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

D8.2 - Technical Evaluation and Assessment - Preliminary Version

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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 Technical Evaluation and Assessment is written within the context of WP8 – Evaluation and Assessment of **ASSIST-IoT** project, under Grant Agreement No. 957258. The Deliverable D8.2 aims to provide an update of deliverable D8.1 (Evaluation plan) focused on initial results over technical KPIs as well as updating the evaluation plan and status of all the defined KPIs of the project.

ASSIST-IoT evaluation plan in D8.1 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.

By M27 (delivery time of D8.2), the evaluation plan is updated by providing more detail on the exact procedure and mechanisms to be used for the final evaluation of the identified KPIs. These KPIs have kept the partitioning into five different dimensions of assessment. Those 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.

With regards to the actual evaluation, it is divided in three parts.

First, the technical evaluation plan, which assesses ASSIST-IoT from a technical standpoint, has been the main focus of this deliverable. In D8.2, technical KPIs have been tackled with more detail, providing initial results (now that enablers of WP4 and WP5 are in a more advanced status and are being packaged and integrated through WP6 activities).

Second, the evaluation of the pilots has been also updated since D8.1. Here, the work performed in the period M18-M27 has focused on revising the validity of the original KPIs and to better clarify how those will be measured (including baselines, etc.).

Third, the process evaluation plan, which is the most encompassing of all three has been updated from a joint viewpoint: in some cases, some measurements have already been proceeded (e.g., dissemination or communication KPIs) while in other cases an enhancement of the description alongside specific measurement means are provided.

The final evaluation will be performed by the end of the project and will be evidenced via D8.3

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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
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
MFT	Malta Freeport Terminal
MR	Mixed Reality
NFV	Network functions virtualization
NO_x	Nitrogen Oxides
NGI	Next Generation Internet
OCR	Optical Character Recognition
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 D8.2 is to provide an update to D8.1, focusing on technical KPIs. The ultimate goal of D8.2 is to iterate over the basis for a quantitative assessment of ASSIST-IoT both from the standpoint of its users and stakeholders, as well as its developers.

1.1 Deliverable context

Table 1: Deliverables

Keywords	Lead Editor
Objectives	D8.2 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 objectD8.1 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	D8.2 directly maps to T8.2 (mainly) and T8.3 (with less intensity at this stage) as it provides an initial analysis of evaluation results that are generated in those tasks. In addition, it related to task T8.1 (although it is already finalised) as it enhances the description of all KPIs, especially focusing on clarifying the measurement means of all KPIs.
Milestones	Deliverable D8.2 is indirectly linked to milestone MS8 Feedback at the end of the project as the enhancements to the evaluation plan given in D8.2 already presents some evaluation results and paves the way for the final round of documenting the evaluation of the project in MS8.
Deliverables	The KPIs defined in the deliverable D8.2 are directly derived from D81, which were initially inspired 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 iterate over the identified KPIs, their measurement processes and targets, it can be considered an update of D8.1 and a document to set a middle step towards D8.3. The final results of the evaluation will be reported in D8.3 against the defined evaluation plans in this deliverable.

Main objective of the deliverable D8.2 is to update the evaluation methodology and to early report first evaluation results over the KPIs defined in D8.1. D8.2 will thus provide an updated methodology, enhanced measurement means and review of KPIs validity, 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.

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. Deliverable D8.2 mainly points to the developments of this task.

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. Deliverable D8.2 advances on the measurement means and procedure for evaluating pilot KPIs, considering that pilots are still being executed in WP7.

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. Deliverable D8.2 advances on the measurement means and procedure for evaluating process KPIs.

Tasks are being 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. I. In the Key Performance Indicators section, the notion of KPIs is introduced and portioned into dimensions, introduced in the previous section, and replicating (with some additions) the agreed structure in D8.1. The enhanced evaluation plan and early evaluation results over the KPIs of ASSIST-IoT, consisting of three separate sub-sections, 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 extends the evaluation plan (D8.1) that laid the framework of target setting and measuring and sets the KPIs used throughout the ASSIST-IoT project. In addition, a specific focus of D8.2 has been to provide an early report on (especially technical) KPIs as well as enhancing the description of the measurement means. These KPIs and their targets were tentatively defined at D8.1, and have been slightly refined via this deliverable D8.2 (and they may also be subject to changes in D8.3)

2 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.

2.1 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 2: 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)* KPI.1.1.2 KPI.1.1.3 *(KVI-5.1)* KPI.1.1.4 KPI.1.1.5 KPI.1.1.6	Stakeholders/innovators expressing interest of willing to join the project or to adopt ASSIST-IoT. External adopters Satisfaction of tactile applications IoT pillar institutions involved System usability scale 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 3 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	Boolea n	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	Numbe r	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.	Numbe r	10

2.2 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 4: 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 KPI.2.3.6 KPI.2.3.7	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 Number of Drivelets, which can be stored on a GWEN for later download Server capacity to manage and monitor vehicle fleet
Field 2.4	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 5: 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	Boolean	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.

2.3 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 6 and 7 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.

Table 6: 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	Communication and community building activities organised
		KPI.3.3.2	Subscribers to ASSIST-IoT communication channels and related activities
		KPI.3.3.3	Online communications (news, posts, articles)
		KPI.3.3.4	Online traffic attracted (website, social media)
		KPI.3.3.5	Participation in external IoT Communities
		KPI.3.3.6 *(KVI-8.1.3)*	IoT related organisations
		KPI.3.3.7 *(KVI-8.1.2)*	Joining communities
		KPI.3.3.8 *(KVI-8.1.1)*	Professionals engaged for impact
		KPI.3.3.9	External Professionals involved

Table 7: 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).

2.4 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.

In this document the current status and outlook is given for these KPIs as well as KPIs presented below are partitioned into fields (connected with interoperability) as follows.

Table 8: 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.4.8.4 KPI.4.8.5 KPI.4.8.6	Automated accountability of interactions /communications performed (defining responsible) Data governance services supported by IoT-enabled DLT. 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 9: 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.4.8.4	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

2.5 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).

Table 10: 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 11: 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	Positive results (100 answers)	>75%

		at least 2 countries that ASSIST-IoT is compliant with.		
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 accountability specific publications	Has the project produced a social impact and helped the community with its material?	# of publications	12
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%

3 Evaluation Plan

This chapter describes the evaluation plan, in a similar way as done in deliverable D8.1. This document gives an update of the current status of each KPI which is basically an intermediate result. Most enablers are still under development and the pilots are still not in their end phase where results are known or can be predicted. This means that for some KPI's no progress can be reported yet. However, for all KPI's where some progress has been made in one way or another, progress and outlook are reported.

3.1 Technical evaluation of ASSIST-IoT

The technical assessment is the major part currently under development, hence the KPI's in this section are in progress and reporting is of importance. Most KPI's are in a phase were a prediction of the outcome can be made and an estimation if the KPI is achievable or not. Due to proceeding development also insight has been gained resulting in modifications of some requirement in order to be able to have them measurable. In case a KPI had to be modified or changed, the old KPI description is left with strike trough marking to be able to track whichever has changed.

3.1.1 Selected KPIs

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 8, 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.

3.1.2 Data collection and measurement

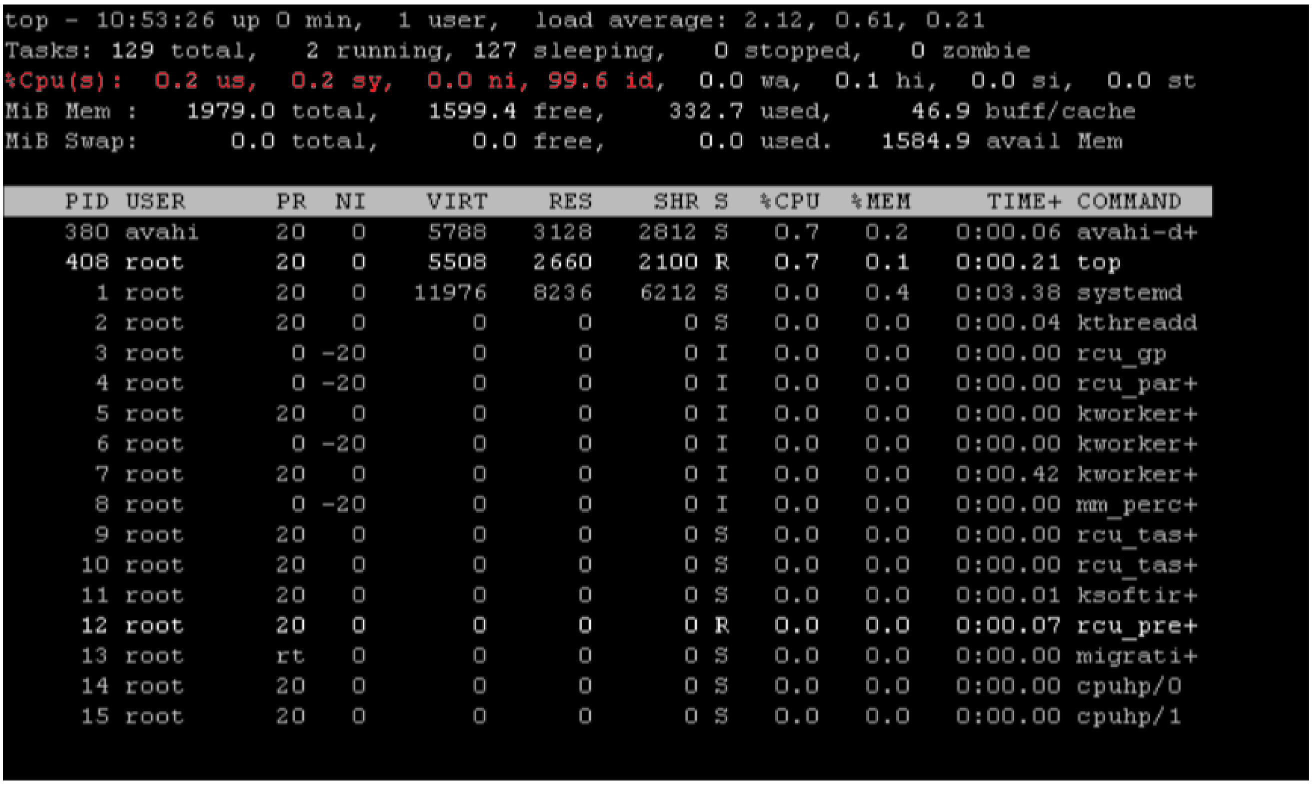
KPI.4.1.1 CPU load of GWEN

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%.

Since the Pilot has not started yet and not all components needed for the pilot are finished this KPI cannot be proven yet to be met. The current status is that the board support package works in combination with the Linux kernel and a docker environment. In the docker environment the Ultra-Wide Band (UWB) component has been integrated and is operational, thus receives localization data though a USB port.

The current CPU load under operational circumstances, thus Linux Yocto running with docker and the UWB container on top is:



```
top - 10:53:26 up 0 min,  1 user,  load average: 2.12, 0.61, 0.21
Tasks: 129 total,   2 running, 127 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.2 us,  0.2 sy,  0.0 ni, 99.6 id,  0.0 wa,  0.1 hi,  0.0 si,  0.0 st
MiB Mem :   1979.0 total,   1599.4 free,    332.7 used,     46.9 buff/cache
MiB Swap:      0.0 total,      0.0 free,      0.0 used.   1584.9 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
  380 avahi     20   0    5788   3128   2812 S   0.7   0.2   0:00.06 avahi-d+
  408 root      20   0    5508   2660   2100 R   0.7   0.1   0:00.21 top
    1 root      20   0   11976   8236   6212 S   0.0   0.4   0:03.38 systemd
    2 root      20   0       0      0      0 S   0.0   0.0   0:00.04 kthreadd
    3 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 rcu_gp
    4 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 rcu_par+
    5 root      20   0       0      0      0 I   0.0   0.0   0:00.00 kworker+
    6 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
    7 root      20   0       0      0      0 I   0.0   0.0   0:00.42 kworker+
    8 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 mm_perc+
    9 root      20   0       0      0      0 S   0.0   0.0   0:00.00 rcu_tas+
   10 root      20   0       0      0      0 S   0.0   0.0   0:00.00 rcu_tas+
   11 root      20   0       0      0      0 S   0.0   0.0   0:00.01 ksoftir+
   12 root      20   0       0      0      0 R   0.0   0.0   0:00.07 rcu_pre+
   13 root      rt   0       0      0      0 S   0.0   0.0   0:00.00 migrati+
   14 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/0
   15 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/1
```

Figure 1: Screenshot CPU usage

Since the GWEN has been designed with a flexible and modular approach, modules can be exchanged allowing specifications of the GWEN to be adjusted to their needs. With limited effort the processing module can be swapped with a more powerful one allowing processor and memory to be configured as required.

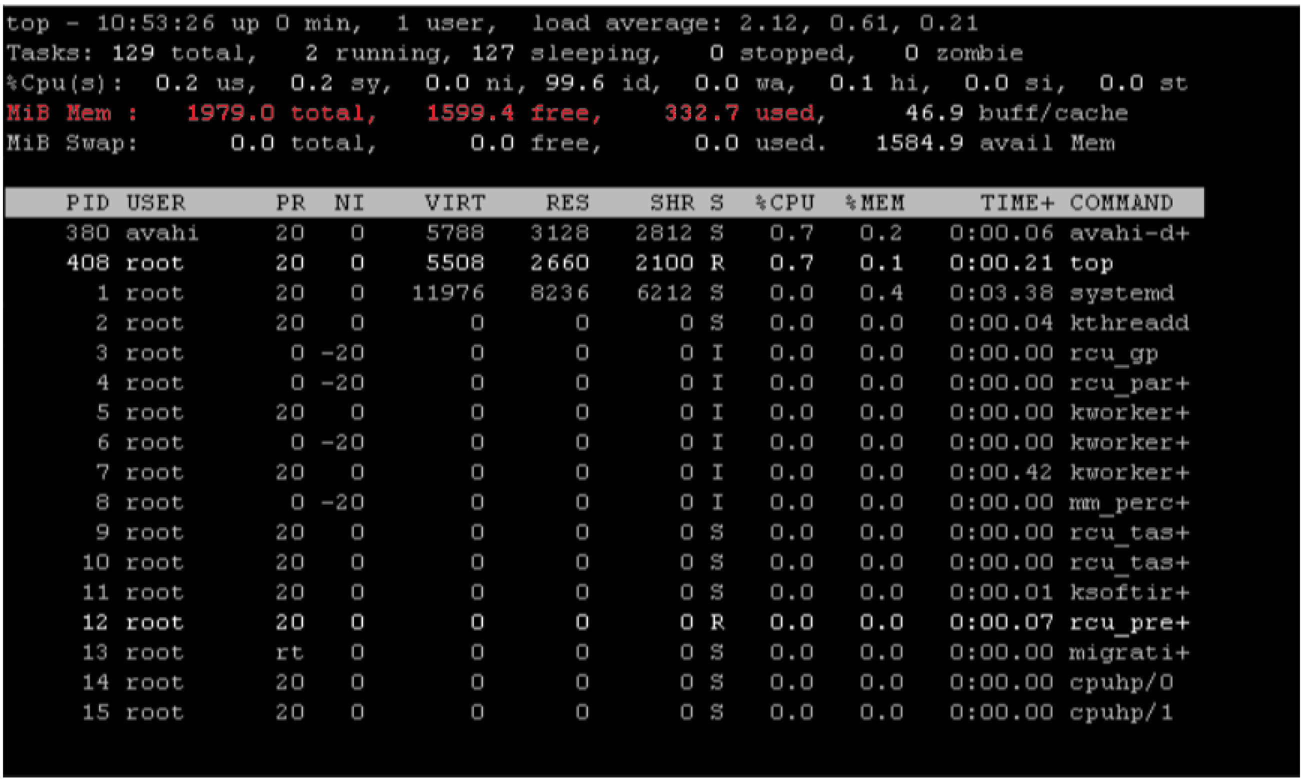
KPI.4.1.2 Memory usage of GWEN processes

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%.

Since the Pilot has not reached it's mature level yet and not all components needed for the pilot are finished this KPI cannot be proven yet to be met.

However, based on a functional operating system with some modules integrated the current status can be reported and an estimation can be made for the full functionality of the pilots.



```
top - 10:53:26 up 0 min,  1 user,  load average: 2.12, 0.61, 0.21
Tasks: 129 total,   2 running, 127 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.2 us,  0.2 sy,  0.0 ni, 99.6 id,  0.0 wa,  0.1 hi,  0.0 si,  0.0 st
MiB Mem :   1979.0 total,   1599.4 free,    332.7 used,     46.9 buff/cache
MiB Swap:      0.0 total,      0.0 free,      0.0 used.   1584.9 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
  380 avahi     20   0    5788   3128   2812 S   0.7   0.2   0:00.06 avahi-d+
  408 root      20   0    5508   2660   2100 R   0.7   0.1   0:00.21 top
    1 root      20   0   11976   8236   6212 S   0.0   0.4   0:03.38 systemd
    2 root      20   0       0      0      0 S   0.0   0.0   0:00.04 kthreadd
    3 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 rcu_gp
    4 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 rcu_par+
    5 root      20   0       0      0      0 I   0.0   0.0   0:00.00 kworker+
    6 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
    7 root      20   0       0      0      0 I   0.0   0.0   0:00.42 kworker+
    8 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 mm_perc+
    9 root      20   0       0      0      0 S   0.0   0.0   0:00.00 rcu_tas+
   10 root      20   0       0      0      0 S   0.0   0.0   0:00.00 rcu_tas+
   11 root      20   0       0      0      0 S   0.0   0.0   0:00.01 ksoftir+
   12 root      20   0       0      0      0 R   0.0   0.0   0:00.07 rcu_pre+
   13 root      rt   0       0      0      0 S   0.0   0.0   0:00.00 migrati+
   14 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/0
   15 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/1
```

Figure 2: Screenshot Memory usage

Since the GWEN has been designed with a flexible and modular approach, modules can be exchanged allowing specifications of the GWEN to be adjusted to their needs. With limited effort the processing module can be swapped with a more powerful one allowing processor and memory to be configured as required.

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.

