of the evaluation (process – T8.3) will take into serious consideration the different usages that ASSIST-IoT could have. While ASSIST-IoT as a whole could be considered a single, potentially adoptable product, it relies on a rather modular architecture, in which not all modules are mandatorily needed to be included, and where only some of them would be present. On the other side, those modules have also been designed and understood as interoperable pieces, thus it is possible that ASSIST-IoT enablers could be used outside the scope of the whole solution, being just one or some of them used integrated into other tools (e.g., a PCS, an ERP, isolated…).

All the previous will be considered during the performance of the process evaluation within the "Transferability Analysis".

Finally, another stakeholder (or final user) of the results of this evaluation would be researchers, both within the Consortium (UPV, SRIPAS, ICCS and CERTH are academic institutions) but also outside, where PhD students could select potential research lines out of ASSIST-IoT outcomes or full teams could create specific research groups.

4.3.1.3 Description of the evaluation approach and timeline

In order to reach the mentioned stakeholders and to meet the described goals, the process evaluation has been organised in ASSIST-IoT as follows.

A single task has been created (T8.4) that will oversee the participation of several partners (actually, most partners are part of this task) to cover the previous scope.

A two-fold operative strategy is devised for this task as it is indicated in the following image:

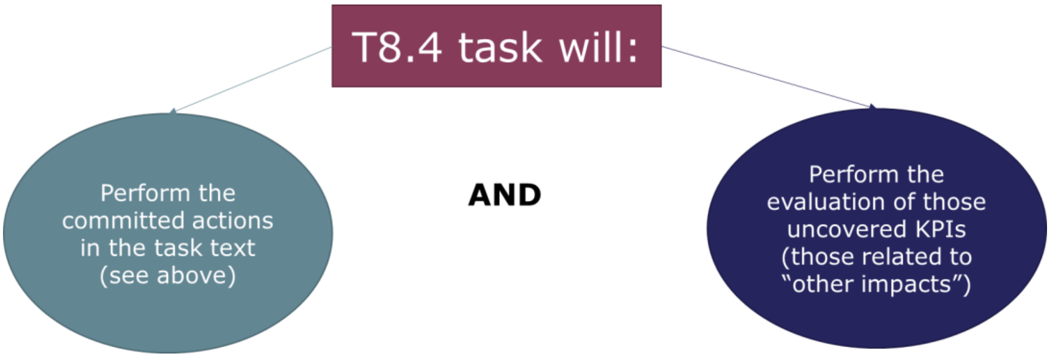

Figure 9 Two-fold approach for the process evaluation

First, aligning with the rest of the tasks in the WP, and following the overall evaluation spirit and approach in ASSIST-IoT, the works in this task will aim at defining, describing, initiating, measuring, reporting and assessing a set of indicators (KPIs) associated to the different parts of the process evaluation that must be covered. As it has been done in previous sections, the sub-section 4.3.2 illustrates the KPIs that will be used till M36 to report process evaluation over.

However, this task also contemplates a second course of action. Apart from the KPIs measuring and reporting, some activities will be performed with the goal of gathering impressions and feedback from external and internal actors about the transferability, impact, usability, adoption potential, acceptance, and other traits of the ASSIST-IoT solution so that a sound report moving forward could be elaborated.

In that regard, it has been decided that the following actions will be performed:

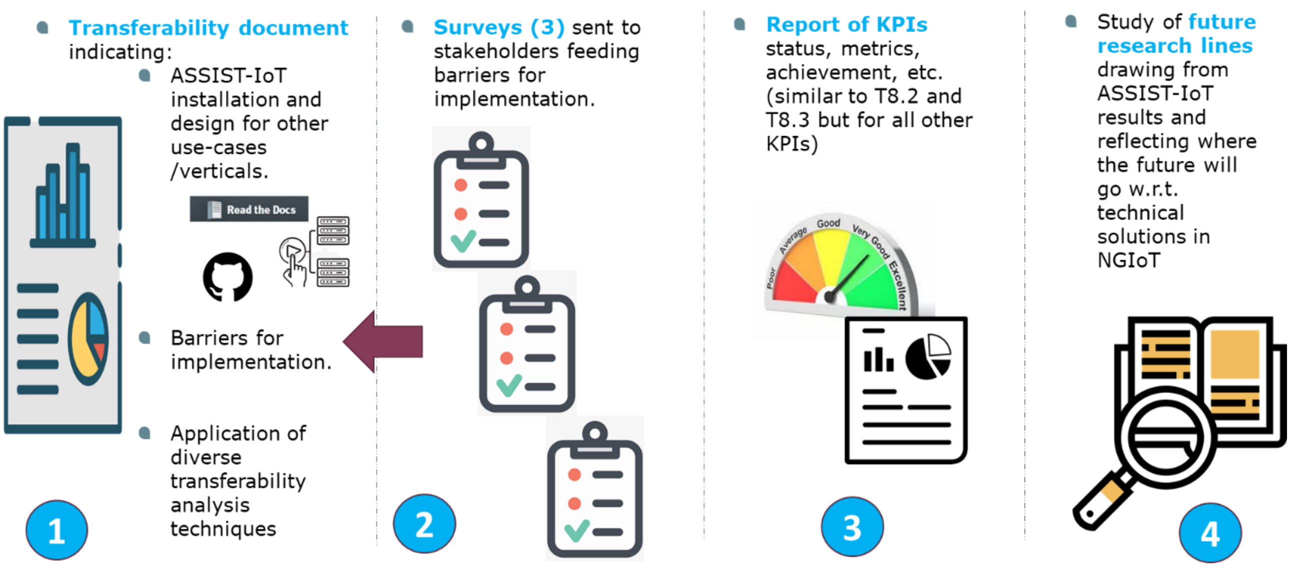

Figure 10 Activities to be performed in the process evaluation in ASSIST-IoT

Block #1: Transferability and future sustainability of ASSIST-IoT solution. The goals of this block are:

- Analyse potential barriers hindering implementation; drivers that can have positive influence on implementation; and lessons learned.
- Deliver a comprehensive picture of **expectable benefits from using ASSIST-IoT**.
- Deliver results for improvement of ongoing implementation of ASSIST-IoT action.

In order to achieve those goals, the following activities will be conducted during the course of task T8.4 (ending M36 of the project):

1 The creation of a transferability document, that will include enough information for an external reader to be able to understand the actions and steps to be done to adopt ASSIST-IoT. It does not stop at mere installation instructions (other tasks are devoted to this in the project – T6.4), but instead it will clearly analyse when it is a good idea to install each enabler or not depending on the scenario, it will include enough documentation to illustrate potential barriers of implementation, etc. Finally, it will include a transferability analysis using different validated techniques such as the Transferability Analysis tool developed by the CSA DocksTheFuture (among others).

2 Three surveys with most important stakeholders, where questionnaires will include info about all types of potential barriers for the transferability. It is expected that the feedback obtained from these surveys together with the experience by Open Call participants, enough lessons learnt will be generated to properly position ASSIST-IoT for future adoption.

4 A document studying the future research lines that might arise from ASSIST-IoT activities. This will be a mix between a state-of-the-art study and a prospective analysis and trends for the technologies that will be outputted from ASSIST-IoT.

Block #2: KPI reporting. The goal of this activity is the same as the rest of the tasks in this work package.

3 Definition of KPIs, periodic measurement and reporting. The goal is to reach the target values for each KPI before the finalisation of the project.

With regards to the timing, the following timeline has been designed. Enough and structured participation of all necessary partners has been planned accordingly.

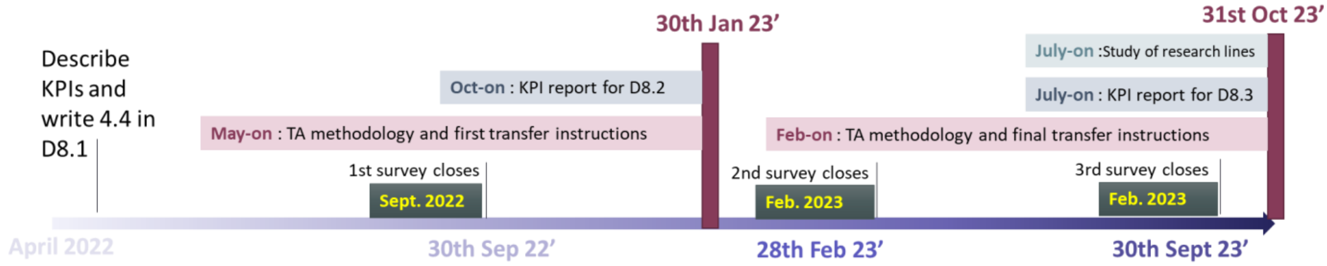

Figure 11 T8.4 timeline plan

4.3.2 Selected KPIs

For the Process Evaluation the KPIs selected are not directly related with any of the defined "dimensions", but rather it pervades several dimensions. As a matter of fact, many of the fields do have a KPI related with process evaluation. The "multi-dimensionality" of this set of KPIS, makes this task a very challenging one, as it will need to be present in all discussions and advance reporting's to ensure stickiness to the final targets. The expected fields where this task will work on are:

- Exploitation
  - Field 1.1 Stakeholders' and third parties' engagement
  - Field 1.2 Business models
  - Field 1.3 Exploitation of products
- Impact
  - Field 3.1 Standardisation
  - Field 3.2 Dissemination

- Field 3.3 Communication
- Ethical, societal, gender and legal evaluation
  - Field 5.1 Legal issues
  - Field 5.2 Holistic innovation
  - Field 5.3 User worktime/life impact
  - Field 5.4 Targeted social groups
  - Field 5.5 Trusted, safe, secure IoT environment promotion
  - Field 5.6 Community engagement

4.3.3 Data Collection and Measurement

KPI.1.1.1 Stakeholders expressing interest

This KPI aims at measuring the pervasiveness of ASSIST-IoT in terms of interest by (external to the project) stakeholders that would be willing to adopt ASSIST-IoT to manage their infrastructure, to deliver NGIoT services or to anyhow improve their businesses. This KPI will be generated drawing from formal expressions of interest (letters/emails/publications/web notes) and will be tightly related with the work exerted in T8.4 and in T9.4.

KPI.1.1.2 External adopters

This KPI measures the adoption scale of ASSIST-IoT results. Intimately linked with the Open Call success, as well as with the transferability analysis, this KPI will register how many "adoptions" of ASSIST-IoT. Here, "adoption" applies either to the solution as a whole or to specific enablers adopted in external eco-systems, interoperating with other technologies. This KPI will be measured in M36 and will be accompanied with a reflection from both WP8 and WP9 perspective.

KPI.1.1.3 Satisfaction of tactile applications

This KPI aims at measuring the satisfaction of end users in ASSIST-IoT that will be making use of tactile applications (dashboard, MR enabler, glasses, AR functionalities, defects inspection, etc.). The surveyed users will come from both the project pilots (stakeholders of WP7) and from the Open Call participants (whenever appropriate).

To measure this KPI, the "*Revised Technology Acceptance Model"* will be used. Again, this ancient methodology has now new, modern ways of application that will be explored in ASSIST-IoT. In principle, a % value will be sought, and the target is 85%.

KPI.1.1.4 IoT pillar institutions involved

This KPI will measure the collaboration capacity with relevant institutions in Europe related to the different technical fields of the project. In particular, entities related to IoT (AIOTI, NGIoT, EU-IoT…), 5G (6GIA, 3GPP…), IA (DSBA, DAIRO, Gaia-X…) will be contacted and requested for collaboration to ensure that the prominent visions of the state of the art and beyond are incorporated into the project. This KPI will, at the end of the project, gather the different interactions and involvement of those entities with ASSIST-IoT.

KPI.1.1.5 System usability scale

This KPI aims at measuring the usability of ASSIST-IoT system as a whole. ASSIST-IoT is an NG-IoT platform that covers all the layers of an IoT deployment and will be able to provide real time services over real time data, devices, network and applications. This KPI will determine how good, in terms of usability, will this platform be.

In order to perform this measurement, the indications settled in the work "*An Empirical Evaluation of the System Usability Scale. Aaron Bangor, Philip T. Kortum & James T. Miller*" will be followed. This work comes from an article originally published in 2008, but it has been reviewed, applied and commented repeteadly over the years. ASSIST-IoT will work on the most recent implementations of such a methodology, targeting a value of 70%.

KPI.1.1.6 Technology acceptance

This KPI will measure the "acceptance" of the technology (ASSIST-IoT as a whole and all the different enablers), drawing from the experiences from both the stakeholders of the project (pilot owners and app developers/IT practitioners) and the Open Call participants.

To measure this KPI, the "*Revised Technology Acceptance Model"* will be used. Again, this ancient methodology has now new, modern ways of application that will be expored in ASSIST-IoT. A target value of >5 has been set as a target.

KPI.1.2.1 Target customers

The project is committed to approach as many stakeholders as possible. With that objective in mind, project partners with the leadership of the Innovation Manager will identify target customers, users, and beneficiaries for whom our hypothetical business model may create sustainability change for ASSIST-IoT. Both, general ICT target customers aiming at exploiting the ASSIST-IoT platform as a whole, as well as more specific ASSIST-IoT Pilots will be identified.

KPI.1.2.2 Business plans for exploitable assets, stakeholders, and key alliances

The main purpose of the Innovation Management activity is to track the innovations generated in the project, analysing, in the form of exploitable assets, namely Innovation Elements. This KPI will be validated if (and only if) the 100% identified Innovation Elements of the project have defined a clearly business plan.

KPI.1.2.3 Addressable market

This KPI is very similar to the KPI.1.2.1. Whereas the target customers of the former KPI refers to those companies subject of being recipients of ASSIST-IoT solutions, the latter will be evaluated by estimating with consulting and statistical reports, the number of users that are actually using their different IoT solutions.

KPI.1.2.4 Innovative business models

Not only all the Innovation Elements of the project will devise their own viable business plans, but also it is expected that some of them will propose a go-to-market strategies sufficiently innovative that can be considered it is going beyond a regular business plan. This KPI will be evaluated by a subjective comparison of the proposed business plans of the ASSIST-IoT Innovation elements, and the publicly business plans presented in other related H2020 and Horizon Europe initiatives.

KPI.1.2.5 Technological advantage

IoT, and subsequent NG-IoT is converting the potential to generate more revenue and entirely new business models. The NG-IoT (like ASSIST-IoT) transition will trigger a cultural shift from Capital Expenditures (CAPEX) sales models to Long-term Operational Expenditures (OPEX) sales models. Therefore, it is expected that the latter will become the dominant economic trend as companies will leverage NG-IoT in several processes. This KPI will be evaluated by identifying the number of deployed IoT services of ASSIST-IoT pilots that are directly (or indirectly) supported by ASSIST-IoT enablers. Once these services are identified, their operational cost will be estimated and compared with the total OPEX demanded by the pilot to be fully functional.