In summary, this KPI quantifies the number of enablers that improve networking, in terms of configurability, bandwidth, availability and security. The following **(7)** VNFs/CNFs/enablers foster such objective:

1. Update: The following VNFs have been identified to improve the performance of the network: (i) the three enablers that comprise the SDN stack: (i) the SDN controller, (ii) the auto-configurable network enabler and (iii) the traffic classification enabler, which work together in SDN-enabled networks to control the networking equipment, selecting the optimal routing policies based on the type of traffic, among other parameters.
2. The (iv) multi-link enabler, which eases the combination of networking interfaces, at layer 2 level, to work as a single, logical one, with real-time reliability mechanisms.

3. The (v) SD-WAN-related enablers, considering (i) the SD-WAN enabler and (vi) the WAN acceleration enabler, which provide security (i.e., via tunnels and firewalls) for connecting delocalised managed networks.
4. The (vii) the Smart orchestrator, which enables the instantiation, and configuration and connection of all the former. With the exception of the SDN controller, these enablers are developed and/or tailored in the project to the needs of NGIoT deployments, and are currently in different development status.

Apart from identifying and developing the enablers that will perform such actions (the ones identified before), the validation of this KPI will entail testing such enablers in at least one of the pilot premises and validate that their basic features are working as expected. So far, only the Smart orchestrator has been tested and validated in the scope of Pilot 3a, fulfilling its basic functionalities, however, the rest of them have not been tested yet as (i) some of them are still being evolved, and (ii) pilots are preparing the final computing infrastructure for their activities. A summary of procedure for measuring this KPI is:

- Having a functional, packaged version of all the enablers (expected by M30).
- Having the computing premises of the pilots provisioned. Currently, Pilot 3a has it ready.
- Each one of the previous enablers will be tested in pilot premises (at least, in one). SDN and SD-WAN-related enablers will be tested in OPL/UPV premises; multi-link in Pilot 1; and the Smart orchestrator in all pilots.
- The features specified in D4.2 will be checked.

It is expected that this KPI will be easily met, as most of the aforementioned enablers already have functional versions validated in laboratory premises and it is just a matter of time of being deployed in the pilot ones.

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".

Update: The main features of the Smart orchestrator have been implemented (i.e., registering K8s clusters, enablers repositories, selecting enablers and controlling their lifecycle, automatic implementation of networking rules, etc.). Basic policies for automatically selecting the optimal place within the managed computing continuum have been developed (see D4.2 [ref] for further information). The AI models will be implemented during the last 8 months of WP4, and therefore they will be tested after being incorporated to the logic of the Smart orchestrator. In contrast to the current basic policies, the first AI model under implementation will rely not only in current but also predicted cluster resources to (automatically) select the optimal placement of enablers.

A set of enablers (from WP4/5, and pilot-specific) selected specifically for each one of the pilots will be deployed automatically by the Smart orchestrator, considering the AI-supported policies to decide in which node of the computing continuum they have to be deployed. A summary of procedure for evaluating this KPI is:

- The first AI mechanisms will be finished and integrated in the Smart orchestrator, expected for M30. It will be preliminary tested in laboratory environments.
- Two additional mechanisms will be developed and integrated in the orchestrator, extending the features provided by the basic policies currently implemented.
- Afterwards, as pilots will have their final computation infrastructures in place, the different mechanisms will be tried, analysing the differences that appear when using different policies.

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%.

An improvement is defined as an increase of total network throughput with reduction of total packet losses in the network and/or a reduction packets latency. These values are determined as average values calculated during measurement time in cases where optimization of network resources is possible in terms of total load generated in the network.

KPI.4.2.4 Hosts connected to VPN k8s clusters

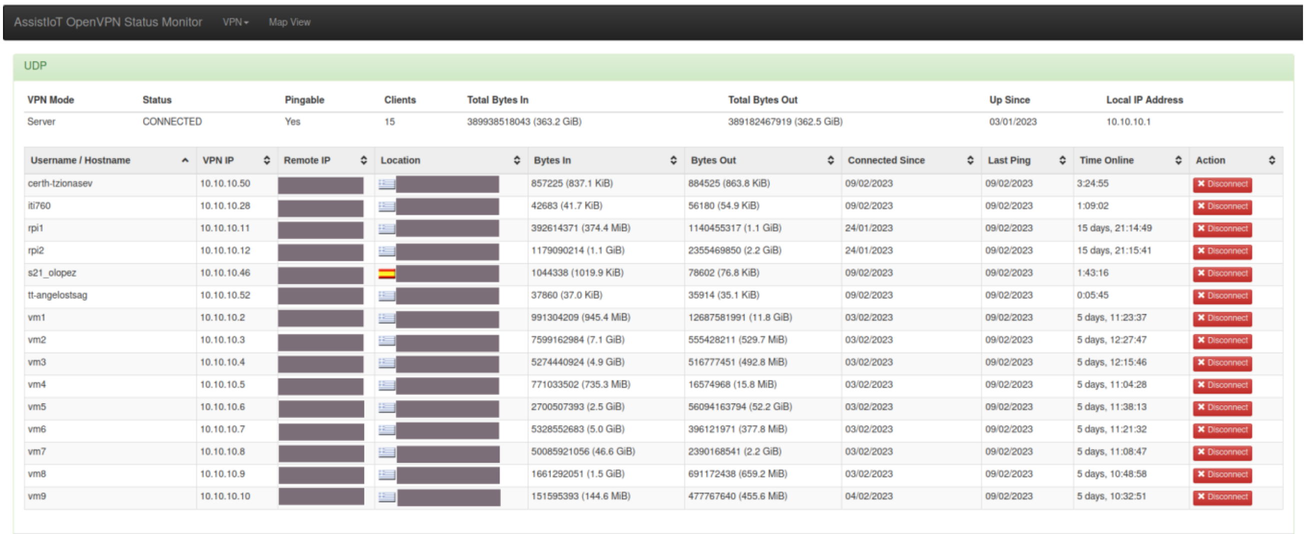
One of the enablers to be delivered by task T4.2 is the VPN enabler. This software (encapsulated as an ASSIST-IoT enabler following the packaging and releasing methodology set out in deliverable D6.4) allows the access to a node or device (in the case of ASSIST-IoT, to a Kubernetes (K8s) -or equivalent- 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. Update: being a generic enabler that can work regardless of the pilot, it will be validated only in one of the pilots' infrastructures (Pilot 3a).

Update: Although the enabler has been finalised, it has not been used in the pilots of the project yet, and therefore it has not been evaluated at this moment. In any case, being developed considering Wireguard technology, it is expected that such number can be easily achieved, theoretically up to 2^{16} with IPv4 (i.e., 65536). It should be highlighted that the throughput per client is reduced when additional ones are added, especially if they have to forward/receive traffic from the VPN server. This limitation depends heavily on the traffic it has to handle, as it can range from handling all (including from/towards the Internet, and from which type), or just K8s signalling, as it may be in ASSIST-IoT-based implementations.

The number selected may not seem that ambitious, still, the number is not that representative as it depends on the expected traffic, as mentioned above. A summary of procedure for measuring this KPI is the following:

- The VPN enabler will be deployed via the Smart orchestration in one of the clusters of the pilot (likely 3a).
- Eight remote hosts will be provisioned and connected to a cluster, using a VPN client at host level (Wireguard-based).
- The communication between the clients and the main server, and among them, will be tested, checking that the communication among them is effectively encrypted.
- Another method for measuring this KPI involves utilizing a monitoring tool that is specifically designed for the Kubernetes cluster and its connected users. This tool has already been implemented, allowing the administrator to continuously monitor the cluster's performance, the number of active users, network traffic, and other relevant metrics. As shown in Figure X, this monitoring tool provides valuable insight into the cluster's performance and overall health.



AssistIoT OpenVPN Status Monitor VPN▾ Map View

UDP

VPN Mode	Status	Pingable	Clients	Total Bytes In	Total Bytes Out	Up Since	Local IP Address
Server	CONNECTED	Yes	15	389938518043 (363.2 GiB)	389182467919 (362.5 GiB)	03/01/2023	10.10.10.1

Username / Hostname	VPN IP	Remote IP	Location	Bytes In	Bytes Out	Connected Since	Last Ping	Time Online	Action
certh-tzionasev	10.10.10.50	[redacted]	[redacted]	857225 (837.1 KiB)	884525 (863.8 KiB)	09/02/2023	09/02/2023	3:24:55	✖ Disconnect
iti760	10.10.10.28	[redacted]	[redacted]	42683 (41.7 KiB)	56180 (54.9 KiB)	09/02/2023	09/02/2023	1:09:02	✖ Disconnect
rpi1	10.10.10.11	[redacted]	[redacted]	392614371 (374.4 MiB)	1140455317 (1.1 GiB)	24/01/2023	09/02/2023	15 days, 21:14:49	✖ Disconnect
rpi2	10.10.10.12	[redacted]	[redacted]	1179090214 (1.1 GiB)	2355469850 (2.2 GiB)	24/01/2023	09/02/2023	15 days, 21:15:41	✖ Disconnect
s21_olopez	10.10.10.46	[redacted]	[redacted]	1044338 (1019.9 KiB)	78602 (76.8 KiB)	09/02/2023	09/02/2023	1:43:16	✖ Disconnect
tt-angelostsag	10.10.10.52	[redacted]	[redacted]	37860 (37.0 KiB)	35914 (35.1 KiB)	09/02/2023	09/02/2023	0:05:45	✖ Disconnect
vm1	10.10.10.2	[redacted]	[redacted]	991304209 (945.4 MiB)	12687581991 (11.8 GiB)	03/02/2023	09/02/2023	5 days, 11:23:37	✖ Disconnect
vm2	10.10.10.3	[redacted]	[redacted]	7599162984 (7.1 GiB)	555428211 (529.7 MiB)	03/02/2023	09/02/2023	5 days, 12:27:47	✖ Disconnect
vm3	10.10.10.4	[redacted]	[redacted]	5274440924 (4.9 GiB)	516777451 (492.8 MiB)	03/02/2023	09/02/2023	5 days, 12:15:46	✖ Disconnect
vm4	10.10.10.5	[redacted]	[redacted]	771033502 (735.3 MiB)	16574968 (15.8 MiB)	03/02/2023	09/02/2023	5 days, 11:04:28	✖ Disconnect
vm5	10.10.10.6	[redacted]	[redacted]	2700507393 (2.5 GiB)	56094163794 (52.2 GiB)	03/02/2023	09/02/2023	5 days, 11:38:13	✖ Disconnect
vm6	10.10.10.7	[redacted]	[redacted]	5328552683 (5.0 GiB)	396121971 (377.8 MiB)	03/02/2023	09/02/2023	5 days, 11:21:32	✖ Disconnect
vm7	10.10.10.8	[redacted]	[redacted]	50085921056 (46.6 GiB)	2390168541 (2.2 GiB)	03/02/2023	09/02/2023	5 days, 11:08:47	✖ Disconnect
vm8	10.10.10.9	[redacted]	[redacted]	1661292051 (1.5 GiB)	691172438 (659.2 MiB)	03/02/2023	09/02/2023	5 days, 10:48:58	✖ Disconnect
vm9	10.10.10.10	[redacted]	[redacted]	151595393 (144.6 MiB)	477767640 (455.6 MiB)	04/02/2023	09/02/2023	5 days, 10:32:51	✖ Disconnect

Figure 3. VPN monitoring tool GUI

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.

The validation of this KPI will be done by using the traffic classification enabler. To this end, the next summary of procedure will be followed:

- Representative traffic of each pilot will be selected.
- An example of such flow of traffic will be captured (via traffic sniffer such as e.g., Wireshark, in pcap format). The idea is to capture ~125 messages per pilot.
- They will be classified with the traffic classification enabler, consuming its API (offline, passing key extracted features).
- Its performance will be evaluated manually, checking if the analysed traffic has been
- been classified correctly.

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.

Message processing latency after initial tests was measured to be 7ms on average, with minimum of around 0,9ms and maximum of 50ms. 90% of messages are processed with latency below 10ms. It was observed, that the annotation core is gets more efficient when processing a message that is already processed before, so the messages were randomised for the test.

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.

Message processing latency after initial tests was measured to be 10ms with minimum of 5ms and maximum of 100ms. 90% of messages are processed with latency below 35ms. Alignment and message size make a big impact on processing speed, with large alignments (1000 cells) taking significantly longer, than smaller or medium ones (<100 cells). Message and alignment size in ASSIST-IoT pilots is expected to be small, following the general principle observed in IoT, of high amount of small messages, rather than large messages that are sent less often.

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.

Initial tests reveal, that the annotation streamer is able to easily support 20 parallel channels.

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.

After initial tests it was revealed that, when configured with parallelism in line with the number of virtual CPU cores available to for the software, resource saturation is highly hardware dependent. For 4 CPU cores and configured parallelism of 4, the streaming translator easily supports 4 parallel channels that are constantly busy. In such cases network saturation occurs before local resource saturation. Constant saturation of channels is defined as a never ending stream of messages, where processing of a new message starts as soon as the previous one finishes. In practice (e.g. in testing messages in the pilots) constant saturation never occurs. Even under constant saturation, more channels may be supported. It should be noted, however, that (if allowed) the streaming translator will saturate CPU usage, and a constant CPU load will increase temperatures and, in general, prevent full efficiency in CPU performance in the long term. When not under constant saturation 32 active channels were working on 4 CPU cores. Inactive channels (channels, that don’t have messaging passing through them) have negligible effect on performance.

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.

This KPI cannot be largely updated as this stage of the project as this action have been mostly focused on development and integration activities. This validation action will take place during the following months. The target KPI originally identified still remains valid, while the measurement means are kept the same as in the first definition.

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.

The following human-centric interfaces are being (or are already available in the projects pilots): Pilot 1 (2xWeb applications, 1xCV service on top of regular video streams); Pilot 2 (1xsmartwatch custom interface, 1xMR googles with pilot-specific dashboard); Pilot 3A (1xWeb application, 1xMR glasses); Pilot 3B (1xWeb application for the data collection). Therefore, there are 8 human-centric components of the project. It is expected that in the forthcoming months, additional interfaces under development will be available, so that the KPI is mostly fulfilled.

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. The following 13 ASSIST-IoT use cases are making (or are expected to make) use of different human-centric technologies of the project.

- **Pilot 1** (4): UC-P1-3 Asset location management; UC-P1-4 Truck identification and authentication; UC-P1-5 RTG truck alignment; UC-P1-7 Target visualization during RTG operation
- **Pilot 2** (5): UC-P2-2 Geofencing boundaries enforcement; UC-P2-3 Construction site access control; UC-P2-4 Detection of falls and immobility; UC-P2-5: Safe navigation instruction; UC-P2-6: Health and safety inspection support.
- **Pilot 3A** (3): UC-P3A-1 Fleet in-service emissions verification; UC-P3A-2 Vehicle's non-conformance causes identification; UC-P3A-3 Updating the diagnostics methods pool.
- **Pilot 3B** (2): UC-P3B-1 Vehicle's exterior condition documentation & visualisation; UC-P3B-2 Exterior defects detection support.

Consequently, it is considered that this KPI has been already achieved.

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.

The initial list of questions to form part of the SUS questionnaire are extracted from available sources:

1. *I think that I would like to use this system frequently.*
2. *I found the system unnecessarily complex.*

3. *I thought the system was easy to use.*
4. *I think that I would need the support of a technical person to be able to use this system.*
5. *I found the various functions in this system were well integrated.*
6. *I thought there was too much inconsistency in this system.*
7. *I would imagine that most people would learn to use this system very quickly.*
8. *I found the system very cumbersome to use.*
9. *I felt very confident using the system.*
10. *I needed to learn a lot of things before I could get going with this system.*

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

Self-* Enablers can take autonomous decisions. An autonomous Decision as a decision triggered either on internal (deployment state) or external (notification sent to a deployment) stimuli that are taken during runtime by the Self-* Enabler independently from a human operator.

It is expected to have at least 5 such autonomous decisions taken by a deployment involving Self-* Enablers during the pilot's execution. Therefore, the KPI target value is still valid.

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

A resource is a "Thing" in the context Internet of Things. It may vary from a physical device to a software component. For a Self-* Enabler this might mean physical devices available within the scope of the deployment, components of itself, and other Enablers. This KPI will track how many such Things (excluding Self-* Enabler's internal components) will be influenced by Self-* Enablers

It is expected to have at least 5 resources being affected during the pilot's execution. Therefore, the KPI target value is still valid.

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.

The evaluation of this KPI has not started yet, as the required infrastructure for successfully performing the pilots' executions is not fully finalised.

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.

The ASSIST-IoT FL system relies on the capabilities of the Flower FL framework. According to works, theoretically, Flower can perform FL experiments with up to 15M in client size using only a pair of high-end GPUs. The below figure shows the expected initial speed-up in convergence when selecting 10 to 500 clients per round in the aforementioned experiment.