KPI.1.2.6 Diversification

ASSIST-IoT aims to be a realistic, pilot-driven, NG-IoT platform. To validate ASSIST-IoT features and associated enablers, the project is addressing three main verticals: port logistics; construction, and automotive. However, the scope of ASSSIST-IoT is to become a vertical-agnostic platform, so that any vertical market can apply the functionalities of ASSIST-IoT without significant changes on the overall platform. This KPI will be evaluated by performing different interviews and/or questionnaires with stakeholders from other vertical sectors than the ones contemplated in ASSIST-IoT with the aim of verifying that the identified Innovation elements are of interest for their companies. This will be closely related with the Transferability Analysis and the surveys to be performed in task T8.4.

KPI.1.3.1 IPRs

This KPI represents the number of partners and third parties who are planning to exploit the intellectual property from their own results. To collect the data for this KPI, ongoing individual exploitation questionnaires, including face-to-face interviews with partners are periodically generated. These activities may result in the generation of several exploitation models, such as licensing, joint ventures, pay-per-service, spin-off, patents, etc. Therefore, this KPI will evaluate the number of innovation potentials that have been extracted from the project results.

KPI.1.3.2 Revenue growth

H2020 in general, and ASSIST-IoT in particular, aim at empowering European SMEs in their efforts and challenges towards successful commercialisation of their innovations. ASSIST-IoT will, thus, reinforce project's SMEs capabilities to successfully evolve towards their next lifecycle NG-IoT stage. To do so, from the very beginning of the project, a turnover and employee tracking of project's SMEs is being conducted. This KPI will be validated if the ASSIST-IoT SMEs' turnovers from 2020 and 2023 are, in average, increased by at least 15%.

KPI.1.3.3 Market share

Despite IoT potential, its market is still relatively small, facing with complexity, interoperability, cost, privacy and security concerns/issues. In addition, high energy consumption, or potential job losses due to automation are also limiting the final explosion of IoT. Nevertheless, some of the aforementioned barriers are expected to be broken down by the further virtualization of NG-IoT systems, like the ones envisioned in ASSIST-IoT. Therefore, it is foreseen that the innovations that are under development in the project will allow to reduce reluctancy from partners' contacts, letting them achieve relevant market share gains. This KPI will evaluate the market share gained by ASSIST-IoT partners, by comparing their market share analysis before and after ASSIST-IoT commenced (including partners' expectations for the 3 years after the end of the project). It can be considered as fulfilled if this gain is in average higher than 15%.

KPI.1.3.4 Return of Investment (RoI)

When reflecting about the calculation of the Return of Investment in regard to a technological solution delivered by a group of partners within an EC-funded project, it could be understood three-fold: (1) user/adopter viewpoint: assuming a potential customer would acquire ASSIST-IoT and deploy in their premises for their business, a RoI could be calculated analysing the expenditure for acquisition and the profits obtained from its usage. (2) EC's viewpoint: analysing the investment performed by the EC in the project (budget, etc.) and the benefits extracted from the execution of the action (in terms of publications, position of partners, outcomes, open-source products available, influence, etc.). (3) Partners' viewpoint: comparing the resources devoted to the developments in the project (personnel, etc.) to the outcome and benefits obtained.

In ASSIST-IoT, this KPI will also be framed into the viewpoints (2) and (3). An analysis of the RoI in those two perspectives will be performed at the end of the project and will be reported in D8.3.

KPI.1.3.5 Architecture made available

This KPI represents the participation in technological forums and events (webinars, etc.) on the internet to showcase that ASSIST-IoT architecture as a whole has been outputted by the project (as an exploitation result). To collect the data for this KPI, a summary of all communications and meetings that ASSIST-IoT has participated in will be created. This will also include meetings and presentations to show ASSIST -IoT to prospective customers (of the architectures as the baseline of the solution as a whole).

KPI.1.3.6 Conformance to new techs

This KPI measures the alignment of ASSIST-IoT technological outcomes (Innovation Elements, exploitable products, global results) with the current trends and de-facto standards in the IoT-edge-cloud and NGIoT fields. First, a list will be elaborated with those current to-be-conforming-with technologies (to be indicated in D8.2). Afterwards (in M36, through D8.3), from such a selected set of specific protocols, technologies and standards recently appeared (post 2010), a conformance checking, together with a justification, will be included. Such a list (original and conformed) will be agreed within the Consortium and with the members of the Advisory Board.

KPI.1.3.7 New verticals identified

Whereas KPI.1.2.6 will identify those vertical markets upon which ASSIST-IoT could be adopted without significant changes on the business models (pivoting), this one (KPI.1.3.7) will directly report (in a justified way) all the verticals that have been identified during the project over which ASSIST-IoT could be deployed (providing enough added value). This KPI will be measured drawing from a reasoned justification of those verticals that could be counted as potential market niches for ASSIST-IoT, at the end of the project.

KPI.1.3.8 Collaborating IoT Security Projects

ASSIST-IoT has as one of its pillars: security and privacy. It is expected that active collaboration will take place with different initiatives and/or projects focused on the merge of IoT with cybersecurity, including privacy, authentication, authorisation, integrity verification and DevSecOps, among others. This KPI aims at measuring that "collaboration effort", listing the number of joint workshops/webinars in collaboration with IoT security projects/initiatives, together with other ways of collaboration (always including enough endorsement claims). This KPI will be measured at the end of the project.

KPI.3.1.1 Internationally recognized standards supported in ASSIST-IoT solutions

This KPI measures the number of supported/applied existing, well-renowned and market-applied standards in the different components of the ASSIST-IoT. To identify the compliance of this KPI a list of ASSIST-IoT should be conformed, including in this one each of the standards supported by the component. Thus, having this list we can extract a final set of applied standards in ASSIST-IoT.
Is considered the fulfilment of this KPI, when the number of standards supported by all software components are over 40 at the end of the project.

KPI.3.1.2 Communications to modify / improve existing standards used in ASSIST-IoT

This KPI measures the number of identified existing standards where the modification or improvement is required in relation to developed ASSIST-IoT components, enablers, or overall architectural design. The list of these standards in relation to ASSIST-IoT components will verify the KPI compliance. To fulfil this KPI the number of identified standards should be over 2 in the half period of the project and 6 at the end.

KPI.3.1.3 Recommendations in relevant SDO's and initiatives

To measure this KPI we need to count the number of activities and performed contributions to different SDO's and initiatives for recommendations work purposes. The contributions will be prepared according to relevant ASSSIT-IoT research and development activities in different technical and non-technical subjects. The list of activities and contributions will be collected. The target values of this KPIs are: 4 in M18 and 10 at the end of the project.

KPI.3.1.4 SDOs and pre-normative initiatives engaged

This KPI is collecting the number of different engagements in SDO's, and pre-normative initiatives described in D9.3. All activities will be counted regarding participation in different SDO's, initiatives and forums for different standardisation subjects. The active participation in different standardisation working groups, study groups, task forces and their working subjects will be included.
To fulfil this KPI we need to have activities at least in 6 standardisation subjects and 40 at the end of the project.