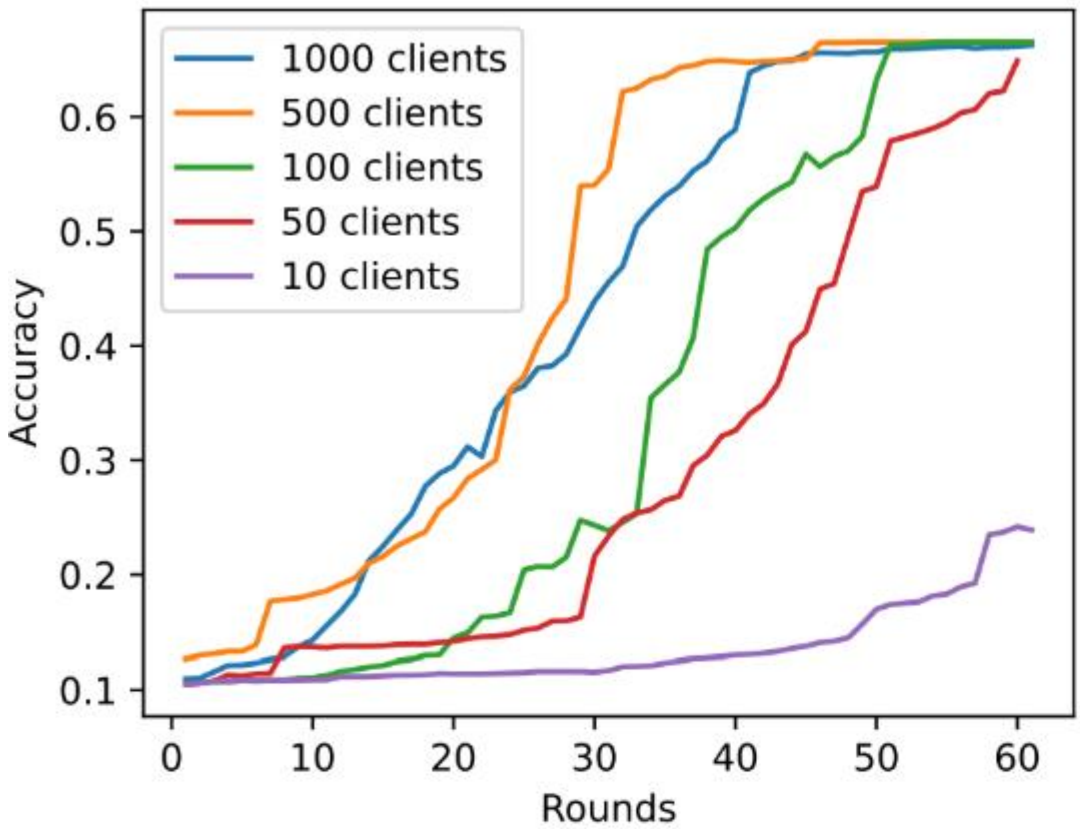


Figure 4 FL large number of users emulation

Thus Figure 3, it can be considered that theoretically, the ASSIST-IoT FL system is capable to support more than 10 clients involved simultaneously. Nevertheless, practical tests with ASSIST-IoT infrastructure will be carried out in the near future, once all the FL enablers are in their final release.

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).

Again, like previous KPI, given that the ASSIST-IoT FL system relies on the capabilities of Flower, and according to the Flower github documentation, several ML frameworks can be, including, PyTorch, TensorFlow, MXNet, scikit-learn, Pandas, or NumPy. Considering that, for instance, TensorFlow hub supports 8 pre-trained ML models for text generation, +400 pre-trained ML models for image classification, or 10 pre-trained ML models for speech-to-text translation, it can be considered that once all the FL enablers of the project are in their final release, the KPI will be broadly fulfilled.

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).

For the time being, one of the use cases of the project, is testing the ASSIST-IoT FL system. In particular, the UC-P3B-2 Exterior defects detection support.

This KPI is fulfilled at 50%, but considering that there are two more pilots interested in testing the platform before the project ends, it is expected that this KPI will also be covered before ending project's lifetime.

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.

In order to measure the potential number of users that could be covered by implementing security/privacy (including the identity, authorization, and cybersecurity monitoring services) methods through the Assist-IoT platform, this KPI has been established.

The idea in this project is to maximize the number of users to whom security/privacy methods are implemented by means of the elements that have been designed and developed for the project. As explained before, the TRL expected for the project is associated to RIA and thus the products developed at the end of the project are not expected to be completely ready for production deployment. Therefore, this KPI is not ready for being measures at this stage of the project.

Nevertheless, an estimation of this KPI can be obtained through surveying project stakeholders on their use of security / privacy mechanisms.

It should be noted that the number of 20k users covered by Assist-IoT security/privacy methods is very ambitious, but it will be aimed to maximise the number of users covered in the project.

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.

Due to the fact that the cybersecurity enablers are in the process of being integrated and deployed in the Assist-IoT pilots, it is not possible to identify and measure the pervasiveness of user coverage by this security/privacy methods at this stage. It is also not possible to obtain hard evidence before running the pilots.

An assessment framework for the KPIs related to cybersecurity enablers is being defined at this stage of the project, with the aim of addressing the measurement needs of these indicators. Several options are being considered for this purpose, such as, the design of a performance monitoring dashboard in the Kibana interface of the Security Monitoring Enabler that will monitor the user activity on the different Cybersecurity Enablers.

The idea is to maximize the coverage so that all users connecting to the platform comply with the security and privacy requirements. It should be borne in mind that the different participants in the pilot, with their applications, will have to implement the connection to the security enablers. At this point we think it is feasible that at least 75% of the users of the Assist-IoT pilots will manage to implement the security enablers by connecting their applications to the security enablers.

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.

Due to the fact that the cybersecurity enablers are in the process of being integrated and deployed in the Assist-IoT pilots, it is not possible to identify and measure the correct identification attempt ratio covered by this security/privacy methods at this stage. It is also not possible to obtain hard evidence before running the pilots.

Again, an assessment framework for the KPIS related to cybersecurity enablers is being defined at this stage of the project, with the aim of addressing the measurement needs of these indicators. Several options are being considered for this purpose, such as, the design of a performance monitoring dashboard in the Kibana interface of the Security Monitoring Enabler that will monitor the authentication activity of the Identity Manager enabler.

At this stage it is not possible to give an exact value for this KPI as the integration and validation of the cybersecurity enablers is ongoing, but it is estimated that, assuming that the trial participants' applications are correctly configured, the percentage of correct identifications will exceed 75% of the attempts.

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.

Due to the fact that the cybersecurity enablers are in the process of being integrated and deployed in the Assist-IoT pilots, it is not possible to identify and measure the validated authorization requests covered by this security/privacy methods at this stage. It is also not possible to obtain hard evidence before running the pilots.

Again, an assessment framework for the KPIs related to cybersecurity enablers is being defined at this stage of the project, with the aim of addressing the measurement needs of these indicators. Several options are being considered for this purpose, such as, the design of a performance monitoring dashboard in the Kibana interface of the Security Monitoring Enabler that will monitor the authorization activity of the Authorization Server enabler.

At this stage it is not possible to give an exact value for this KPI as the integration and validation of the cybersecurity enablers is ongoing, but it is estimated that, assuming that the trial participants' applications are correctly configured, the percentage of correct identifications will exceed 40% of the attempts.

In order to increase the percentage of this KPI it is key to correctly define the different authorization scenarios on the project trials. This will allow to define appropriate authorization policy for the use cases and thus increase the rate of successful authorisations.

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.

Due to the fact that the cybersecurity enablers are in the process of being integrated and deployed in the Assist-IoT pilots, it is not possible to identify and measure the detected alerts covered by this security/privacy methods at this stage. It is also not possible to obtain hard evidence before running the pilots.

This KPI depends directly on the number of users connected to the Assist-IoT platform at any given time. Considering the estimated number of participants in each use case, it is estimated that around 10 events per hour will be received. These events will be monitored by the SIEM, through the event dashboards (see Figure 5) that allow to apply the appropriate time filters to be able to measure the number of events detected per hour.

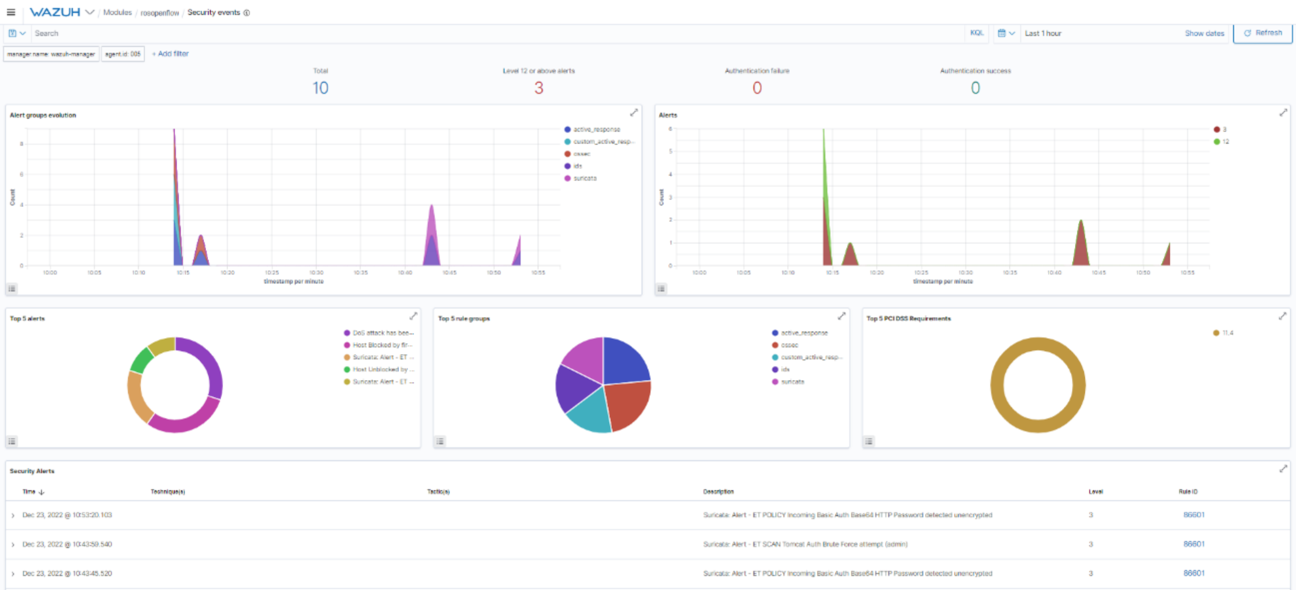


Figure 5: Detected alerts per hour

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. We consider that we comply with this KPI when the number of critical interactions/communications performed in integrated IoT setting is >85%.

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

This KPI measures the number of services provided by DLT enablers that enhance security, integrity, availability of data, and accountability of actors. If each of the 4 DLT enablers provides a service of this type (for example, the integrity verification enabler provides the integrity and security of data recorded in its ledger), and we multiply this by the number of pilots/use cases utilizing it, we get the number of services for the integrity verification enabler. We consider that we comply with this KPI when the number of these data governance services is 5. The enablers will be leveraged by two pilots. So, for future versions of this evaluation the target value might decrease slightly (down to 5, maximum). However, this fact does not diminish the innovative capacity of the project nor would jeopardise the consecution of objectives. This has been selected to adjust the developments of the enablers to the real needs of the pilots, that will, in turn, comply with their ambitious goals.

KPI.4.8.3 Availability of FL ML local models' collection - No longer applicable

The original description of this KPI was: *"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 % "*

However, this KPI has been decided to be removed as the functionalities of the enabler (as per its final conception, in D5.3 and D5.4) do no longer include recording of models. This does not affect the global scope of task T5.2 nor jeopardises a single bit the potential of the enablers. This fact will be largely described in the deliverable D5.5.

.

KPI.4.8.4 Decrease in training dataset biases

This KPI identifies the reliability of the local operators who participate in the training. To define the reliability of the local operators we calculate reputation scores for each of them. To measure this KPI, we compare these reputation scores with proper statistical metrics corresponding to the reputation scores of all the local operators. We consider that we comply with this KPI when the number of unreliable local operators that we identify is.

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. 1Compliance with this KPI is achieved when at least 1 use case has successfully tested the distributed broker enabler. The plan is to test it in Pilot 2, specifically in the monitoring and notification enabler use cases outlined in D7.3. Target value still remains valid.

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 the use cases in which the integrity verification enabler was successfully tested, is 1. The plan to meet this KPI is to test integrity verification enabler in a use case of pilot 3B. Target value still remains valid.

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.

Since most of the pilots are still provisioning their final computation infrastructures, this KPI cannot be proven yet to be met. Also, some of the enablers have not been packaged as Helm charts, following the specifications of the project. For now, some provisional enabler deployments have been performed in the (provisional) premises of pilots 1, 3a and 3b, including Edge Data Broker, Long Term Storage enabler, Business KPI enabler, PUD enabler and VPN enabler, and therefore only 15 enabler instances have been tested via a graphical manageability interface at this point. The summary of procedure for measuring this KPI is the following:

- As pre-requisite, it is needed to have a functional, packaged version of the required enablers (expected by M30), and the computing premises of the pilots provisioned. Currently, Pilot 3a has it ready.
- The Smart orchestrator with the manageability interfaces installed in the main cluster.
- This KPI will be validated by installing the needed enablers using such interfaces, deploying them either manually (selecting the target cluster/host), or letting the system decide (automatically, based on policies).
- Around 15 enablers will be deployed with such graphical interfaces per pilot, either coming from WP4/5 or developed specifically for fulfilling pilot needs. An example of (manual) enabler instantiation can be seen in Figure 6:

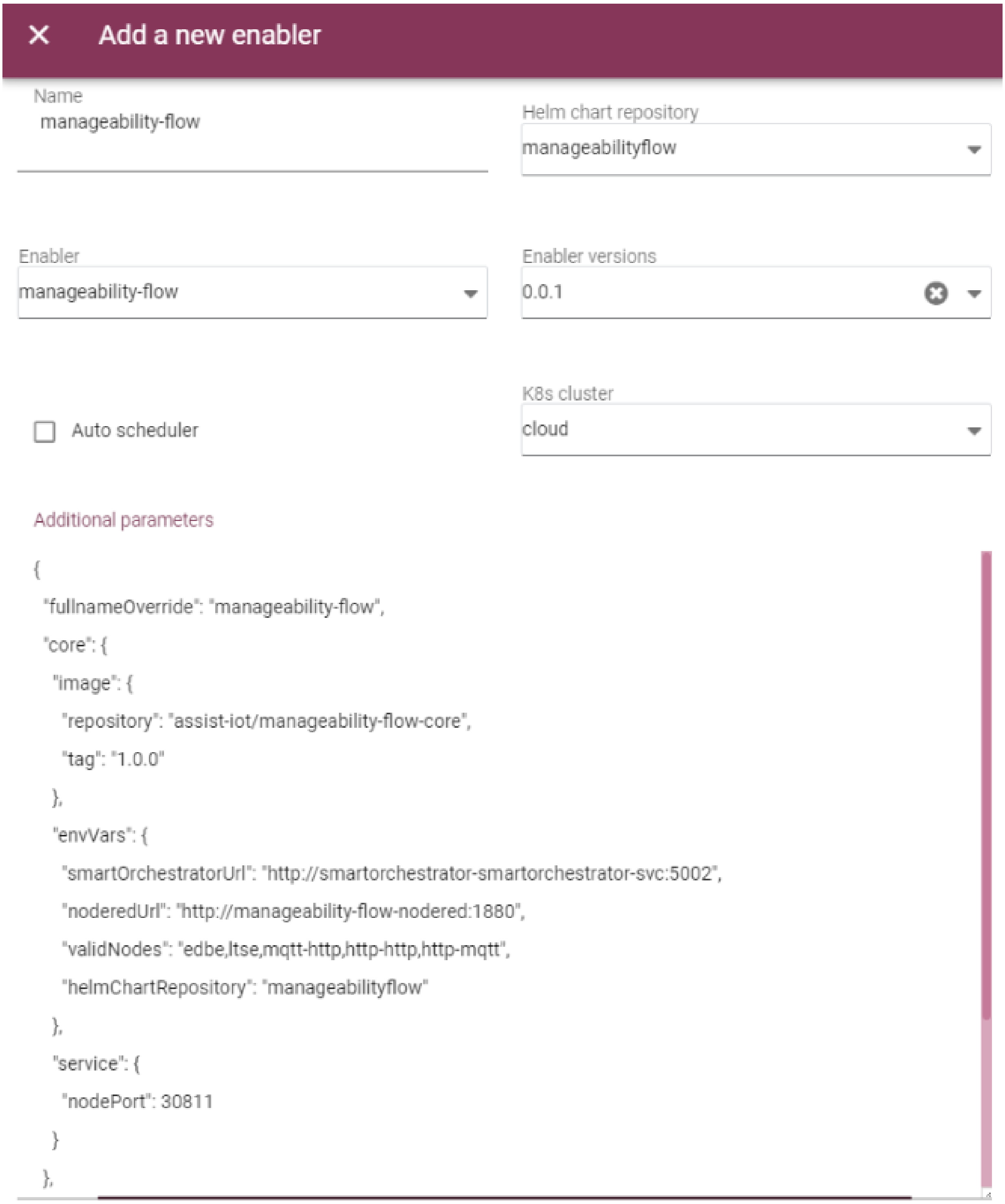


Figure 6: Example of enabler configuration at deployment time

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.

The current graphical interfaces can display the topology of a deployment managed by the Smart orchestrator of ASSIST-IoT, including the clusters, the hosts belonging to each cluster, and the enablers deployed in them. It also offers the possibility of deploying an enabler directly in a given host by interacting with it. The final topologies of the pilots will be represented in the final report, having then the four target topologies expected for this KPI. As ~15 enablers are expected to be deployed per pilot, it is expected that information of at least 10 of them can be easily shown in each topology representation, hence fulfilling the expectations of this KPI. There is no need of a specific procedure for evaluating this KPI, as it will be fulfilled naturally if the ASSIST-IoT Smart orchestrator and manageability tools are used. An example of the current topology representation of an emulated, minimal representation of Pilot 3b is provided in Figure 7,in which two clusters (edge and cloud) consisting of one computing node are deployed (info related to the deployed enablers in the cloud cluster is shown).

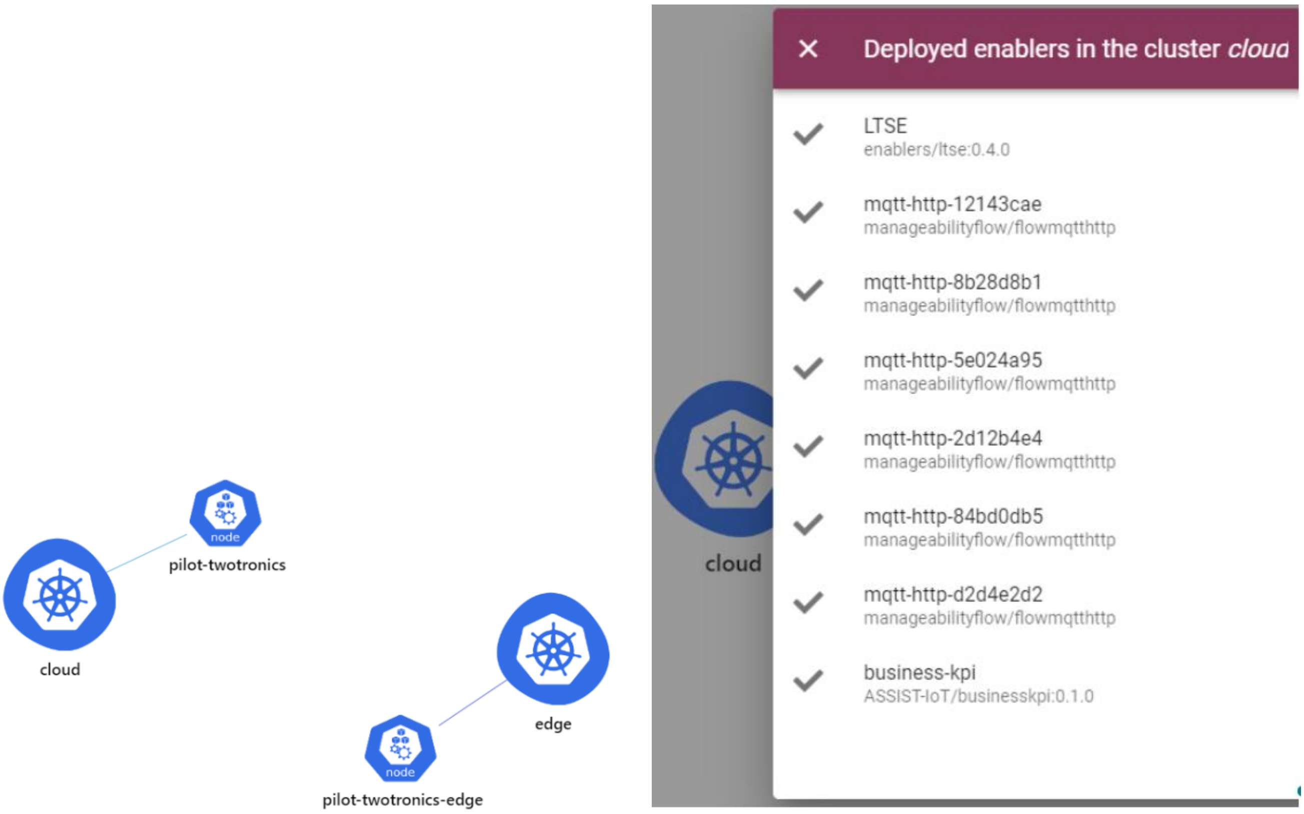


Figure 7: Topology representation

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.

The packaging format used in the project allows to configure several aspects of an enabler to be deployed before its deployment, including among other its:

- Name (related to DNS);
- Docker image repository;
- Version (among the released ones);
- Service port;
- Number of replicas;
- CPU/RAM request and limits;
- Auto-scaling parameters (i.e., if it is enabled, minimum and maximum of replicas, threshold of CPU/RAM to deploy additional replicas when surpassed);
- Node-selector or affinities (i.e., to either decide or let K8s decide the node to deploy an enabler);
- Container environment variables (specific to each enabler component).

Thanks to the followed format, several configuration options can be passed at deployment time, and hence there is no need to evaluate such number totally in pilot deployments as more than 15 common configuration aspects can be tailored per enabler component, apart from their custom properties (passed via containers' environment variables). An example of configuration via the manageability interface can be seen in the previous Figure 6. In that example, 8 parameters of the component named *core* of the composite services enabler have been configured, being the ones below the *env vars* key the specific options of such component (the rest involve its name, ports, image repository and container version).

To evaluate this KPI, the full list of parameters configured for all the (components of the) enablers deployed on each pilot will be listed, expecting a much larger figure than the one specified as target.

3.2 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.

3.2.1 Introduction

3.2.1.1 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.

3.2.2 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

3.2.3 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 monitored and compared to that general value. To do so, the work instruction data collected in the LTSE from the TOS will be analyzed. In detail, the elapsed time from the MVHS_T_CARRY_DISPATCH up to the MVHS_T_CARRY_COMPLETE values will be used for obtaining this process for internal truck drivers. An example of these parameters for a filtered truck in the port is shown below.

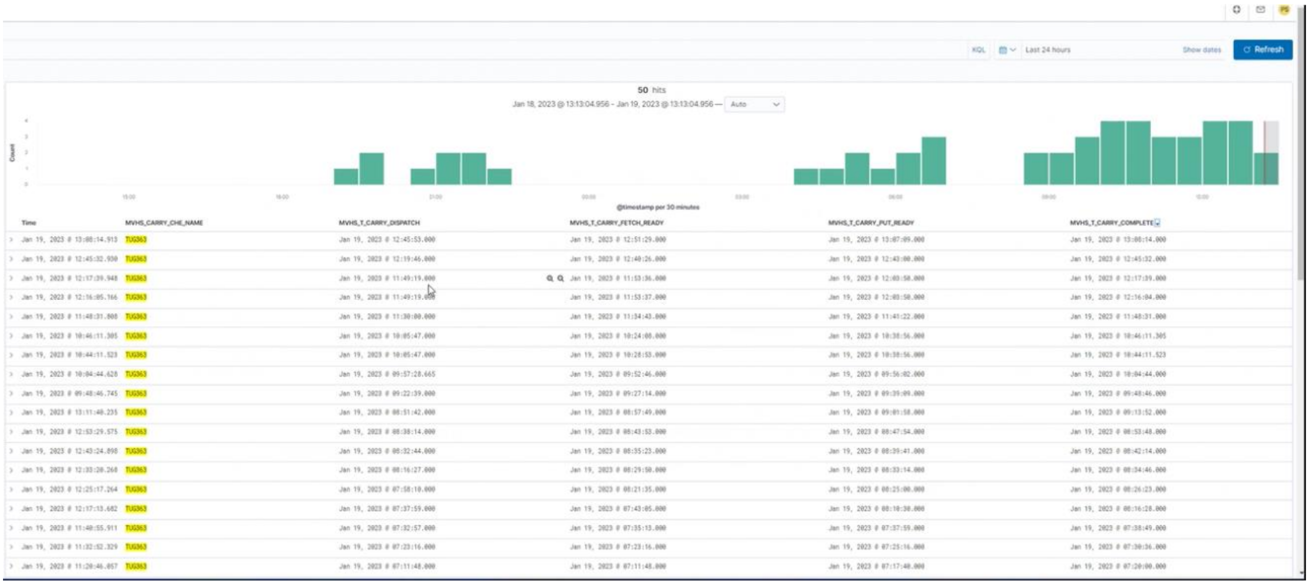


Figure 8: Screenshot of the trucks turnaround time

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.

This KPI cannot be largely updated as this stage of the project as this action have been mostly focused on development and integration activities. This validation action will take place during the following months. The target KPI originally identified still remains valid, while the measurement means are kept the same as in the first definition.

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.

This KPI cannot be largely updated as this stage of the project as this action have been mostly focused on development and integration activities. This validation action will take place during the following months. The target KPI originally identified still remains valid, while the measurement means are kept the same as in the first definition.

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. The average value of yard accidents in a month in 2021 for the Malta Freeport in a container terminal was 4.92. 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 iperf3 open-source tool will be used. Iperf3 is a cross-platform CLI-based program that performs real-time network throughput measurements. To do so, iperf3 will be installed on the two machines to be used for benchmarking running any Linux distribution. To test the network throughput the following commands should be performed:

First connect a remote machine as the server and fire up iperf3 in server mode using `-s` flag, and listening on port 5201 by default. The size format to be reported can be specified (k/K → Kbits/Kbytes; m/M → Mbits/MBytes; g/G → Gbits/GBytesGbytes) using the `-f` switch. Then on the machine to be treated as the client (and where the actual benchmarking will take place), client mode using `-c` flag should be specified, plus the server IP (or domain or hostname). After about 18 to 20 seconds, the client should terminate and produce results indicating the average throughput for the benchmark, as shown in the following screenshot.

```
[admin@vps1 ~]$ iperf3 -s -f K
-----------------------------------------------------------
Server listening on 5201
-----------------------------------------------------------
Accepted connection from 41[redacted]20, port 10966
[  5] local 13[redacted]47 port 5201 connected to 41[redacted]0 port 11023
[ ID] Interval           Transfer     Bandwidth
[  5]   0.00-1.00   sec  2.71 KBytes  2.71 KBytes/sec
[  5]   1.00-2.00   sec  13.6 KBytes  13.6 KBytes/sec
[  5]   2.00-3.00   sec  4.07 KBytes  4.07 KBytes/sec
[  5]   3.00-4.00   sec  47.4 KBytes  47.4 KBytes/sec
[  5]   4.00-5.00   sec  66.4 KBytes  66.4 KBytes/sec
[  5]   5.00-6.00   sec   142 KBytes   142 KBytes/sec
[  5]   6.00-7.00   sec   126 KBytes   126 KBytes/sec
[  5]   7.00-8.00   sec  19.0 KBytes  19.0 KBytes/sec
[  5]   8.00-9.00   sec  2.71 KBytes  2.71 KBytes/sec
[  5]   9.00-10.00  sec  2.71 KBytes  2.71 KBytes/sec
[  5]  10.00-11.00  sec  92.2 KBytes  92.2 KBytes/sec
[  5]  11.00-11.26  sec  33.9 KBytes   132 KBytes/sec
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth
[  5]   0.00-11.26  sec  0.00 Bytes  0.00 KBytes/sec                  sender
[  5]   0.00-11.26  sec   553 KBytes  49.1 KBytes/sec                  receiver
-----------------------------------------------------------
Server listening on 5201
-----------------------------------------------------------
```

Figure 9: Connections and remote bandwidth

KPI.2.1.6 Remote wireless latency

Application latency has a large impact on user experience for web sites and applications. Testing latency provides insight into its origin. Latency is defined as the time that takes for an IP packet of data to arrive from one specific point (source) to another (destination). In that sense, for Pilot 1, the remote operation use of the RTG cranes to be deployed 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. For testing the capabilities of the platform to basic OS-native mechanisms will be used: `ping`, and `traceroute` (or `tracert` in Windows OS). While ping is the simplest mechanism that measures the round trip time (RTT) between a client and a specified target server (domain or IP address), traceroute uses the TTL (Time To Live) field of IP packets to discover intermediate routers between a source and a destination, providing more insights into the origin of network latency problems.

- For using ping, a console or terminal window should be opened, and just by typing ping domain, it will provide the RTT latency of 4 IP packets, as shown in the figure below:

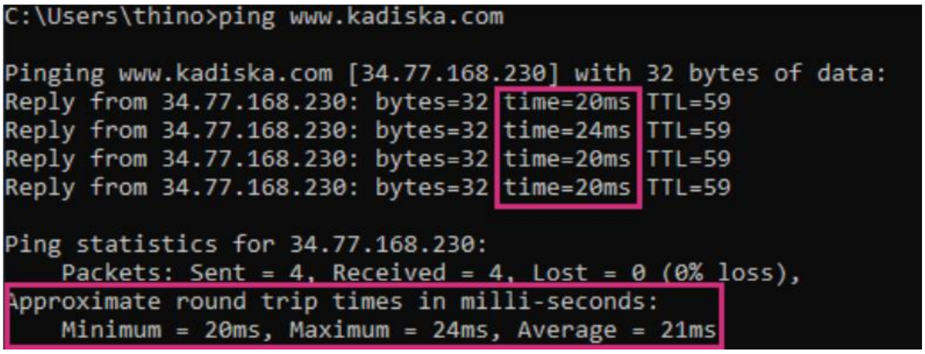


Figure 10: Latency

- Similarly, for using traceroute in a console or terminal window, type the command plus the destination domain like the next figure. traceroute uses ICMP protocol for sending four packets per hop to test latency along the network path.

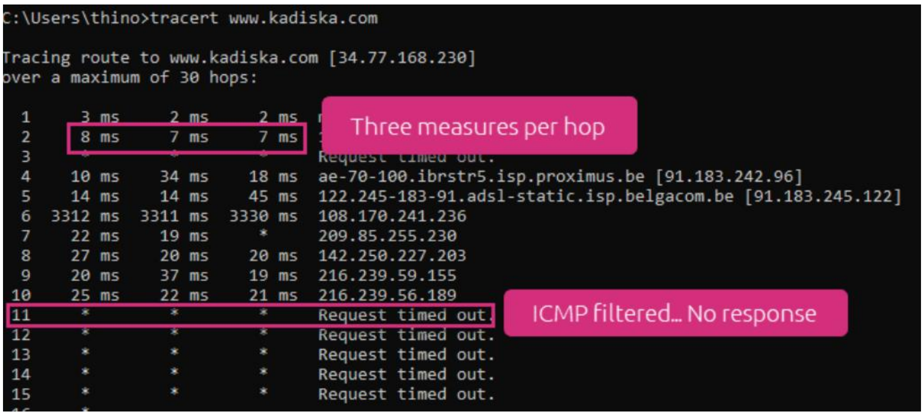


Figure 11: Latency by treaceroute

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 extentfar the short-range wireless UWB systems tags to be installed on the cranes devices within trucks can be properly communicated with the UWB anchors to be installed on cranes for triggering the authentication detects the incoming trucks. The coverage range will be measured by performing a ToF test. To do so, the Arduino DW1000 library will be run with the longest operation mode that the library supports (110 kbps, 16 MHz, 2048 preamble length) according to the UWB-manufacturer specifications (receiver sensitivity of the longest operation mode is shown in the figure below). According to different references, it is expected to achieve around 20-25m ToF distance properly calculated, fulfilling the proximity range required.

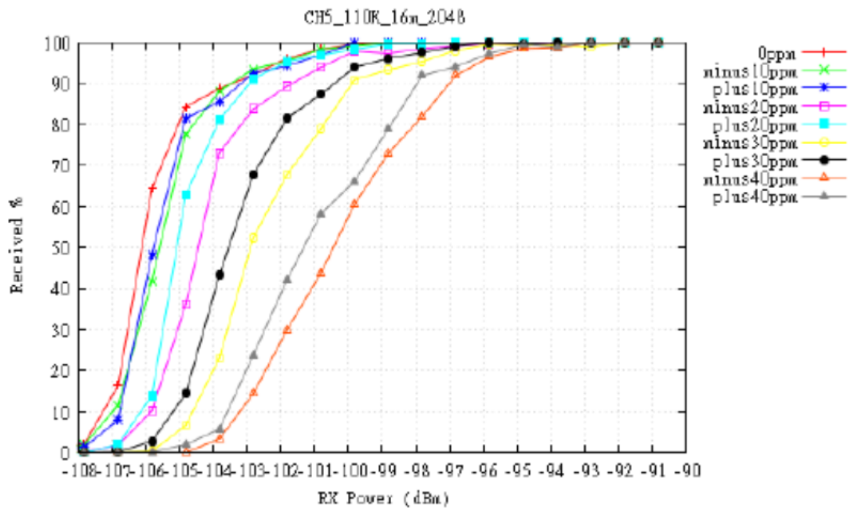


Figure 12: Proximity range

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, like the ones shown in the below screenshot.

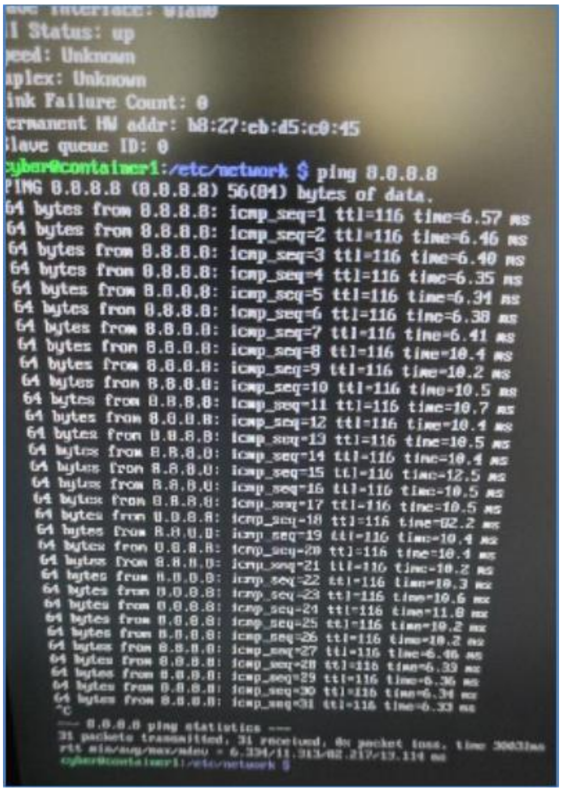


Figure 13: Redundancy

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.

At the time of the project, this KPI can be considered fulfilled given the different frontend interfaces that Pilot 1 has been generated until now and showed in the following screenshots.

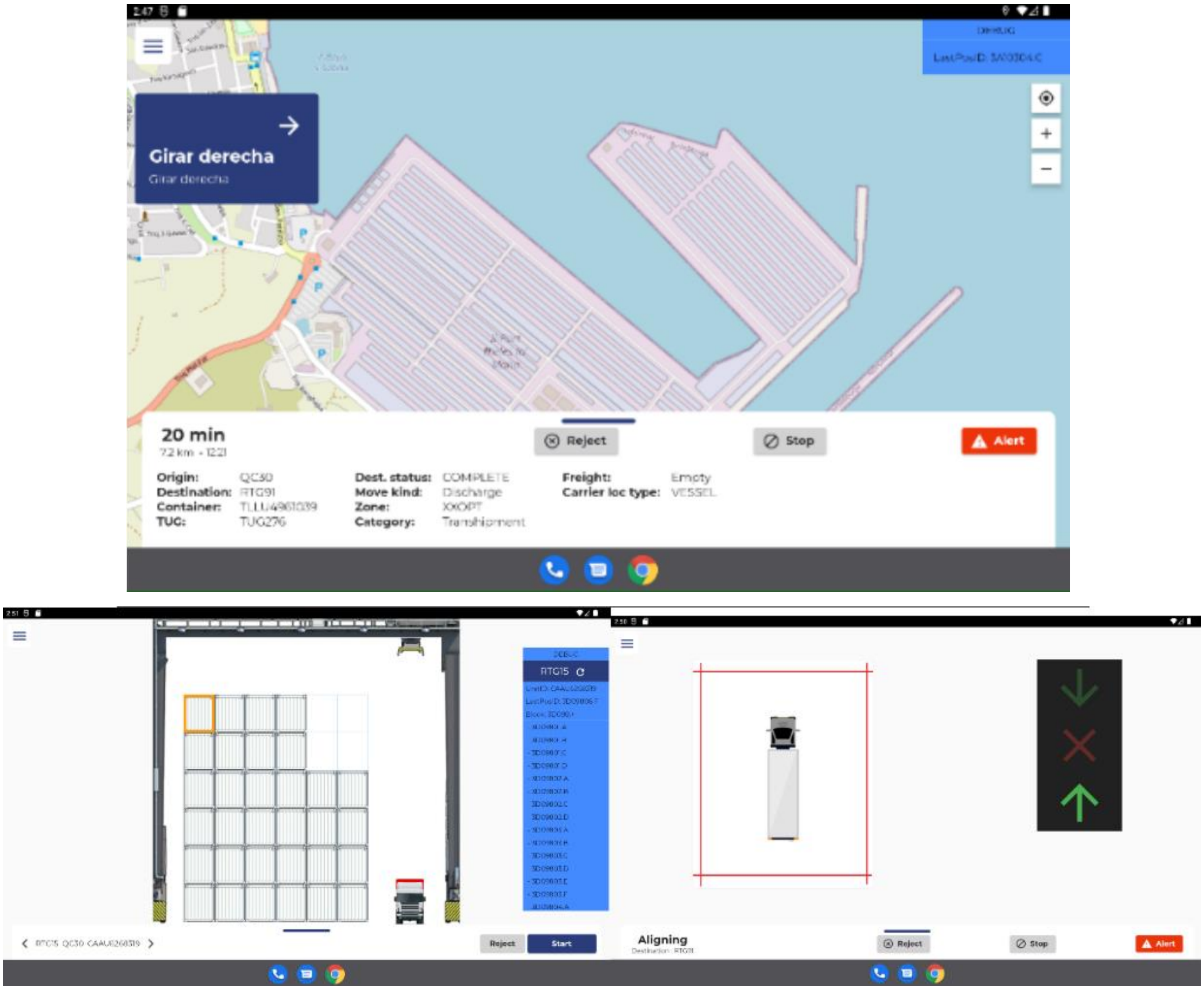


Figure 14: Screenshots of the new human interface

KPI.2.2.1 Safety notification false positive rate

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.