KPI.3.1.5 Identified standards related to ASSIST-IoT activities

This KPI measures the identified standards related to different subjects of ASSIST-IOT solutions (components, enablers, architecture) that are supported or not supported in the developed solutions. The analysis of the standards from different SDO's and initiatives is presented in D9.3. Based on this analysis we can calculate the number of identified standards and technical reports which is the KPI measure. In D9.3 this KPI as well as all above standardisation KPI's were calculated and presented. To fulfil this KPI we need to identify 50 standards at the current stage (M18) and 120 standards at the end of the project.

KPI.3.2.1 Number of scientific publications

This KPI measures how many scientific publications (in journal and conference material) in different technical area related to ASSIST-IoT will be published. In D9.5 one can find the detailed information about publications (where, who published, when and so on). To identify the compliance of this KPI, WP9 closely monitors and documents the activities performed. Fulfilment of this KPI is considered when at least 12 publications have been performed during the first 18 month of the project and 38 in M36

KPI.3.2.2 European IoT Platforms compatible and connected to ASSIST-IoT modules

This KPI measures the practical interoperability of ASSIST-IoT solution with other IoT platforms. ASSIST-IoT focuses one of its verticals in the scalability and interoperability of the technology. For that concern, an Open API, altogether with structured virtualisation and containerisation of the enablers, and a single interface to manage the framework are created. This should help interoperate with other platforms that might wish to leverage any of ASSIST-IoT modules. This KPI will be measured at the end of the project and will report how many IoT platforms are functioning or have functioned connected to ASSIST-IoT. Open Call participants are expected to play a key role towards this KPI. Expected target is 4 platforms. Interoperability must be justified and explained.

KPI.3.2.3 Letters of interest to adopt ASSIST-IoT technologies

Towards the end of the project, the partners of T8.4 will work together with T9.4 (Exploitation) to obtain letters of interest from relevant external actors expressing their willingness to adopt ASSIST-IoT technologies in the future. These letters will be attached to D8.3 and the target value is 2 (only demonstrable relevant actors to be counted).

KPI.3.2.4 Research actions including one or several modules developed on ASSIST-IoT

This KPI aims at measuring the pervasiveness of ASSIST-IoT technological outcomes in the research field. In particular, it is the goal of T8.4 participants to tackle new research proposals to request further funds to continue the work over ASSIST-IoT portfolio (as a whole and as per module). This KPI will report about the number of such actions envisioned and tackled. In order for an action to be accepted to be counted in this KPI, deliverable D8.3 will need to include: - idea, - summary of ambitions, - call/program where it has benn submitted or that will be submitted. Target is 2.

KPI.3.2.5 Industrial actions including one or several modules developed on ASSIST-IoT

This KPI aims at measuring the pervasiveness of ASSIST-IoT technological outcomes in the private/industrial field. In particular, the idea is to achieve the inclusion of one or some ASSIST-IoT modules in the innovation lines / innovation policies / product portfolio / improvement route of private actors related (or not) to the verticals of the project (being the subject a partner of ASSIST-IoT or not). This KPI will be justified in D8.3 by including the following info: - ASSIST-IoT module, - How it contributes to the company/product/innovation/investment line, - company, - expectations for medium-long term. The target value is 2.

KPI.3.2.6 Number of cyber-security fairs/congresses attended

This KPI determines the number of events attended by ASSIST-IoT such as fairs and congress related to cyber-security. To identify the compliance of this KPI, WP9 closely monitors and documents the activities performed. Fulfilment of this KPI is considered when at least 3 activities have been performed during the first 18 months and 8 activities in M36.

KPI 3.3.1 Communication and community building activities organised/co-organised

This KPI determines the number of events organised/co-organised/attended by ASSIST-IoT such as workshops, webinars, events, open trials etc. To identify the compliance of this KPI, WP9 closely monitors and documents the activities performed. Fulfilment of this KPI is considered when at least 12 activities have been performed.

KPI 3.3.2 Subscribers to ASSIST-IoT communication channels and related activities

This KPI determines the number of visitors, subscribers and followers in ASSIST-IoT communication channels. To identify the compliance of this KPI, WP9 closely monitors and documents the visitors/followers/subscribers of ASSIST-IoT communication channels on a quarterly basis through the release of Statistical Dashboards per social media channel. Fulfilment of this KPI is considered when at least 2,000 website visitors and social media followers/subscribers have been reached in total.

KPI 3.3.3 Online communications (news, posts, articles)

This KPI determines the number of posts and news communicated through the website and social media. To identify the compliance of this KPI, WP9 closely monitors and documents the news communicated. Fulfilment of this KPI is considered when at least 600 posts/news have been communicated throughout the project lifetime.

KPI 3.3.4 Online traffic attracted (website, social media)

This KPI determines the number of visitors and persons reached/engaged with the online communication activities of ASSIST-IoT website and social media. To identify the compliance of this KPI, WP9 closely monitors and documents the number of visitors/persons reached/engaged on a quarterly basis through the release of Statistical Dashboards per social media channel and closely monitoring of Google analytics for the website. Fulfilment of this KPI is considered when at least 50,000 reach/engagement activities have been recorded in all communication channels.

KPI.3.3.5 Participation in external IoT Communities

This KPI measures the number of participations, interactions, and involvement of ASSIST-IoT in external IoT Communities (e.g., AIOTI), SDOs and related associations. To identify the compliance of this KPI, WP9 and also rest WPs and partners, closely monitor and documents the interaction of ASSIST-IoT with external IoT communities and their common presence/executions of activities at events, conferences etc. Fulfilment of this KPI is considered when at least 25 participations, interactions, and involvement of ASSIST-IoT in external IoT Communities have been recorded.

KPI.3.3.6 IoT related organisations

This KPI determines the capacity of ASSIST-IoT of involving external organisations (related to IoT) to participate/collaborate/follow with the project. Closely monitoring and documenting the co-organised events, activities, and social media followers (especially in professionals-oriented communication channels such as ASSIST-IoT LinkedIn account) is considered as the compliance identification method of this KPI. Fulfilment of this KPI is considered when at least 10 IoT related organisations participate/collaborate/follow ASSIST-IoT.

KPI.3.3.7 Joining communities

This KPI refers to the tentative (and potential achievement) of ASSIST-IoT to join external communities (e.g., ALICE ETP) or interact with them through the social media (mentions, references, follows). Fulfilment of this KPI is considered when at least 20 interactions and involvement of ASSIST-IoT in external communities have been recorded.

KPI.3.3.8 Professionals engaged for impact

This KPI refers to the tentative (and potential achievement) of ASSIST-IoT to join external communities (e.g., ALICE ETP) or interact with them through the social media (mentions, references, follows). Fulfilment of this KPI is considered when at least 20 interactions and involvement of ASSIST-IoT in external communities have been recorded.

KPI.3.3.9 External Professionals involved

This KPI measures external professionals involved (open-source developers, events, and hackathons participants) with the project. Fulfilment of this KPI is considered when at least 80 such evolvements with open-source developers, events/ hackathons participants etc. have been recorded.

4.3.3.1 Assessment of ethical, societal, gender and legal aspects

This sub-section (although still falling under the Process Evaluation task) aims at particularising the work that will be done towards those KPI related to ethical, societal and legal aspects. These are of special relevance and will need to be measured following a slightly particularised methodology.

According to the H2020 online manual there are standard ethics that all ASSIST-IoT partners are obligated to follow. This piece of text clarifies the strategy of technology, use cases and processes that ASSIST-IoT will follow for evaluation of its use. The United Nations Development Program (UNDP) guideline states that the evaluation process should be independent, transparent, ethical, purposeful and unbiased.