Update: Since the Pilot has not started yet and not all components needed for the pilot are finished this KPI cannot be proven yet to be met. The current status is that a method for validating the detection of a dangerous situation on a construction site is being developed. The need to create an algorithm to simulate a dangerous state, e.g. elevated heart rate, was detected. During all validation tests conducted on the construction site, records of notifications (alerts) provided by ASSIST-IoT will be kept separately for the worker and OSH manager. The records will be extended with information on the actual status, i.e. whether the notification (alert) was sent correctly or not.

The KPI will be measured over the course of validation activities in Pilot 2, which are expected to last several weeks. All notifications emitted during the activities will be logged, and, additionally, any false-positive notifications will be noted. These values will be used to determine the value of the KPI.

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.

Update: Since the Pilot has not started yet and not all components needed for the pilot are finished this KPI cannot be proven yet to be met. The current status is that the monitoring camera has been placed at the entrance to the construction part and is being adapted so that it can detect lack of PPE (8) and unauthorised entrance (9). The PineTime smartwatch and the weather station is being deployed in the ASSIST-IoT in terms of downloading data from devices and sending messages to the worker. Means of checking the detection of individual hazards:

- 1) heart disruptions – development of an algorithm that simulates, for example, an incorrect pulse value, a heart attack, alerting worker, OSH manager
- (2) overheating – monitoring UV radiation and the time of UV exposure, adopting the cooling intensity by ASSIST-IoT, monitoring the number of changes made by ASSIST-IoT, alerting worker
- (3) immobility – development of an algorithm for simulation, alerting OSH manager
- (3) slips and falls on the ground – development of an algorithm that simulates slips and falls on the ground based on data gathered during laboratory tests, alerting OSH manager
- (4) fall from heights – development of an algorithm that simulates fall from a height based on data gathered during laboratory tests, alerting OSH manager
- (5) collision with machines, (6) entrance to a dangerous zone, (8) lack of PPE, (9) unauthorised entrance – Validation scenario of arranged cases to be detected, alerting worker, OSH manager
- (7) UV radiation – development of an algorithm for simulation, alerting worker
- (10) too high air velocity in relation to crane work – development of an algorithm for simulation, alerting worker

Each of these will include counting correctly and incorrectly detected dangerous situations or undetected situations

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).

Update: Since the Pilot has not started yet and not all components needed for the pilot are finished this KPI cannot be proven yet to be met. The current status is the same as described in KPI.2.2.2 as meeting this KPI is related to Types of OSH hazards being detected. To check the achievement of this KPI, time synchronization will be introduced between the individual elements of the architecture. The time from the occurrence of the event to the moment the OSH manager receives notification of the hazard/risk situation will be monitored.

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.

Update: Since the Pilot has not been fully unleashed yet and not all components needed for the pilot are finished this KPI cannot be proven yet to be met. During the validation tests, end-users participating in the ASSIST-IoT solutions' evaluation will receive a questionnaire with several variables (e.g. perceived use, perceived ease of use) and statements (e.g. using this technology improves my work performance, I find the technology useful in my work) related to technology acceptance by the user. For each statement, test participant will be asked to choose the score from 1 to 5, where 1 according to the Likert scale means 'Strongly disagree' and 5 means 'Strongly agree'. The statements will be selected in a way that they will be appropriate for all validation tests, nevertheless kind of technology applied. On the basis of gathered results from all test participants, mean values for each statement will be calculated and on this basis verification whether 75% of statements reached mean value over 4 (meaning 'Agree'). All Ethics instructions put in place in ASSIST-IoT will be properly followed.

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, should achieve more than 90% success rate to deliver the message.

Update: Since the Pilot has not started yet and not all components needed for the pilot are finished this KPI cannot be proven yet to be met. Up to this time, we have successfully tested the integration between the MR enabler and the Edge Data Broker Enabler, where the notification will be transmitted. During the integration tests, out of the 100 messages sent, 96 of them were successfully transmitted to the MR devices through MQTT protocol. During the final evaluation stage at the pilot facilities, tests will be performed in the actual device (GWEN), as well as the success rate of transferred message will be further assessed among the linked devices such as MR device, GWEN and alerting components.

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 photos and relevant information, and the system will save it to the LTSE. To achieve this KPI, more than 90% of the reports should be saved to the ASSIST-IoT databases successfully.

Update: Regarding the progress of the KPI related with Reporting features, we cannot measure it as the integration between Edge Data Broker Enabler and the Long-Term Storage Enabler has not been achieved yet. To this end, the Reporting feature has been developed, as it is presented in the Figure 14, where the OSH manager can report unusual or dangerous situations.

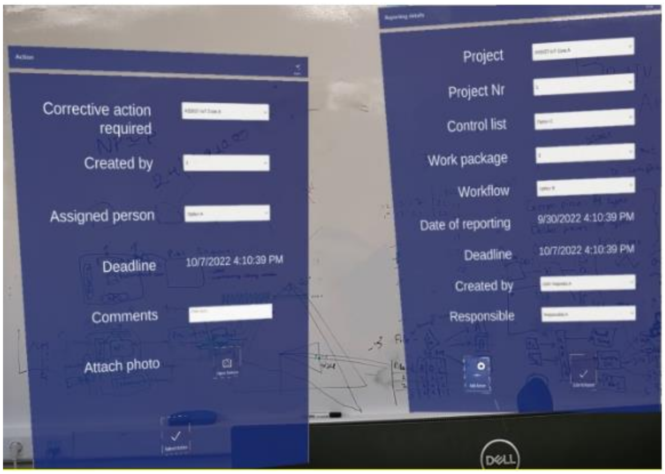


Figure 15: The interface of the reporting functionality within the Pilot 2 (Construction)

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.

The MR enabler is designed in a way that allows the user to manipulate the 3D model rendered in order to provide better understating of the information linked to it. The model includes some handlers in the corners of the BIM model, that allows the user to scale the mode, as presented in the following Figure.

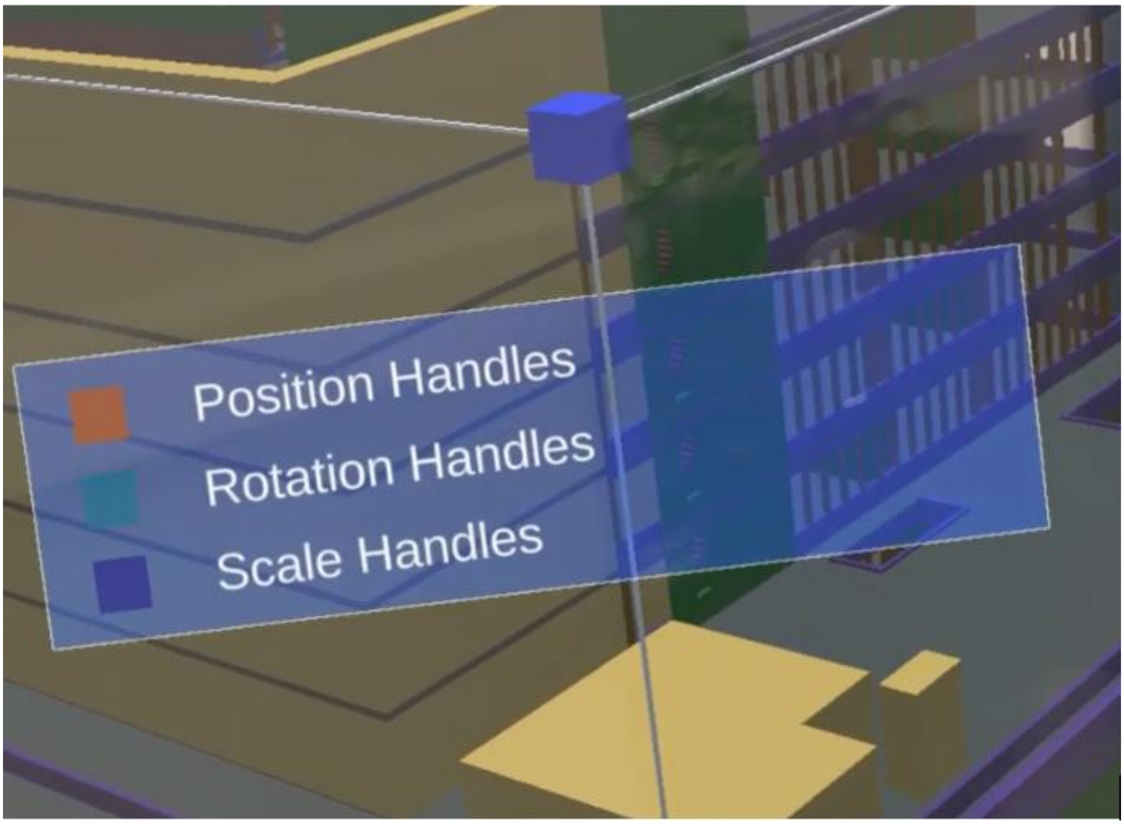


Figure 16: The legend of position, rotation and scale handles, that help user to manipulate the BIM model through the MR device

In addition, the handlers that are located in the middle of the BIM edges allows the user to rotate the model in each direction, as presented in the following Figure.

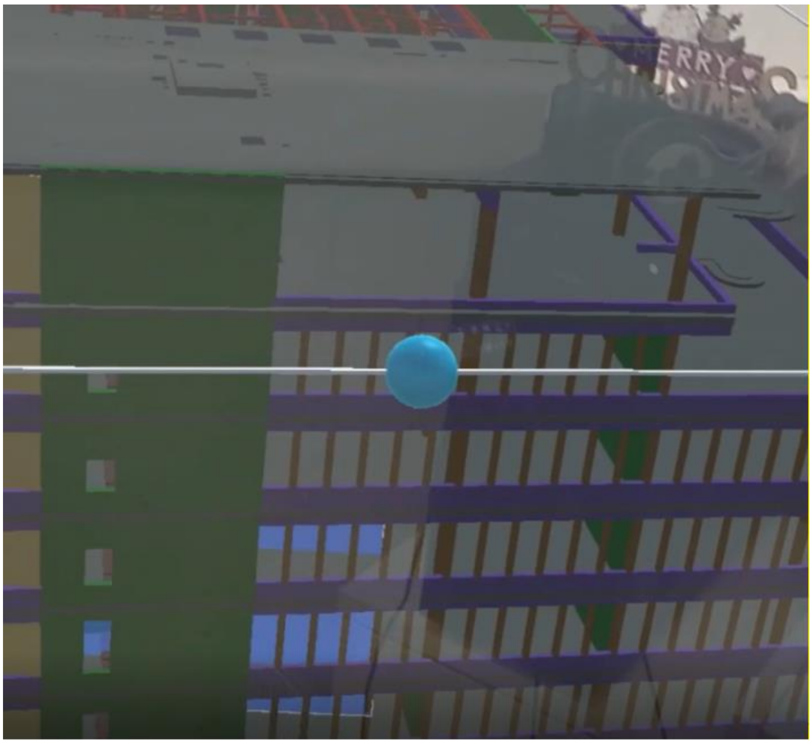


Figure 17: The light blue handler which is used to rotate the BIM model

Finally, user can transfer the 3D model in each location of their field of view by selecting the handler which is located in the centre of each edge of the BIM model and visualised in the following Figure.

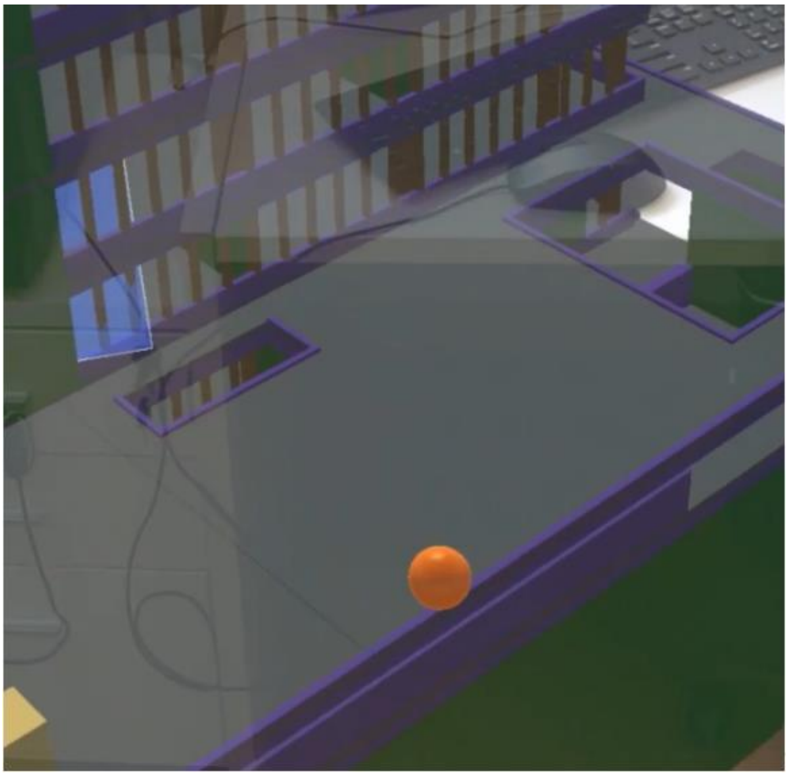


Figure 18: The orange handler (position) which is used to transfer the BIM model in each position in the "Mixed" environment

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.

This KPI cannot be largely updated as this stage of the project as the specific use-case scenario associated to this action is still focused on development and integration activities. This validation action will take place during the following months. The target KPI originally identified still remains valid, while the measurement means are kept the same as in the first definition. Several hazardous situations will be emulated using a mannequin and ASSIST-IoT integrated system is expected to recognize the 85% of the situations.

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.

This KPI cannot be largely updated as this stage of the project as the specific use-case scenario associated to this action is still focused on development and integration activities. This validation action will take place during the following months. The target KPI originally identified still remains valid, while the measurement means are kept the same as in the first definition. Workers in the pilot will be asked to enter a signalled area that will be indicated (via ASSIST-IoT technology as an alerting zone) and the system will need to detect it and trigger the alert in less 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.

This KPI cannot be largely updated as this stage of the project as the specific use-case scenario associated to this action is still focused on development and integration activities. This validation action will take place during the following months. The target KPI originally identified still remains valid, while the measurement means are kept the same as in the first definition. Workers in the pilot will be asked to enter a signalled area that will be indicated (via ASSIST-IoT technology as an alerting zone) and the system will need to detect it and trigger the alert in less than 1,5 seconds and afterwards, the notification to the manager in charge will need to take place. The goal of latency here is, maximum, 5 seconds. Report on this KPI will also occur in deliverable D8.3.

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.

A series recall will occur as a consequence of the in-service conformity (ISC) verification mechanism when a faulty or several faulty vehicles are detected in a sample of vehicles from the fleet. For determining if a vehicle is faulty, a third party is in charge of testing the vehicle under RDE (real-driving emissions) test. In order to avoid the occurrence of such series recall, non-compliant vehicles must be detected and serviced before-hand.

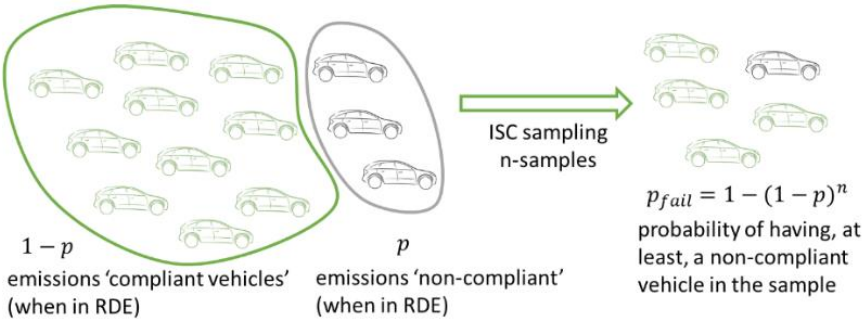


Figure 19: Probability of non-compliant vehicles

By the application of ASSIST-IoT tools the quantity of non-compliant vehicles may be drastically reduced since in-service emission (ISE) levels are monitored. In order to assess the fulfilment of the KPI, it is necessary that a sufficient amount on non-compliant vehicles is detected. If the rate of non-compliant vehicles is, at least, reduced from p to $p' = 1 - \sqrt[n]{\frac{1 + (1-p)^n}{2}}$, then the probability of a recall will fall to 50% (this considering that compliant vehicles succeed in the test always, and non-compliant vehicles fail for all cases, which is a simplification).

The true difficulty is to avoid the number of false alarms while keeping a sufficient detection rate of faulty vehicles. Moreover, it must be noticed that ISE metrics are significantly affected by the use scenario, and RDE compliant vehicles may experience a high ISE level due to specific use (e.g., sportive driving, very short travel distances, cold or high-altitude operation). In order to avoid false detection, it is necessary to restrict the detection of outliers to the cases where RDE-like driving is performed.

The KPI assessment will be done on the basis of the collection of real-life data with the pilot vehicle. While the generated data does not cover all possible (and infinite) driving situation, it is a sample of realistic driving conditions. In addition to the runs in nominal operation, a couple of mechanism will be used for generating biased data:

- Real-life driving data, where specific bias on engine-out (SCR upstream) NOx sensor has been injected into the PCM calibration.
- Synthetic outliers where the emission level is modified from the original value in order to go beyond ISC limit.

The assessment strategy will be based on the following procedure:

- Using of nominal real-life data, plus RDE and ISE metrics for rating the vehicle in its nominal operation. The objective is to filter the driving conditions where ISE metrics must be evaluated since the driving data is relevant from ISC perspective. This will serve to provide statistical values for the distribution of the NOx emission as a function of the RDE metrics.
- Using biased data (from experimental tests) for verifying the effect of the vehicle bias on the emission distribution, and determination of thresholds as a function of RDE metrics.
- Seeding the database with genuine outliers (synthetic and experimental tests) and verify the capacity of the system for detecting non-compliant vehicles for different scenarios.
- Quantification of the detection rate, and statistical analysis of the impact on triggering recall events.

KPI.2.3.2 Reduce development time for diagnostic software updates

Although vehicle manufacturers invest a tremendous amount of time and resources into testing, in reality not all flaws on hardware or software level can be identified before a vehicle is brought into the market. This is a dissatisfying situation both for the customer and the car manufacturer alike and puts significant pressure on the car manufacturer to understand the issue, then solve it, and afterwards deploy the resulting solution to the customer as soon as possible.

While the above mentioned three steps – understanding the problem, solving the problem and deploying the solution to the customer – seem simple, in reality this sequence of actions is one of the more difficult tasks in the automotive environment.

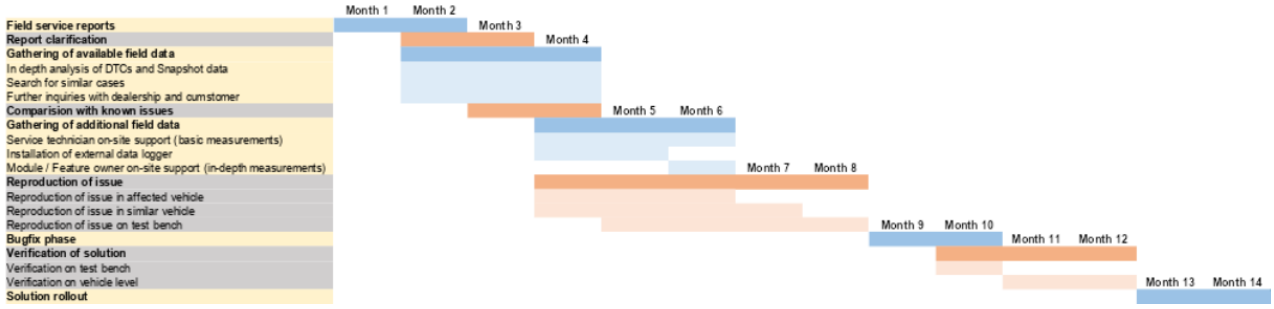


Figure 20: Field issue action sequence (worst case timeline)

The figure above shows all the steps which are usually taken, in order to understand, solve and fix a problem seen in the field. Depending on the severity of the issue, the technical nature of the underlying problem and the amount of vehicles affected, both the steps taken and the duration of each step can differ substantially. Therefore, the above shown figure can be seen as a realistic, yet worst-case scenario.

Using the Active Monitoring feature described in previous deliverables, the time to reproduce an underlying fault can be reduced significantly. Either high frequency data is stored automatically, for example by storing the content of a ring-buffer if a certain DTC is raised, or the driver can trigger the storage of information manually, in case unwanted behaviour is noticed while driving. In both cases the OEM is provided with in-depth information, which simplifies the understanding and reproduction of the failure significantly.

Once the problem has been encircled, the development team is able to solve the issue. This part of the process is not addressed by Pilot 3A.

Once an individual vehicle is sent to a dealer for a repair action, the Augmented Reality features provided by ASSIST-IoT will help to simplify process for the service technician, for example by indicating the affected module. In the larger context however, from a time perspective, this improvement is neglectable, therefore it will not be covered within KPI.2.3.1.

As described above, the limitations of the current process are well known from various field incidents across several ECUs. For KPI.2.3.2, numerous real-life examples in the context of various ECUs will be used as a baseline. As only the timely aspect is relevant, a technical description of the past incidents will not be part of this discussion.

Based on these real-life examples, a comparison with the envisioned process improvements facilitated by the ASSIST-IoT ecosystem will be utilized to ratify KPI.2.3.2. As mentioned in the description of the KPI, a reduction of the development time for diagnostic software updates of 50% and more and is within reach here. 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

Modern vehicle architectures include a plethora of electronic modules and sensors, which are connected via various networks like LIN or CAN. At the same time, state-of-the-art propulsion systems are dependent on a wide range of data input, to allow the performant operation both car manufacturer and customer are expecting.

Emission related tasks within propulsion system controls are no different in this regard and the PCM is both receiver and transmitter of a large variety of data signals to allow an operation at optimum level.

Given this background, the number of data channel is an obvious key performance indicator for Pilot 3A. However, in order to ratify a successful passing of the KPI, also the data type and the according update frequency of the signal have to be taken into account, as only a combined reflection of these factors gives a realistic answer, how many data channels can be measured in parallel.

Information in the propulsion system controls sector can be anything from primitive data types like Boolean to complex data structures like composite or even abstract data types. Additionally, like stated above, the update frequency for individual signals has to be taken into account, which typically ranges between 10ms and 100ms in the propulsion system controls perimeter.

For Pilot 3A, currently 274 signals are monitored:

- 20 signals with 8-bit size (including encapsulated Boolean)
- 196 signals with 16-bit size
- 57 signals with 32-bit size
- 1 signal with 64-bit size
- Additionally: 38 CAN signals of various sizes and update frequencies

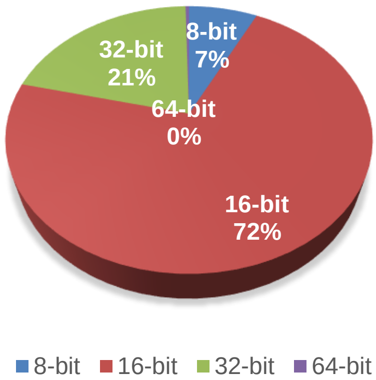


Figure 21: Signal sizes in Pilot 3A

Based on the fact that the vast majority of signals show a size of 16-bit and in order to simply the ratification of the KPI, 200 signals with 16-bit size and a high update frequency of 10ms (100 Hz) are chosen as demanding real-world reference to ratify the KPI.

Data measurement in the automotive sector is relying on quasi-standard tools, some of them used commonly on supplier and OEM side throughout the industry. One of these quasi-standard tools, ATI Vision, was utilized in Pilot 3A and described in several deliverables before, will serve as the reference measurement system. Pilot 3A is gathering data streams from various vehicle and prototype sensor sources into so called Drivelets, timely bounded measurement files, containing the data of a well-defined driving situation. This data is then transferred to the ASSIST-IoT GWEN, which is hosting all the intelligence for Pilot 3A. In order to simplify this approach and to focus on the innovation brought to the project by ASSIST-IoT, it was decided early in the project, to utilize ATI vision as the Drivelet server, meaning the reference measurement tool is already a part of the Pilot setup. Therefore KPI.2.3.3 can be ratified comparing the input provided by the industry-wide accepted measurement suite with the output provided by the ASSIST-IoT GWEN. The ratification is deemed successful, if the comparison of 100 random Drivelets, based on the above-mentioned structure, with the GWEN data output proves neither data was lost, nor any information was altered.

KPI.2.3.4 Available connectivity channels provided by ASSIST-IoT

Within the automotive sector, there is a fine line to be respected between cost efficiency on the one hand and high performance on the other hand. Another important aspect of automotive engineering is the question on how to increase the availability of systems. The rightful customer expectation is the availability of all systems 100% of the time, while non-availability of functionality – even temporary – will understandably lead to immediate customer dissatisfaction. KPI.2.3.4 focuses on network availability and cost efficiency at the same time.

The former, network availability, is an obvious requirement for customer satisfaction and perpetual functionality. So far car manufacturers are hesitant to implement a variety of network connection options inside a vehicle, a major concern being the on cost related with adding additional network infrastructure (namely software, hardware or license fees) to the vehicle. Therefore, adding this functionality to a vehicle must provide significant benefit which will be valued by the customer and the OEM alike. The ASSIST-IoT Multilink Enabler increases system availability by offering network redundancy in case the preferred network connection is unavailable by switching to the next available network connection in line.

The other important aspect – cost efficiency – is at least partially addressed by the ASSIST-IoT Multilink Enabler, as it allows to differentiate between small sets of important data made available via mobile networks and large sets of raw data, downloaded only on demand utilizing WiFi.

For KPI.2.3.4 two aspects are important. Firstly, the automatic switching between available networks if the preferred network is lost. In order to test this requirement a connection to the preferred network has to be established. Once the preferred connection is confirmed, it will be manually switched off and the GWEN is expected to automatically connect to an available alternative.

A potential setup in this regard could look like this:.

1. Establish a connection to the 4G / 5G mobile network
2. Switching off the mobile network router
3. Ratification, if the GWEN automatically enables a WiFi / 2G / 3G connection as a backup

Secondly, the GWEN should support a variety of networks, with the most important network connections for Pilot 3A listed below:

- 2G mobile network
- 3G mobile network
- 4G mobile network
- 5G mobile network
- WiFi

To ratify the second aspect of KPI.2.3.4, a data transfer should be initiated on all of the above listed networks, to verify availability and data integrity, by comparing data input with data output of various data packages accompanied by latency measurements.

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

KPI.2.3.5 was introduced to ratify, if an updated PCM calibration will be deployed to a vehicle, which was previously offline and is now online again, in a timely manner. While most moving vehicles will likely connect to a mobile network provider sooner or later, even in rural areas, this is not necessarily true for vehicles which are located in an underground car park or have a disconnected battery. It’s within reasonable imagination, that such vehicles could be offline for several days or weeks, few vehicles even for months or longer. It therefore has to be ensured, that these vehicles will receive an update as soon as possible, once a network connection has been established again.

To ratify this KPI the GWEN simulating the offline vehicle will be disconnected from any network connection. Then an updated calibration will be deployed to a simulated fleet of vehicles, with the test vehicle still being offline. Once the initial deployment of the software is completed, the GWEN will be switched online again to measure the time, until the software update on the remaining vehicle is triggered. Several aspects have to be considered here:

- Identification, Authentication and Authorization are key aspects to ensure security and safety in the automotive sector and should be applied during the ratification of the KPI

- Verification of uploaded data to ensure a flawless exchange of software
- Verification of matching software and calibration, to ensure software component levels are not conflicting

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

As mentioned already in the previously described KPIs, for Pilot 3A, a major focus lies on the enhancement of diagnostic capabilities. KPI.2.3.6 is adding to this target, by ensuring, that a relevant amount of raw data files can be stored on the edge for later download and detailed analysis.

Raw data in the form of so called Drivelets are generated and processed on the edge. Once this process is finalized, a ratification of the significance of the Drivelet is initiated, utilizing edge intelligence and emission models located on the ASSIST-IoT GWEN. While at first glance significance might sound subjective, Pilot 3A applies a well-defined set of rules to every single Drivelet, allocating proper metadata labels in the aftermath. These labels can be defined as needed, for example "high speed driving", "low emission", "cold temperature", simplifying the process to find data in a data base significantly.

As memory space is limited on an edge device, not all data can be stored. This is where the term "significance" comes into play, as only these Drivelets should be stored, which are deemed helpful to improve the insight of previously unknown vehicle states. This can include both unwanted failures and vehicles performing on the lower end of the expected emission spectrum alike. However, also the amount of significant Drivelets might fill up the available memory over time. Therefore KPI.2.3.6 was introduced to ensure, that a relevant amount of Drivelets can be stored for later detailed analysis.

As a Drivelet storage buffer overflow should occur at no time, the available memory on the edge will be checked before a new significant Drivelet will be stored. If there is not enough memory space left, either the latest Drivelet cannot be stored or the oldest Drivelet has to be deleted from the storage.

Either way, at least 100 Drivelets with an average size of 50MB shall be stored on the GWEN, before a limitation of memory is detected and Drivelets will be discarded automatically.

KPI.2.3.7 Sever capacity to manage and monitor vehicle fleet

Within ASSIST-IoT no other Pilot has a more demanding need for a large amount of edge node than Pilot 3A, making it a very interesting and challenging part of project. Given the fact, that car manufacturers aim to produce up to 2000 vehicles of a single model a day, fleets can easily grow to six figures and more. With KPI.2.3.7 it shall be ratified, that these large numbers can be handled by the ASSIST-IoT ecosystem and no negative side effects are noticed. The KPI is intended to find a good compromise between highly demanding load-peaks, average usage scenarios and an expected fleet size, to provide a realistic measure of the ASSIST-IoT capabilities in the automotive sector.

The compliance of this KPI will be ratified by two different methods:

- jmeter SW with mqtt plugin will be used for emulating 100.000 vehicles connected to the MQTT broker at the cloud server. Each one of the connections will emulate the MQTT messages of a real system and will serve for showcasing the ability of the system for dealing with a big number of concurrent connections.
- A synthetic data base of 10.000 vehicles will be used at the server for demonstrating the different use cases.

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.

One of the fundamental components of the pilot is defects detection, as it is the main business objective for the pilot. The pilot aims to apply components developed in ASSIST-IoT for its system without resulting in a loss of the current quality of service. To ensure the quality of services for the pilot, the method applying ASSIST-IoT's components must bear results at a minimal 40% recognition detection of the various damage categories without human intervention in inspecting the vehicle.

The quantification requires a sequence of steps for measuring the effect. Initially, the damage categories are defined as scratch, rim-related, dent, deformation, corrosion, crack, and paint damages. The measurement will be performed based on a test dataset that is labelled by humans. The dataset will act as the testbed of the developed solution for the pilot, and the measurements will be known before conducting the acceptance test. The dataset is selected as a method due to the difficulty in scanning damaged vehicles on specified damages; thus, a control dataset is more appropriate for the evaluation.

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.

Another element for defect detection is the elapsed time between a vehicle passing through the scanner until the verdict in the system. The use of the ASSIST-IoT architecture is intended to speed up the pipeline and reduce the amount of time that has elapsed. When compared to the conventional and manual process, the time required to complete an examination of a vehicle will be reduced by thirty (30%) percent, which will result in a substantial difference.

The KPI is the comparison between two numerical values indicating the elapsed time between the scenarios. The amount of time necessary for a manual inspection will serve as the basis for the comparison that will be made. While we are going to measure the amount of time that has passed for the ASSIST-IoT platform.

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.

The implemented technology should have a significant influence on the revenue streams of the stakeholders implementing the solution. Their operations could expand as a result of the impact. For instance, garages and their service advisers can streamline their processes to promote solutions that are uniquely suited to the needs of their clients. They benefit from the enhanced solutions by gaining upselling opportunities for their daily operations. For instance, if the service consultant of a garage discovers a damaged rim on a scanned vehicle, he might ask the customer if he would be interested in purchasing a smart repair service for his rim, thereby generating unanticipated revenue for the company. The indicated revenue increase of the industry partners can be approximately ten percent (10%) of the present 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.

The initial estimation of 50% decrease in the volume of data transferred still appears to be a reasonable goal, as the bulk of the data being transferred consists of weights and models, which are relatively small in size compared to large datasets.

A summary of procedure for measuring this KPI is the following:

- Monitor the rate at which data is being transferred over the network and compare it with the target data transfer.
- Analyze the utilization of network bandwidth over time and ensure that it does not exceed a certain threshold, and if it does, make the according adjustments.
- Track the volume of data that is being transferred over the network, in order to understand the impact of data transfer over the network bandwidth and make changes to optimize it.
- Use a network monitoring tool: All of the above can be concluded by utilizing a network monitoring tool to help keep a close eye on the KPI and make adjustments as needed.
- Monitor the data privacy and ensure that is not being tampered or accessed by unauthorized parties. This can be implemented by the DLT encryption techniques and cybersecurity access control measures respectively.

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 monitor that all work is in line with the plan of Testing and integration (D6.2-6.3).

Testing of selected Pilot 2 components has begun in laboratory or controlled field test conditions. Namely, the Location Tracking enabler was tested on the construction site (site of the pilot) – more details can be found in deliverable D7.3. Secondly, during data collection activities for Pilot 2's machine learning models, data collection components and the Edge Data Broker enabler were integrated in laboratory conditions. Target KPI value still remains valid and the update of this measurement will be reported in D8.3.

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.

This KPI cannot be largely updated as this stage of the project as this action have been mostly focused on development and integration activities. This validation action will take place during the following months. The target KPI originally identified still remains valid, while the measurement means are kept the same as in the first definition. The Open Calls success (and AI coverage) will be considered to report this KPI in D8.3.

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.

This KPI cannot be largely updated as this stage of the project as this action have been mostly focused on development and integration activities. This validation action will take place during the following months. The target KPI originally identified still remains valid, while the measurement means are kept the same as in the first definition. The Open Calls success will be considered to report this KPI in D8.3.

3.3 Process evaluation

3.3.1 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 Dissemination approach
  - Field 3.2 Educational Effectiveness
  - Field 3.3 Promotion of resources & Openness
  - Field 3.4 Community engagement
- 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

3.3.2 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.

This KPI is still relevant and the target number is realistic.

Up to M25, only informal expressions of interest have been registered to adopt/leverage ASSIST-IoT.