The KPIs of ethical, societal, gender and legal aspects must be well-defined and must have a measurement to clarify the results. The tools that will be used for the successful measurement of the KPIs will be internet surveys with binary questions.

ASSIST-IoT partners that will get involved in the process of evaluating the KPIs will be multiple to achieve transparency and integrity and the partners that will be involved in the development will be documented to achieve the best results.

The evaluation of the KPIs will take place in October of 2023 and will be documented in D8.3. Furthermore, the evaluation process will be internal so problems can still arise, that's why all partners will get involved in the process of evaluation and in the reviewing process. Therefore, ASSIST-IoT will achieve results that are reflective of the actual state.

KPI.5.1.1 Regulation adherence

This KPI measures the number of legislations (regulation and public policies) from different countries that have been considered during ASSIST-IoT developments. Collecting data for this KPI will be done by listing the number of regulations and policies that have been considered during the project lifetime.

KPI5.1.2 Legalisation assessment

This KPI is about how users and stakeholders feel about legal and IPR concerns linked to IoT interoperability in the context of this KPI. Filling out an internet survey with binary yes/no questions will be used to gather data for this KPI.

KPI5.2.1 Worktime - Time Saving

We evaluate how ASSIST-IoT users and stakeholders feel about ASSIST-IoT's solutions to improve their efficiency and contribute their business output, in the context of this KPI. Filling out an internet survey with binary yes/no questions will be used to gather data for this KPI.

KPI5.2.2 Human-centred innovations

We examine how ASSIST-IoT users and stakeholders view the social effect of ASSIST-IoT innovation results in the context of this KPI. Filling out an internet survey with binary yes/no questions will be used to gather data for this KPI.

KPI.5.3.1 Threat on the labour demand

We evaluate how ASSIST-IoT users and stakeholders estimate the impact of ASSIST-IoT technologies on the labour market in the context of this KPI. Filling out an internet survey with binary yes/no questions will be used to collect data for this KPI.

KPI.5.4.1 Life - Social inclusion

We evaluate how ASSIST-IoT users and stakeholders feel about ASSIST-IoT's solutions regarding social inclusion and positive influence on overall wellness, in the context of this KPI. Filling out an internet survey with binary yes/no questions will be used to gather data for this KPI.

KPI.5.4.2 Gender equality

In the context of this KPI, we evaluate how ASSIST-IoT users and stakeholders feel about the impact of ASSIST-IoT solutions to gender equality. Filling out an internet survey with binary yes/no questions will be used to gather data for this KPI.

KPI.5.5.1 Security and privacy institutions engaged

ASSIST-IoT will make use of its network and participate in events to engage with stakeholders in the security and privacy sector. ASSIST-IoT aims to motivate and engage the public with security and privacy issues, as awareness about security and forming a network of connections are vital for the growth of the field. The goal set in the Grant Agreement is to involve at least 20 institutions in the project, considering various types of engagement (expression of interest, attending to ASSIST-IoT events/webinars, applying for Open Calls, reaching out via usual contact channels, requesting formal meetings, pitches…).

KPI.5.5.2 Security, privacy, trust and accountability specific publications

The number of scientific publications related to related to IoT networks and security issues. This will be measured coming from WP9 reports and will be analysed at the end of the project.

KPI.5.6.1 Minority groups inclusion

In the context of this KPI, we evaluate how ASSIST-IoT users and stakeholders feel about the impact of ASSIST-IoT solutions to the inclusion of minority groups. Filling out an internet survey with binary yes/no questions will be used to gather data for this KPI.

KPI.5.6.2 Accessibility

In the context of this KPI, we evaluate how ASSIST-IoT users and stakeholders feel about accessibility of ASSIST-IoT technology. Filling out an internet survey with binary yes/no questions will be used to gather data for this KPI.

5 Conclusions

This document presents the basis for rigorous assessment of the ASSIST-IoT success. In it we have first established the methodology for gathering data that we will use in the assessment of project's success. To complement the methodology, we have defined indicators that score this data, and thus enable us to judge success of individual parts of the project.

In the evaluation methodology, we have defined five dimensions of measurement (exploitation, impacts, pilots, technology and ethical, societal, gender and legal evaluation), and partitioned these dimensions of measurement into fields. For each field we further define a list of KPIs with their description, target and data collection methods. Majority of these were taken from ASSIST-IoT project requirements (WP3), as well as design/implementation tasks (WP4 – WP7) from earlier project stages. We have based the evaluation of KPIs on the notion of KPI targets, which provide benchmarking values against which to judge individual KPI's success. To assign scores to KPIs, functions have been defined in the Annex of this deliverable, which are based on predefined constraints, presented in this document. Using KPI scores, we can calculate Field scores and later also Dimension scores. We have thus established a rigorous assessment of project's success, as well as success of individual project parts.

Based on all this work we have defined three different evaluation plans. In them we have described in detail how and when evaluation activities are going to be carried out, as well as who will accomplish them.

Technical evaluation approach was described so that it will assess ASSIST-IoT from a technical perspective, assessing its interoperability capabilities, usability of its framework, its performance and usability as per user's and stakeholder's judgment. It also judges whether the project has met its requirements and performs gap analysis. Technical evaluation shall be performed in task T8.2, judging all four main ASSIST-IoT development areas: Device and Edge plane, Smart Network and Control Plane, Data Management Plane and Application and Service Plane components. Its results shall be fed back to the development team, driving further ASSIST-IoT development, while they will also benefit future ASSIST-IoT users in the pilots and administrators of systems who will use ASSIST-IoT.

The plan for evaluation of the results of the pilots will assess main products developed through the project from the standpoint of ASSIST-IoT pilots, thus aiding developers in improvement of project's efficiency in real-life scenarios as well as creating new business models for ASSIST-IoT deployment and usage in the future. It will be executed in the task T8.3.

Process evaluation plan was designed as being the most encompassing of all three evaluation plans. It considers project's stakeholders and users, their interest in the project and their potential gain from the project, as well as also project's legal, gender, societal and ethical aspects, etc. It will therefore deliver a comprehensive picture of the expectable benefits from implementing the system as well as of the modalities required for its successful implementation. Its results will feed back into the ASSIST-IoT development process.

Annex 1 - KPI score calculation

This table contains all the KPIs of the project. Rows in “white” come directly from the Grant Agreement of the action, either as KVIs (related to project goals) or as KPIs (described in the Impact section of the Description of Action). Rows in ”yellow” represent those KPIs that have been created during the first months of WP8 (M14-M18) drawing from the action performed (and lessons learnt) in other WPs.