By the end of the WP (M41), this KPI will be measured and evaluated. The measurement means will be to gather formal expressions of interest (letter/emails/publication/web notes) by entities that are external to the project. Those formal documents will be attached as appendices at the end of document D8.3, accompanied with a brief reference of the submitter company/individual.

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 have been successfully performed. 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.

This KPI is still relevant. However, according to the complexity of integration from different tools, and the time required to envisage a successful case, members of ASSIST-IoT request to reduce the target number of this KPI to 25. It is worth mentioning that the former figure was indicated when both the architecture and the enablers were at their infancy, therefore the integration perspective was not properly grasped. This does not mean that ASSIST-IoT will not be transferrable. On the contrary, recent experience with Open Call projects and other external interested parties (see KPI 1.1.1) are showing great potential on ASSIST-IoT transferability. Nonetheless, 50 adoptions would require (it is now clear) additional time and an operational structure that is not currently envisioned during the lifetime of the project.

However, there is still the plan to document how the targeted adoptions have been done. The ways of measurement of this KPI will be by providing the following information out of each of those adoptions:

- Scope (brief description)
- Adopting entity
- Integrated components (enablers, architecture…)
- Timeframe
- Lessons learnt

The previous will be attached as an appendix to deliverable D8.3 in M41.

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 classic 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%.

This KPI is still relevant and the target percentage is maintained as the goal in the final evaluation.

As indicated, the measurement means will consist of a survey to be distributed to several persons that will be making use of ASSIST-IoT's tactile applications (dashboard, MR enabler, glasses, AR functionalities, defects inspection, etc).

The detailed procedure will be as follows:

1. A survey will be prepared, including questions directly inspired from the Revised Technology Acceptance Model, adapted to the features of the ASSIST-IoT specific tactile application.
2. This survey will be circulated to the funded Open Call projects of the first round, around M26 of ASSIST-IoT. Results will be gathered following all ethics and data protection instructions.
3. This survey will be circulated to the funded Open Call projects of the first round, around M39 of ASSIST-IoT. Results will be gathered following all ethics and data protection instructions.

4. This survey will be fulfilled by the stakeholders of ASSIST-IoT pilots before the finalisation of the project (M40-M41). Partners requested will be KONECRANES, MFT, CMA CGM, MOSTOSTAL, CIOP-PIB, UPV and TWOTRONICS.

Both the survey and statistics and reflections on the condensed results will be attached to deliverable D8.3.

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.

This KPI is still relevant and the target figure is maintained as the goal in the final evaluation.

The measurement means of this KPI will consist of listing the contact/interaction/liaison activities performed with the relevant IoT pillar institutions. It will comply with the following table format:

Activity	Description	Entity

This table will be fulfilled in deliverable D8.3. It will be accompanied with a reflection on the impact of the interactions with relevant entities.

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 repeatedly over the years. ASSIST-IoT will work on the most recent implementations of such a methodology, targeting a value of 70%.

This KPI is part of the activities scheduled for task T8.4. It represents the usability of the system for both experts (system administrators, enablers developers, IT staff…) and non-experts (stakeholders, data scientists…) in NG-IoT deployments.

As drafted in deliverable D8.1, the measurement means of this KPI will be based on the provisions by A. Bargor, P.T. Kortum and J.T. Miller. The detailed methodology that will be followed can be found at Section X.Y.Z of this document. A summary of the procedure for measuring this KPI is:

- Categorisation of the respondents depending on their profile and the results of ASSIST-IoT that they use.
- A division of "type of systems to be rated". Here, every respondent category will be assigned to one or more "surveys" that will differ from each other. Based on this classification, each respondent type will be in charge of evaluating the usability of their corresponding results.
- The usability will be measured using the 10 original statements of the SUS instrument (left image below) by marking each of the statements to a specific rating among a list (right image below).

- More statements will be added to the statements depending of the type of result whose scalability is being measured.
- Statistics will be generated, as well as reflections on the usability scale of each identified type of result.

Rating
Best imaginable
Excellent
Good
OK
Poor
Awful
Worst imaginable

Statement
1. I think that I would like to use this product frequently.
2. I found the product unnecessarily complex.
3. I thought the product was easy to use.
4. I think that I would need the support of a technical person to be able to use this product.
5. I found the various functions in the product were well integrated.
6. I thought there was too much inconsistency in this product.
7. I imagine that most people would learn to use this product very quickly.
8. I found the product very awkward to use.
9. I felt very confident using the product.
10. I needed to learn a lot of things before I could get going with this product.

Figure 22: Usability scale

Regarding the target, according to references those products (in this case, ASSIST-IoT evaluated results) that are acceptable are those of score 70 and beyond (in ASSIST-IoT, the maximum score will be more than 100 so a weighting factor will be applied). Those truly superior results will be those scoring better than 90. Parts of ASSIST-IoT with scores of less than 70 will be considered candidates for increased development/integration I WP4, WP5 or WP6.

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 explored in ASSIST-IoT. A target value of >5 has been set as a target.

This KPI is still relevant and the target figure is maintained as the goal in the final evaluation.

This KPI is very similar to KPI-1.1.3. The main difference is that now the objective is to gather information about usability of the whole platform (architecture, enablers, etc.) while KPI-1.1.3 was specifically addressed to tactile applications.

Thus, the procedure will be quite the same, only with some variations (that are indicated in colour purple):

A survey will be prepared, including questions directly inspired from the Revised Technology Acceptance Model, in a very generic way for the whole ASSIST-IoT platform and its enablers.

This survey will be circulated to the funded Open Call projects of the first round, around M26 of ASSIST-IoT. Results will be gathered following all ethics and data protection instructions. It is expected that the number of participants here will be larger than for KPI-1.1.3, as all Open Call projects use some part of ASSIST-IoT, and thus are recipients of this survey (while not all of them would be using tactile applications).

This survey will be circulated to the funded Open Call projects of the first round, around M39 of ASSIST-IoT. Results will be gathered following all ethics and data protection instructions. Ibid.

This survey will be fulfilled by the stakeholders of ASSIST-IoT pilots before the finalisation of the project (M40-M41). Partners requested will be KONECRANES, MFT, CMA CGM, MOSTOSTAL, CIOP-PIB, UPV and TWOTRONICS.

It is expected that both KPI-1.1.3 will be conducted in parallel, existing 2 different surveys that will be asked to be answer (or not) depending on the applications that have been used by each consulted entity.

Both the survey and statistics and reflections on the condensed results will be attached to deliverable D8.3.

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.

This KPI will be analysed in detail and reported in D8.3

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 worth-to-pay for Key Exploitation Results of the project have defined a clear and sustainable 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.

Currently, an initial research desk has been performed by taking a look at different consultancy reports from 2020 and 2021. This KPI will be analysed in detail and reported in D8.3.

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.

This KPI will be analysed in detail and reported in D8.3

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.

This KPI will be analyzed at the end of the project and and will be reported in D8.3.

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.

To do so, the following questionnaire has been prepared.

1. Do you consider IoT as critical for your business applications or processes? YES/NO
2. Does your company host any applications using an IoT? YES/NO
3. If you would move from a simple (or not at all) IoT implementation to a NG-IoT deployment, do you consider ASSIST-IoT as good opportunity for your business applications or processes? YES/NO
4. Which solution do you see as the best option for deploying innovative NGIoT features?
    a. Public cloud
    b. Private cloud
    c. On-premises
    d. Hybrid
    e. N/A
5. Which do you think would be the most relevant areas/departments of your business that could benefit the most from a well deployed fully functional edge computing solution of ASSIST-IoT?
    a. Operations
    b. Management
    c. Selling
    d. Innovation
    e. Human Resources
6. What may be your organization's main concerns/challenges for ASSIST-IoT solution deployment? Select three
    a) Data collection & analytics processes
    b) Privacy;
    c) Securing network, devices or data;
    d) Regulatory and safety certification/compliance;
    e) Integration complexity;
    f) Costs of maintenance/management;
    g) Scalability;
    h) Connectivity device to edge to cloud
    i) Vendor lock-in;
    j) Time to market or delivery acceleration;
    k) End-to-end IoT solution monitoring and management
7. With which applications/systems would you believe a company could maximize the exploitation and benefits of ASSIST-IoT?
    a. Big Data
    b. E-commerce
    c. For testing purposes

   d. For monitoring real-time operations
   e. For gathering more intelligence towards smarter decision making, predictive maintenance
   f. Financial prediction
   g. Enterprise applications/products
   h. Other (mention)
8. What would be the most relevant factors that would motivate your organization to adopt ASSIST-IoT platform?
   a. Cost-effective solution
   b. Low price
   c. Cost savings by automatizing tasks
   d. Improve business performance
   e. Higher bandwidth for data transfer
   f. Gathering better insights of own business
   g. Gathering better insights of the surrounding environment
   h. Increase the skills level of the company staff
   i. Better position in the market by the usage of more modern technology

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.

Furthermore, an IPR patents table has been provided in order to successfully track the status of the different IP filed by ASSIST-IoT partners. This KPI will be analyzed at the end of the project and and will be reported in D8.3.

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%.

According to the latest reports from the three ASSIST-IoT SMEs (Prodevelop, Infolysis, and Twotronic), an average revenue growth of 30,1% was obtained from 2019 until 2021. If similar trend is followed until the end of project’s lifespan, this KPI will be fulfilled. The final value of this KPI will be reported in D8.3.

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 started (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%.

This KPI will be analyzed at the end of the project and and will be reported in D8.3.

KPI.1.3.4 Return of Investment (RoI)

When reflecting about the calculation of the Return of Investment in regards 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 be framed into the viewpoints (2) and (3).

The ROI is measured as a percentage and its calculation is versatile, simple, and easy to understand, based on the equation below:

$$RoI = \frac{Current\ value\ of\ investment - Cost\ of\ investment}{Cost\ of\ investment}$$

In the above equation, whereas the ***cost of investment*** refers to the total costs of the ASSIST-IoT system, including the deployment of the essential enablers, maintenance, etc., the ***current value of investment*** is the generated value from having **ASSIST-IoT** running at a company. Due to the volatility of the IoT market, the accuracy of a ROI analysis is limited. Therefore, the below steps for better digest the ASSIST-IoT ROI analysis will be followed:

1. **Identify direct and indirect costs for building a new ASSIST-IoT solution**. For example, deploying an ASSIST-IoT platform which allows to enterprise automation (like in Pilot 1) would mean that Terminal Link may not need as many field technicians (fewer salaries to pay) leading to an increase in indirect savings.
2. **Specify the initial cash expenses**. Since an initial cost calculation that encompasses things such as inventory costs, delivery costs, training of staff involved, etc. should be considered. This also affects to the k8s underlying orchestration platform of ASSIST-IoT. Therefore, a comparison between the estimated the cost of current IoT infrastructures and Kubernetes infrastructure should be taken into account.
3. **Consider the value produced over time.** The quality of ML models of ASSIST-IoT capabilities are expected to improve over time. The data pool increases with time and so does the accuracy and quality of the data.
4. **Make an estimate of possible net cash from the future investment.** This step will require the most time and the best scrutiny of all approximate returns on the part of the platform.

A detailed analysis of the ASSIST-IoT 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 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.

This KPI is still relevant and the target value remains valid for the final evaluation to take place in D8.3.

The task T9.4 is in charge of dealing with the Innovation Elements of the project as well as with the Key Exploitable Results and the business analysis of ASSIST-IoT outcomes. This KPI aims at measuring how those activities have transpired into actual inclusion of ASSIST-IoT technology as operational parts of private companies in their day-to-day business.

The measurement means of this KPI are very much the same as defined in M18 of the project. Every industrial action (see definition above) performed by private partners of the Consortium or detected from outsider entities will be logged and described considering:

- ASSIST-IoT enabler, principle or asset reutilized and to which extent (fully, partially, conceptually…)
- How it contributes to the company/product/innovation/investment line
- Company and its business scope
- Expectations for medium-long term.

As the results of ASSIST-IoT that would be able to be incorporated as business products will become ready from M30 on (whenever finishing WP4 and WP5), this KPI cannot be reported at this moment. A reference (and a listed completing the values above) will be provided in D8.3

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.

This KPI is still relevant and the target value remains valid for the final evaluation.

As expected, this KPI will not be measured till the end of the project (through deliverable D8.3). However, several actions have been conducted during the period M18-M25 to comply with the objective settled for D8.2. According to the plan, this intermediate document would be in charge of document those techniques and technologies to serve as a baseline for the final evaluation. The task was to find the current dominant de-facto standards and also the trends in the IoT-edge-cloud and NGIoT fields.

This document (see the list below) presents such analysis. In order to arrive to the exposed conclusions, partners in T8.4 proceeded with the following actions:

- Participated in several events organised by EU-IoT (standardization gaps, NGIoT roadmap, etc.) including the contribution to book chapters on NGIoT applications
- Contributed to some (and reviewed all) of the whitepapers published in NGIoT about research directions.
- Participated in activities organised by NGOs (ETSIoTWeek, AIOTI Task Forces meetings…).
- *Among others*

Out of their participation in such activities the following list was extracted about candidates to meet those *de-facto standard* and research priorities:

1. Contextual IoT and IoT/edge operating systems: Go beyond "meta" Operating Systems, focusing on semi-autonomous orchestration. In the long run, move from centralised orchestration towards decentralised coordination with AI developments to increase autonomy.
2. Interoperability, reliability and scalability: Deploy secure and highly scalable IoT and digital infrastructures with special focus on edge capacity, leveraging on global networking technologies such as IPv6 and 5G
3. 5G/6G: The deployment of advanced network management and deployment mechanisms and the predominance of virtualization and software-controlled approaches are one of the most relevant topics.

4. A/ML, MLOps and data management across IoT deployments, as fundamental pieces to ensure Data Act and Artificial Intelligence Act and crucial elements for implementing innovative use cases.
5. Trustworthy AI, lightweight AI/ML and federated ML: introduction of a variety of techniques, schemas, mechanisms and technologies for federating algorithms and nodes as well as reducing size of models or training data size and quality.
6. Cloud principles and cloud technologies, prominently for the management of infrastructure and for orchestrating workloads across the IoT-edge-cloud deployments.
7. Hardware and sensors including energy efficiency and green approaches.
8. Future-proof security and privacy: Develop security and privacy by-design to deal with future threats, increasing traceability and trust beyond regulatory compliance.

The previous list has been identified by the partners and will be further endorsed/modified by the members of the Advisory Board. This action was planned for D8.2, but considering the timing of the meetings with AB members (end of January 2023 and end of April 2023), this interaction will be reported in D8.3. In addition, it is expected that a face-to-face cooperation will be more fruitful in this regard. On another note, it is expected that this list will be enhanced (for instance, listing the standards or particular technologies that dominate -or are called to dominate- each of those innovative fields).

Thus, this KPI will be completely evaluated during D8.3.

The measurement means of this KPI will consist of the following:

- Item per item of the following list, an explanatory paragraph will indicate whether (and, if yes, to how extent) or not is ASSIST-IoT conforming with the trending technologies and techniques.
- For those positive cases, links will be added (readme, videos, deliverables, etc.) where the contribution of ASSIST-IoT to those fields will be described.
- This way, it will be straightforward to understand: (1) how much ASSIST-IoT complies with the selected list, (2) how ASSIST-IoT directly contributes to foster and enhance the trending technological lines in the IoT technological field.

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.

This KPI is still relevant and the target value remains valid for the final evaluation to take place in D8.3.

Being delivered as a generic, blueprint, reference NGIoT architecture, ASSIST-IoT could be deployed in (virtually) any vertical. While this remains true, this KPI points directly to a deeper reasoning of specific cases in which this could be realized. Drawing from the experience of the partners preparing demonstrators, attending to IoT-related and industrial events (e.g., IoTWeek, TRA2022, among others), it has been noticed that this transfer is feasible and that the expressed needs from ASSIST-IoT's stakeholders are shared in other fields of action.

For measuring this KPI, the team in T8.4 will follow the instructions (to be) settled in the Transferability Analysis document to envisage the application of ASSIST-IoT's technology in other domains. The (at least) 3 expected verticals to be documented will contain the following information:

- Sector
- Specific problems on the sector that might leverage ASSIST-IoT technology
- ASSIST-IoT enablers, modules, principles or concepts of application
- TA methodology (virtually) applied

The results of the evaluation of this KPI will be attached to deliverable D8.3 as appendices.

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

This KPI is still relevant and the target value remains valid.

This KPI cannot be measured at this moment of the project as this action is expected to take place after the cybersecurity enablers are completely finalized (after WP5's end). Till then, only preliminary contacts have been performed.

This KPI will be measured by listing the number of joint activities performed together with such entities or projects. It is expected that liaison with sister projects and Open Call funded actions will boost this collaboration.

The information that will be included is:

- Type of action
- Entity in collaboration
- Scope of the collaboration

This KPI will be measured at the end of the project and will be documented via deliverable D8.3.

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.

This KPI is measured based on developed software components in different enablers designed in the project. The final value will be calculated at the end of the project based on the list of developed components.

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.

The KPI was measured over half period of the project and fulfil the assumed value. The same evaluation of this KPI will be done at the end of the project with the list of standards in relation to developed components.

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.

This KPI is continuously monitored and was fulfilled in M18. At the end of the project

overall list of standardisation activities and contributions will be documented (D9.4) for evaluation of the planned value of this KPI.

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.

Similarly to previous KPI, our active participation in different standardisation initiatives will be documented and final evaluation of the KPI will be done at the end of the project and included in D9.4. In M18 the KPI was fulfilled.

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.

This KPI was evaluated at M18 where it was fulfilled and will be evaluated at the end of the project with collecting all standards related to the subjects used in the project and its relation to project solutions. Detailed description will be included in D9.4.

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.

As expected, results actually publishable in journals and scientific conferences started to materialize around M20 of the project. This fact can also be observed in the number of publications that (i) have been submitted for publication, and (ii) are currently in preparation.

Moreover, it is worth noting that the project has been extended by 5 months. This brings extra time to turn key results into scientific publications.

Therefore, the original KPI=38 (publications), while seen as needing extra attention (see project risks analysis), is assumed to be reachable.

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.

This KPI is still relevant and the target figure is maintained as the goal in the final evaluation.

Potential interoperability cases that could be reported are:

- IoT platforms by Open Call funded projects that have been connected (interoperability achieved)
- Open IoT platforms available in the open source community that have been connected to ASSIST-IoT (e.g., PIXEL platform, INTER-IoT, IntellIoT, TERMINET, ThingWorx…).