Table 17 Dimension 2 - Pilots; distribution of KPIs/KVIs

KVI-Num	KPI Num	Title of KPI	Metric	Target (M36)
KVI-1.1	KPI.1.3.5	Reference architecture available, published and presented to relevant IoT and NGI related entities	Boolean	VERDADERO
KVI-1.2	KPI.2.5.1	Reference implementation of the architecture available and working in laboratory and real conditions	Boolean	VERDADERO
KVI-2.1.1	KPI.4.2.1	VNFs (CNFs) achieved for improving performance and network reconfiguration and other network tasks.	# of CNFs	6
KVI-2.1.2	KPI.4.2.2	AI models achieved for improving performance and network reconfiguration and other network tasks.	# of AI models	3
KVI-2.2	KPI.4.2.3	Network transmissions execute one of the routines and get an improvement from the baseline.	From baseline TBE	20%
KVI-3.1	KPI.4.8.1	Automated accountability of interactions/communications performed (defining responsible)	% out of total interactions	> 85%
KVI-3.2	KPI.4.8.2	Data governance services supported by IoT-enabled DLT.	# of services	10
KVI-4.2	KPI.4.6.1	Reduction of processing needs/costs of distributed AI with regard to equivalent performing algorithms.	From baseline TBE	50%
KVI-5.2	KPI.4.4.1	Human-centric components with traceable and quantifiable impact in the quality of work/life	# of components	9
KVI-6.3	KPI.4.4.2	Number of Human-centric UCs per pilot with NGI technologies performing meaningful tasks.	# of UCs per pilot	3
	KPI.4.1.1	CPU load of GWEN processes	% of average CPU load	<75%
	KPI.4.1.2	Memory usage of GWEN processes	% of average memory usages	<75%
	KPI.4.2.4	Number of hosts clusters connected to remote k8s clusters thanks to VPN enabler (in total of all pilots)	# of hosts	8
	KPI.4.2.5	Messages classified in all pilots by the traffic classificator	# of messages	>500
	KPI.4.3.1	Streaming Annotation Latency	time	<10ms
	KPI.4.3.2	Streaming Translation Latency	time	<10ms
	KPI.4.3.3	Streaming Annotation Clients Number	number	>9
	KPI.4.3.4	Streaming Translation Clients Number	number	>9
	KPI.4.3.5	Semantic Repository File Size Support	file size	>5GB
	KPI.4.4.3	UX Usability	Level of satisfaction	70
	KPI.4.5.1	Number of autonomous decision taken while executing pilots	# of decisions	>5
	KPI.4.5.2	Number of components/resources involved in self-* process	# of resources	>5

	KPI.4.6.2	Number of FL simultaneous users/parties participated in the federated training	# of users	10
	KPI.4.6.3	Number of ML models supported by the ASSIST-IoT FL system	# of FL models	2
	KPI.4.6.4	Number of use cases that has been made use and successfully tested with ASSIST-IoT FL system	# of use cases	2
	KPI.4.7.3	Correct identification attempt ratio	% of a baseline	75%
	KPI.4.7.4	Validated authorization request ratio	% of a baseline	40%
	KPI.4.8.3	Availability of FL ML local models' collection.	% baseline	75%
	KPI.4.7.5	Detected alerts per hour	# of alerts	10
	KPI.4.8.4	Decrease in training dataset biases.	% baseline	50%
	KPI.4.8.5	Number of use cases successfully tested with the DLT registry enabler	# of use cases	2
	KPI.4.8.6	Number of use cases successfully tested with the DLT integrity verification enabler	# of use cases	2
	KPI.4.9.1	Number of enablers deployed using the interface	Number of enablers	60
	KPI.4.9.2	Different topologies managed by the service flow enabler / enablers per deployment handled in each topology	# of topologies / # of enablers total	4 \ 40
	KPI.4.9.3	Configurable parameters that are able to be tuned in the manageability interface	Number of parameters (total from all enablers)	50
KVI-4.1	KPI.2.5.2	Pilots are AI driven, getting historic and online data from IoT deployments.	% over total UCs	> 20%
KVI-6.1	KPI.2.5.3	Successful implementation of the 3 real-world pilots fulfilling a high % of use cases established initially	% over total UCs	95%
	KPI.2.1.1	Decrease of quay to stack and gate to stack turnaround time due to real-time and correct data	From baseline TBE	5%
	KPI.2.1.2	Increase of yard CHE fleet dispatching dynamics due to remote operation	From baseline TBE	30%
	KPI.2.1.3	Increase of yard equipment workforce due to remote operability from office environment	From baseline TBE	20%
	KPI.2.1.4	Decrease of accidents due to automation and less persons at quay and yard	From baseline TBE	80%
	KPI.2.1.5	Bandwidth required to support remote operation of CHEs via wireless access	available bandwidth (in Mbps)	> 60 Mbps
	KPI.2.1.6	L2 network latency required to support remote operation of CHEs via wireless access	duration (in ms)	20 ms
	KPI.2.1.7	Coverage area (in m) for starting M2M authentication process in order to avoid unauthorised accesses	area (in m)	15 m
	KPI.2.1.8	Number of supported wireless access networks for the remote operation of CHEs	From baseline (1)	2
	KPI.2.1.9	Human-to-machine interfaces provided for CHE drivers	From baseline (0)	3
	KPI.2.2.1	False positives or negatives when alarming a worker of a risk nearby.	% out of the total	< 5%
	KPI.2.2.2	Types of OSH hazards to be detected and prevented	# of types of hazard	10
	KPI.2.2.3	Reduction of detection time of hazard/risk situation	From baseline TBE	50%
	KPI.2.2.4	User acceptance of technology applied	5-point Likert scale	> 75%

	KPI.2.2.5	The OSH shall be informed about hazardous events within the construction area	success rate	>90%
	KPI.2.2.6	The OSH shall report context-based media reports (photo and information) through the MR device.	success rate	>90%
	KPI.2.2.7	Users are able to manipulate the BIM models through the MR devices:	degrees of freedom	>6
	KPI.2.2.8	Detection of near-miss fall from a height	success rate	>85%
	KPI.2.2.9	Latency between worker entering a dangerous zone and them being warned	time	<1.5s
	KPI.2.2.10	Latency between worker entering a dangerous zone and the OSH manager being notified	time	<5s
	KPI.2.3.1	Cut in vehicle series recalls by unit and fleet monitoring.	From baseline TBE	50%
	KPI.2.3.2	Shortening of ECU diagnostics software dev. time, since diagnostics software will be evolved along vehicle life.	From baseline TBE	>50%
	KPI.2.3.3	Number of data channels measured in parallel	Number of data channels	≥200
	KPI.2.3.4	Available connectivity channels provided by ASSIST-IoT Availability of 2G, 3G, 4G, 5G, WiFi, Ethernet	Boolean	TRUE or FALSE for all channels
	KPI.2.3.5	Time to update a PCM calibration on the edge, after a vehicle was offline	Time until calibration update starts	<1h
	KPI.2.3.6	Number of drivelets, which can be stored on a GWEN for later download	Number of stored drivelets on a GWEN	≥100
	KPI.2.3.7	Server capacity to manage monitor vehicle fleet	Number of vehicles to be managed and monitored in parallel	≥ 200
	KPI.2.4.1	Increase on detected defects on the outer body of vehicles that would otherwise be unnoticed	From baseline TBE	> 40%
	KPI.2.4.2	Faster vehicle inspection compared to current manual practices	From baseline TBE (in minutes)	> 30%
	KPI.2.4.3	New revenue through additional repair services	From baseline TBE (in minutes)	>10%
	KPI.2.4.4	Minimisation of data transfer in the pilot thanks to FL	Percentage	50%
KVI-7.2	KPI.1.1.1	Stakeholders/innovators expressing interest of willing to join the project or to adopt ASSIST-IoT.	# units	> 10
	KPI.1.1.2	External adopters	# units	50
	KPI.1.1.5	System usability scale	Questionnaire	70%
	KPI.1.1.6	Technology acceptance	TAM	>5
KVI-5.1	KPI.1.1.3	End-users satisfaction with tactile applications	TAM	85%
	KPI.3.1.1	Internationally recognized standards supported in ASSIST-IoT related to IoT	# units	40
	KPI.3.1.2	Communications to modify/improve existing standards used in ASSIST-IoT	# units	6
	KPI.3.1.3	Recommendations in relevant policy oriented organisms regarding ASSIST-IoT technologies	# units	10
	KPI.3.1.4	SDOs and pre-normative initiatives engaged	# units	40

	KPI.3.1.5	Identified standards related to ASSIST-IoT activities (supported or unsupported)	# units	120
	KPI.3.2.1	Number of scientific publications	# units	38
	KPI.3.2.2	European IoT Platforms compatible and connected to ASSIST-IoT modules	# units	4
	KPI.3.2.3	Letters of interest to adopt ASSIST-IoT technologies	# units	2
	KPI.3.2.4	Research actions including one or several modules developed on ASSIST-IoT	# units	2
	KPI.3.2.5	Industrial actions including one or several modules deveoloped on ASSIST-IoT	# units	2
	KPI.1.3.6	Conformance to new techniques and technologies	% out of a list	100%
KVI-7.1	KPI.1.2.2	Business plans for exploitable assets, stakeholders and key alliances identified and contacted	% of expl. assets covered	100%
KVI-8.2	KPI.1.2.4	Innovative business models	# units	> 6
KVI-8.3.1	KPI.1.3.2	Revenue growth – increase for SMEs and industries	From baseline TBE	15-25%
KVI-8.3.2	KPI.1.3.3	Market share gained	From baseline TBE	15%
	KPI.1.3.4	Return of Investment (RoI)	From baseline TBE	5-10%
	KPI.1.2.5	Technological advantage	% from baseline	10-15%
	KPI.1.2.3	Total addressable market	# of users	10000
KVI-6.2	KPI.1.3.7	Identification of different new verticals to deploy architecture reference implementations	# of new verticals	at least 3
	KPI.1.2.6	Diversification (justified)	# of new vertical markets	8
	KPI.5.5.1	Security and privacy institutions engaged	# institutions	20
	KPI.3.2.6	Number of cyber-security fairs/congresses attended	# fairs/congresses	8
	KPI.5.5.2	Security, privacy, trust and accountability specific publications	# publications	12
	KPI.1.3.8	Collaborating IoT security projects	# projects/initiatives	10
	KPI.4.7.1	Potential number of users that could be covered by implementing ASSIST-IoT security / privacy methods	# of users	20000
	KPI.4.7.2	Percentage of users implementing the security and privacy methods in the ASSIST-IoT use cases, including the identity, authorization, and cybersecurity monitoring services.	% of users	75%
	KPI.3.3.5	Participation in external IoT communities	# of communities	25
KVI-8.1.3	KPI.3.3.6	Involving IoT-related organisations	# of organisations	12
KVI-8.1.2	KPI.3.3.7	Joining related communities	# of communities	> 20
KVI-8.1.1	KPI.3.3.8	Professionals attracted to enhance impact.	# professionals	> 2000
	KPI.3.3.9	External professionals involved (open source developers contributions and hackathons participants)	# professionals	80
	KPI.1.1.4	IoT and technological pillars (AI, 5G, smart devices…) institutions involved	# institutions	12
	KPI.3.3.1	Communication and community building activities organised	# of activities	12
	KPI.3.3.2	Subscribers to ASSIST-IoT related activities	# of subscribers	2000

	KPI.3.3.3	Online communications	# of items (tweets, posts, etc.)	2500
	KPI.3.3.4	Online traffic attracted	# of visitors	50000
	KPI.5.1.1	Regulation adherence	Positive results (100 answers)	>75%
	KPI.5.1.2	Legalisation assessment	Positive results (100 answers)	>75%
	KPI.5.2.1	Worktime - time saving	Positive results (100 answers)	>75%
	KPI.5.2.2	Human-centred innovations	Positive results (100 answers)	>75%
	KPI.5.3.1	Threat on the labour demand	Positive results (100 answers)	>75%
	KPI.5.6.1	Minority groups inclusion	Positive results (100 answers)	>75%
	KPI.5.6.2	Accessibility	Positive results (100 answers)	>75%
	KPI.5.4.1	Life - social inclusion	Positive results (100 answers)	>75%
	KPI.5.4.2	Gender equality	Positive results (100 answers)	>75%
	KPI.1.2.1	Target customers	# units	500
	KPI.1.3.1	IPRs	Number	5

Annex 2 - KPI leading partners

This table aims at indicating one of the requirements settled for this deliverable: the WHO. Each KPI has an associated partner that will be in charge of measuring and reporting the value at M36.

Table 18 Dimension 2 - Pilots; distribution of KPIs/KVIs

KPI Num	Title of KPI	Partner
KPI.1.3.5	Reference architecture available, published and presented to relevant IoT and NGI related entities	UPV
KPI.2.5.1	Reference implementation of the architecture available and working in laboratory and real conditions	SRIPAS
KPI.4.2.1	VNFs (CNFs) achieved for improving performance and network reconfiguration and other network tasks.	UPV
KPI.4.2.2	AI models achieved for improving performance and network reconfiguration and other network tasks.	UPV
KPI.4.2.3	Network transmissions execute one of the routines and get an improvement from the baseline.	UPV
KPI.4.8.1	Automated accountability of interactions/communications performed (defining responsible)	CERTH
KPI.4.8.2	Data governance services supported by IoT-enabled DLT.	CERTH
KPI.4.6.1	Reduction of processing needs/costs of distributed AI with regard to equivalent performing algorithms.	PRO
KPI.4.4.1	Human-centric components with traceable and quantifiable impact in the quality of work/life	PRO
KPI.4.4.2	Number of Human-centric UCs per pilot with NGI technologies performing meaningful tasks.	PRO
KPI.4.1.1	CPU load of GWEN processes	NEWAYS
KPI.4.1.2	Memory usage of GWEN processes	NEWAYS
KPI.4.2.4	Number of hosts clusters connected to remote k8s clusters thanks to VPN enabler (in total of all pilots)	UPV
KPI.4.2.5	Messages classified in all pilots by the traffic classificator	UPV
KPI.4.3.1	Streaming Annotation Latency	SRIPAS
KPI.4.3.2	Streaming Translation Latency	SRIPAS
KPI.4.3.3	Streaming Annotation Clients Number	SRIPAS
KPI.4.3.4	Streaming Translation Clients Number	SRIPAS
KPI.4.3.5	Semantic Repository File Size Support	SRIPAS
KPI.4.4.3	UX Usability	PRO
KPI.4.5.1	Number of autonomous decision taken while executing pilots	SRIPAS
KPI.4.5.2	Number of components/resources involved in self-* process	SRIPAS
KPI.4.6.2	Number of FL simultaneous users/parties participated in the federated training	PRO
KPI.4.6.3	Number of ML models supported by the ASSIST-IoT FL system	PRO
KPI.4.6.4	Number of use cases that has been made use and successfully tested with ASSIST-IoT FL system	PRO
KPI.4.7.3	Correct identification attempt ratio	S21SEC
KPI.4.7.4	Validated authorization request ratio	S21SEC
KPI.4.8.3	Availability of FL ML local models' collection.	CERTH
KPI.4.7.5	Detected alerts per hour	S21SEC

KPI.4.8.4	Decrease in training dataset biases.	CERTH
KPI.4.8.5	Number of use cases successfully tested with the DLT registry enabler	CERTH
KPI.4.8.6	Number of use cases successfully tested with the DLT integrity verification enabler	CERTH
KPI.4.9.1	Number of enablers deployed using the interface	UPV
KPI.4.9.2	Different topologies managed by the service flow enabler / enablers per deployment handled in each topology	UPV
KPI.4.9.3	Configurable parameters that are able to be tuned in the manageability interface	UPV
KPI.2.5.2	Pilots are AI driven, getting historic and online data from IoT deployments.	PRO
KPI.2.5.3	Successful implementation of the 3 real-world pilots fulfilling a high % of use cases established initially	PRO
KPI.2.1.1	Decrease of quay to stack and gate to stack turnaround time due to real-time and correct data	TL
KPI.2.1.2	Increase of yard CHE fleet dispatching dynamics due to remote operation	KONECRANES
KPI.2.1.3	Increase of yard equipment workforce due to remote operability from office environment	KONECRANES
KPI.2.1.4	Decrease of accidents due to automation and less persons at quay and yard	TL
KPI.2.1.5	Bandwidth required to support remote operation of CHEs via wireless access	TL
KPI.2.1.6	L2 network latency required to support remote operation of CHEs via wireless access	TL
KPI.2.1.7	Coverage area (in m) for starting M2M authentication process in order to avoid unauthorised accesses	PRO
KPI.2.1.8	Number of supported wireless access networks for the remote operation of CHEs	TL / UPV
KPI.2.1.9	Human-to-machine interfaces provided for CHE drivers	PRO
KPI.2.2.1	False positives or negatives when alarming a worker of a risk nearby.	CIOP-PIB
KPI.2.2.2	Types of OSH hazards to be detected and prevented	CIOP-PIB
KPI.2.2.3	Reduction of detection time of hazard/risk situation	CIOP-PIB
KPI.2.2.4	User acceptance of technology applied	MOW
KPI.2.2.5	The OSH shall be informed about hazardous events within the construction area	ICCS
KPI.2.2.6	The OSH shall report context-based media reports (photo and information) through the MR device.	ICCS
KPI.2.2.7	Users are able to manipulate the BIM models through the MR devices:	ICCS
KPI.2.2.8	Detection of near-miss fall from a height	SRIPAS
KPI.2.2.9	Latency between worker entering a dangerous zone and them being warned	SRIPAS
KPI.2.2.10	Latency between worker entering a dangerous zone and the OSH manager being notified	SRIPAS
KPI.2.3.1	Cut in vehicle series recalls by unit and fleet monitoring.	FORD-WERKE
KPI.2.3.2	Shortening of ECU diagnostics software dev. time, since diagnostics software will be evolved along vehicle life.	FORD-WERKE
KPI.2.3.3	Number of data channels measured in parallel	FORD-WERKE, UPV
KPI.2.3.4	Available connectivity channels provided by ASSIST-IoT Availability of 2G, 3G, 4G, 5G, WiFi, Ethernet	FORD-WERKE, UPV
KPI.2.3.5	Time to update a PCM calibration on the edge, after a vehicle was offline	FORD-WERKE, UPV
KPI.2.3.6	Number of drivelets, which can be stored on a GWEN for later download	FORD-WERKE, UPV

KPI.2.3.7	Server capacity to manage monitor vehicle fleet	FORD-WERKE, UPV
KPI.2.4.1	Increase on detected defects on the outer body of vehicles that would otherwise be unnoticed	CERTH/TWOT
KPI.2.4.2	Faster vehicle inspection compared to current manual practices	CERTH/TWOT
KPI.2.4.3	New revenue through additional repair services	CERTH/TWOT
KPI.2.4.4	Minimisation of data transfer in the pilot thanks to FL	CERTH/TWOT
KPI.1.1.1	Stakeholders/innovators expressing interest of willing to join the project or to adopt ASSIST-IoT.	UPV
KPI.1.1.2	External adopters	UPV
KPI.1.1.5	System usability scale	UPV
KPI.1.1.6	Technology acceptance	UPV
KPI.1.1.3	End-users satisfaction with tactile applications	UPV
KPI.3.1.1	Internationally recognized standards supported in ASSIST-IoT related to IoT	OPL
KPI.3.1.2	Communications to modify/improve existing standards used in ASSIST-IoT	OPL
KPI.3.1.3	Recommendations in relevant policy oriented organisms regarding ASSIST-IoT technologies	OPL
KPI.3.1.4	SDOs and pre-normative initiatives engaged	OPL
KPI.3.1.5	Identified standards related to ASSIST-IoT activities (supported or unsupported)	OPL
KPI.3.2.1	Number of scientific publications	SRIPAS
KPI.3.2.2	European IoT Platforms compatible and connected to ASSIST-IoT modules	UPV
KPI.3.2.3	Letters of interest to adopt ASSIST-IoT technologies	UPV
KPI.3.2.4	Research actions including one or several modules developed on ASSIST-IoT	UPV
KPI.3.2.5	Industrial actions including one or several modules deveoloped on ASSIST-IoT	UPV
KPI.1.3.6	Conformance to new techniques and technologies	UPV
KPI.1.2.2	Business plans for exploitable assets, stakeholders and key alliances identified and contacted	PRO
KPI.1.2.4	Innovative business models	PRO
KPI.1.3.2	Revenue growth – increase for SMEs and industries	PRO
KPI.1.3.3	Market share gained	PRO
KPI.1.3.4	Return of Investment (RoI)	PRO
KPI.1.2.5	Technological advantage	PRO
KPI.1.2.3	Total addressable market	PRO
KPI.1.3.7	Identification of different new verticals to deploy architecture reference implementations	UPV
KPI.1.2.6	Diversification (justified)	PRO
KPI.5.5.1	Security and privacy institutions engaged	CERTH
KPI.3.2.6	Number of cyber-security fairs/congresses attended	SRIPAS
KPI.5.5.2	Security, privacy, trust and accountability specific publications	SRIPAS
KPI.1.3.8	Collaborating IoT security projects	UPV
KPI.4.7.1	Potential number of users that could be covered by implementing ASSIST-IoT security / privacy methods	S21SEC
KPI.4.7.2	Percentage of users implementing the security and privacy methods in the ASSIST-IoT use cases, including the identity, authorization, and cybersecurity monitoring services.	S21SEC
KPI.3.3.5	Participation in external IoT communities	INFOLYSIS

KPI.3.3.6	Involving IoT-related organisations	INFOLYSIS
KPI.3.3.7	Joining related communities	INFOLYSIS
KPI.3.3.8	Professionals attracted to enhance impact.	INFOLYSIS
KPI.3.3.9	External professionals involved (open source developers contributions and hackathons participants)	INFOLYSIS
KPI.1.1.4	IoT and technological pillars (AI, 5G, smart devices…) institutions involved	UPV
KPI.3.3.1	Communication and community building activities organised	INFOLYSIS
KPI.3.3.2	Subscribers to ASSIST-IoT related activities	INFOLYSIS
KPI.3.3.3	Online communications	INFOLYSIS
KPI.3.3.4	Online traffic attracted	INFOLYSIS
KPI.5.1.1	Regulation adherence	CERTH
KPI.5.1.2	Legalisation assessment	CERTH
KPI.5.2.1	Worktime - time saving	CERTH
KPI.5.2.2	Human-centred innovations	CERTH
KPI.5.3.1	Threat on the labour demand	CERTH
KPI.5.6.1	Minority groups inclusion	CERTH
KPI.5.6.2	Accessibility	CERTH
KPI.5.4.1	Life - social inclusion	CERTH
KPI.5.4.2	Gender equality	CERTH
KPI.1.2.1	Target customers	PRO
KPI.1.3.1	IPRs	PRO