- Explanation of the compatibility of ASSIST-IoT with other IoT platforms even though actual integration has not been tested (limited scope, resources and time of the project).

The measurement means will be to document each of the compatibility cases with, at least, the following information:

- Scope
- IoT Platform integrated
- Functionalities shared (in both ways)
- Lessons learnt

Each case will be reported in the deliverable D8.3.

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).

This KPI can be considered a sub-objective of KPI-1.1.2. Please, refer to such KPI to understand the procedure, target goal, measurement means and formalisation of the KPI evaluation.

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 been submitted or that will be submitted. Target is 2.

This KPI is still relevant and the target figure is maintained as the goal in the final evaluation.

Two additions/modifications have taken place to this KPI since the elaboration of D8.1.

First, a table has been created to document the research actions tackled. It has included new fields such as the type of research action, broadening the scope not only to proposals presented to specific calls of H2020 or Horizon Europe but also other type of research initiatives. The table can be seen below.

(Please, note that in the table one action is already documented, therefore the measured value of this KPI in M25 is 1)

Table 122: Research actions

Type of action	Name	Partner	Idea	Summary of ambitions	Call/program
HE proposal (now, project)	aerOS	UPV, SRIPAS, PRO, INFOLYSIS	A meta operating system to orchestrate the edge-cloud continuum.		CL4-2021-DATA-01-05

Second, there was the risk that such a table might embed privacy concerns or disclosure issues. Therefore, partners will fulfil the table on a voluntary basis. This way, every action reported will be communicated without incurring in any violation of privacy terms.

Fulfilment of this table will be done at the end of the project and will be attached to deliverable D8.3.

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.

This KPI is still relevant and the target value remains valid for the final evaluation to take place in D8.3. The task T9.4 is in charge of dealing with the Innovation Elements of the project as well as with the Key Exploitable Results and the business analysis of ASSIST-IoT outcomes. This KPI aims at measuring how those activities have transpired into actual inclusion of ASSIST-IoT technology as operational parts of private companies in their day-to-day business.

The measurement means of this KPI are very much the same as defined in M18 of the project. Every industrial action (see definition above) performed by private partners of the Consortium or detected from outsider entities will be logged and described considering:

- ASSIST-IoT enabler, principle or asset reutilized and to which extent (fully, partially, conceptually…)
- How it contributes to the company/product/innovation/investment line
- Company and its business scope
- Expectations for medium-long term.

As the results of ASSIST-IoT that would be able to be incorporated as business products will become ready from M30 on (whenever finishing WP4 and WP5), this KPI cannot be reported at this moment. A reference (and a listed completing the values above) will be provided in D8.3

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

Between M1 and M18, members of the project attended 4 events (2 virtual) which are listed below:

- Participation in "*Ciberseguridad, el reto de la transformación digital en la industria*", 1st December 2021; Jornadas FER. Federación Empresas de La Rioja
- Participation on NextSecure an event organized by S21Sec for Cybersecurity where ASSIST-IoT was disseminated: *NextSecure, the annual cybersecurity event of S21sec, celebrated its XXIII edition focused on Offensive Security*, 9 June 2021 /
- Attendance and participation on the virtual events organised by NGIoT during IoT week Open Call workshop 30 August 2021. *NGIoT Open Calls workshop, IoT Week session*, 30 August 2021
- Attendance to the virtual events organised by NGIoT during May 2021. *Next-Generation IoT and Edge Computing Strategy Forum*. Thursday, April 22, 2021

Between M18 and M28 (current month) partner S21SEC attended 2 events which are listed below:

- BIEMH (*Bienal Internacional de Máquina-Herramienta)* 2022. 13 Jun 2022 - 17 Jun 2022
- *Barcelona Cybersecurity Congress* @BcnCyberCon an @IOTSWC #BCC23

For the months M28 to M26 it is planned to attend 2 events which are listed below:

- IDC Cybersecurity Forum 21-22 February, 2023
- RootedCON 2023, 9th to 11th March 2023

Therefore, KPI target for M18 has been widely achieved and final value is expected to be met by 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**.

This KPI represents how extrovert is the ASSIST-IoT project. In order to better understand the progress and the success of the communication process the following table summarises this type of communication and community building activities during M1-M25 period.

Table 13: Community activities organized

Organized activities	4
Co-Organized activities	7
Total	**11**
Attended Events by ASSIST-IoT partners	62

As it can be clearly seen during the editing time of D8.2 this KPI has already reached a high value of actions and has no deviations or risks spotted.

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.

This KPI represents the success of the actions in task T9.1. It has been closely monotored during this period by periodically checking the number of visitors/followers/subscribers to the different channels and social media accounts of ASSIST-IoT. Standard tools are being used (those proportionated by the channels themselves: e.g., historic info of the profile) alongside other means like Google Analytics (GA4 – compliant with European legislation and data privacy). In the case of this particular measure established in D8.1, number of subscribers is tackled. For doing so, the following table is reported:

Table 14: Subscribers to ASSIST-IoT channels

Website	Visitors 5,879 (unique) Views 7,700
Facebook	Followers: 120 Posts: 266
Twitter	Followers: 286 Posts: 329
LinkedIn	Followers: 614 Posts: 284
Instagram	Followers: 149 Posts: 250
YouTube	37 Subscribers
Total Visitors/Followers/Subscribers	**5,879 + 1,169 = 7,048**

At this point of the project (M25) it can be considered that the target KPI has been already met, which is a huge achievement. In the next version of this deliverable (D8.3), these values will be updated to inform on the increase on those figures during the last year of the project.

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.

This is a very important KPI as it evaluates how active and up to date the website is maintained. Furthermore, the articles KPI is measuring the openness of the project to external stakeholders and how active are the partners of the consortium in online communication/public media. The following table gives insights on these aspects of the KPI, since the project initiation and up to M25 (November 2022).

Table 15: Online communications

News/Articles/Posts	Total
News Posts at the website	132
Online Articles	14
Social Media Posts	LinkedIn: 284 Twitter: 329 Facebook: 266 Instagram: 250
Total News/Articles/Posts	**1,275**

Currently, the set target has been met by far. However, as the project evolves in the technical aspects more and more content will be communicated through these channels.

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**.

This metric determines the visibility of the project and how impactful is. It is very important metric because it shows how visible the project is to the broadest possible audience. Higher visibility means higher impact which is the main goal of the communication actions of the T7.1. To better perceive the process, we summarise in the following metrics for the M1 -M25 period, that this specific KPI is consisted of.

Table 16: Online traffic attracted

Website unique visitors	5,879
Social media posts reach/engagement/views	178,604
Total online traffic attracted	**184,483**

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 and their events** have been recorded.

External IoT communities is the most appropriate mean to diffuse the knowledge of the project to relevant organisations and targeted audience. Liaison and interaction (through events participation) with IoT related communities is an additional way to promote and communicate project results. The following table briefly elaborates on relevant IoT communities and related activities for the M1 - M25 period.

Table 17: Participation in external IoT communities

Organisation/Community/Association	Participations/Interactions in events
NGIoT/EU-IoT	59
SDOs	8
Total Participations/Interactions/Involvement	**67**

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**.

This specific KPIs describes the involvement of ASSIST-IoT project with other related projects and organizations. ASSIST-IoT project is an active member of the NGIoT community. The Next Generation Internet of Things (NGIoT) initiative is a growing community of projects and related initiatives at work to maximise the power/impact of IoT in Europe. A tentative list that helps us to monitor the progress of this KPI is the following one:

- NGIoT
- ICT-56 projects (IntellIoT, VEDLIoT, TERMINET, IoT-NGIN, Ingenious)
- SDOs (AIOTI, BDVA, ITU-T, IEEE SA, ETSI – 4, ENISA/ESCO, TIC4.0)
- SW FORUM
- ETSI-IoT
- IoT Tribe
- BRAINE project

As it can be easily seen ASSIST-IoT project currently has more than **17 IoT related contacts** with IoT related associations and projects. ASSIST-IoT project has co-organised several activities with these associations such as webinars, workshops, participation in common activities for making presentations, social media promoting and resharing material and extensive utilisation of mailing lists and contacts.

Concerning only the NGIoT association and rest ICT-56 projects, we have jointly performed/participated/attended in more than **50 activities (webinars, workshops, presentations, publications)** and concerning the rest associations we have recorded more than **15 activities**.

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) and mailing lists. Fulfilment of this KPI is considered when **at least 20 interactions and involvement of ASSIST-IoT in external communities** have been recorded.

ASSIST-IoT project is currently connected with various other associations (through its partners participation), beyond the IoT, that helps us to target a biggest audience and create impact. Some of these associations are on the field of 5G and 6G, Big DATA, or other H2020/HE projects. The following list summarizes the progress made in this specific KPI (joining and interacting with external communities other than the IoT ones) for the M1-M25 period:

- 5G-PPP
- SNS
- 6G-IA
- ALICE STP
- BDVA
- NetworldEurope
- SME Working Group
- EVOLVED-5G project
- DataPorts project
- BDV Data week
- HORIZON CLOUD
- WorkingOnSafety.net
- 5G-PPP, 6G-IA and 5G-PPP COMMS mailing lists

This interaction includes participation in **events (8), online articles (2), social media interactions (>20) and utilizing of mailing lists (>15 times)**

KPI.3.3.8 Professionals engaged for impact

This KPI refers to the tentative (and potential achievement) of ASSIST-IoT to attract professionals to enhance impact (attended events, social media interactions). Fulfilment of this KPI is considered when **at least 2000 professionals have been engaged with ASSIST-IoT either through online/live events as attendees or through social media (being followers or engaged with ASSIST-IoT posts).**

As we have seen in previous KPI descriptions ASSIST-IoT project has participated in more than 60 scientific events and has organised/co-organised more than 10 activities. In this context, we make an estimate that an average audience of 75 attendees have been addressed per activity out of which the 25% of the attendees are considered as professionals in various fields. By making this estimation we have acquired more than 1300 professionals so far (**70 events x 75 attendees x 25% professionals= 1300 professionals approx**.).

In parallel, in the most professional social media channel, the Linkedin, ASSIST-IoT has more than 600 followers which have interacted with our posts (likes/shares) more than 3800 times. If again we assume that at least 35% of these followers are professionals, then we have at least 200 more professional interacting with ASSIST-IoT for impact creation (**610+ LinkedIn followers x 40% professionals = 250 unique professionals approx**.).

As it can be easily understood the target of 2000 professionals is close to be met (**currently an estimate of 1300+250=1550 professionals at least engaged by M25**) and it is matter of time to reach and surpass this goal. In D8.3 we will have the final estimate of the professionals engaged.

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 involvements with open source developers, events/ hackathons participants etc. have been recorded**.

In this specific KPI we will present how attractive ASSIST-IoT project to external stakeholders is. In the context of the project several activities have been taken place such as hackathons, workshops and webinars.

In total we have participated (mainly with presentations) in more than 12 events related to hackathons, open source, workshops, webinar and SDOs events. Perceiving an average of 50 attendees per event we can estimate that at least 15% of them are developers, open source developers and hackathons participants. By making this estimation we have involved **more than 90 professionals approximately so far** (**12 events x 50 attendees x 15% professionals= 90 professionals approx**.). This number is much higher if we actually consider all the external professions interacting with ASSIST-IoT through the two ASSIST-IoT Open Calls (15 projects).

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.

The observance of the regulations is pertinent to this document and is essential for designing and deploying the solutions in pilot sites. During the process of developing and integrating ASSIST-IoT, the key performance indicator (KPI) is defined as the number of legislations (regulations and public policies) from European nations that were taken into account.

Deliverables for WP2 and WP3 include the regulations that are essential for the system. The regulations must stem from 3 countries.

KPI5.1.2 Legalisation assessment

This KPI is relevant to the project, as it is the evaluation for the adherence to legislation by the users and stakeholders. Data and IPR concerns are to be addressed by the KPI measured in the project. The measurement will be contacted by providing users and stakeholders of ASSIST-IoT with two questions. The questions should be simple and straightforward such as:

- Are you confident about the collected data's safety?
- Do you believe that Intellectual Property is effectively managed?

The questionnaire needs to be validated by 100 answers with positive assessment by at least 75%.

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.

The KPI for the project indicates the platform's impact for users and stakeholders' time. Users and stakeholders include both the business and employees who are to benefit from the platform's integration. The feedback for measuring the impact of the KPI will be conducted through an internet survey. The questions should be simple and straightforward to answer as follows:

- Do you believe that the integration of ASSIST-IoT platform will accelerate the processes in a timely manner?
- Are you confident that the integration of ASSIST-IoT platform will impact the financial output?

The questionnaire needs to be validated by 100 answers with positive assessment by at least 75%.

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.

The current KPI is relevant to the project for evaluating the societal impact of the ASSIST-IoT platform, and the innovation has to promote the improvement of humans apart from businesses. The evaluation will be performed by filling out an internet survey with simple and straightforward questions with binary answers in yes/no format. The questions to answer for the KPI are as follows:

- Are you confident in the ASSIST-IoT platform’s ability to improve people's lives?

The questionnaire needs to be validated by 100 answers with positive assessment by at least 75%.

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.

The current KPI is relevant to the project and its output platform. The KPI estimates how these technologies and the subsequent innovation will affect the labour market. The collected data will be based on filling out an online survey.

- Do you believe that ASSIST-IoT can pose a risk to the workforce due to the fact it has the potential to replace human and decrease the job vacancies?

The questionnaire needs to be validated by 100 answers with negative assessment by at least 75%. The negative choice implies that the platform will not replace humans or hurt their employability.

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.

This KPI is pertinent to the project’s goal as it evaluates the degree to which the public’s opinion for the platform’s ability in contributing to social inclusion and have a beneficial influence on general welfare. The KPI will be measured through online survey with straightforward questions answered by binary variables for yes/no. The questions will be as follows:

- Are you confident in the ASSIST-IoT platform’s ability to positively impact any aspects of your life (private or professional)?
- Do you believe that the ASSIST-IoT platform will aid in social inclusion?

The questionnaire needs to be validated by 100 answers with positive assessment by at least 75%.

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.

The current KPI is relevant as it estimates an ethic subject relevant to inclusion for genders. The KPI will gather data estimating the perceptions of ASSIST-IoT users and stakeholders on the solutions’ impact on gender equality. The data will be gathered by conducting an online survey with questions as:

- Do you feel that the platform distinguishes users based on their gender?
- Do you feel that the platform advocates for the rights on a specific category based on its gender?

- Do you feel that the platform's use can lead to advantage on a category of users based on its gender?

The questionnaire needs to be validated by 100 answers with negative assessment by at least 75%. The negative choice implies that the platform will not replace humans or hurt their employability.

KPI.5.5.1 Security and privacy institutions engaged

This KPI is relevant to the project as the project aims to engage the community and raise awareness around security on novel technologies. The goal of ASSIST-IoT is to encourage and include members of the general public in discussions about security and privacy problems. Increasing people's level of security awareness and building a network of connections are two of the most important factors in the expansion of this industry. By the end of the project, at least 20 institutions must be involved per the Grant Agreement. The institutions are external entities to the project that have interacted with ASSIST-IoT.

By the time of reporting this deliverable, a considerable number of security and privacy institutions have been engaged. It is worth remarking that, for now, engagement has been constrained to mutual attendance of events, informal exchange of information, presentations leveraging parallel occasions and arrangement of specific teleconferences to discuss on the content of ASSIST-IoT and the counterside initiative. In terms of running research and/or innovation actions, the projects IDUNN, PRAETORIAN and zero-SWARM are included in the list of engaged entities. Here, it is worth mentioning the participation of S21SEC or UPV in those consortia has facilitated the cooperation(partner of ASSIST-IoT project. On another note, the following partnerships are directly participated by ASSIST-IoT partners or the project has had contacts with members of those: INCIBE, CNPIC, CSIRT, CN-CERT, CNCS, CYBASQUE, CYBER MADRID, CERT and ECSO. Other institutions (mainly Spanish companies with which the Consortium has exchanged a certain amounf of information) are: Ikerlan, Vicomtech, Innovalia Association, Tecnalia, INTRASOFT, Gaia, Mondragon Assembly, Fagor Arrasate, COSYTH, AIMENT.

As it can be seen, the KPI target number is very close to be achieved.

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.

The KPI will be ultimately evaluated at the end of the project. For now, the project has published one journal that is uploaded to the proper documentation repository of the project and in open repositories as committed

- *Title*: "DevSecOps Methodology for NG-IoT Ecosystem Development Lifecycle – ASSIST-IoT perspective"
- *Authors*: Óscar López, Jordi Blasi, Mikel Uriarte, Ignacio Lacalle, Gonzalo Galiana, Carlos E. Palau, Eduardo Garro, Maria Ganzha, Marcin Paprzycki, Piotr Lewandowski, Katarzyna Wasielewska, Konstantinos Votis, Georgios Stavropoulos, Iordanis Papoutsoglou
- *Publisher*: Journal of Computer Science and Cybernetics, 37(3):321-33, September 2021.
- *Open repository*: https://vjs.ac.vn/index.php/jcc/article/view/16245

The KPI seems to be falling short by the measure taken in M25. However, enablers of cybersecurity are now completed and scientific publications will follow, together with other kind of communications. Partners of the project plan to slightly broaden the measurement means and to include not only formal publications but also other kind of less formal dissemination actions related to cybersecurity. An update of this strategy and the outcomes of it will be reported in deliverable D8.3.

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.

This KPI assesses the way users and stakeholders of ASSIST-IoT platform feel about the impact on the inclusion of underrepresented groups. Therefore, the KPI is relevant to the project and its human-centric ethics. The KPI will report data gathered by an online survey with the following questions:

- Do you feel that the platform protects the user's uniqueness?
- Do you feel that the platform respects your personal characteristics?
- Do you feel alienation while using the platform?

The questionnaire needs to be validated by 100 answers with positive assessment by at least 75%.

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.

The relevance of the KPI holds true as it is an indicator of the platform's accessibility to users and third parties. The data will be gathered with an online survey with the question:

- Do you believe that the ASSIST-IoT platform will solely help individuals and organisations affluent with resources?

The questionnaire needs to be validated by 100 answers with negative assessment by at least 75%. The negative choice implies that the platform will not address the needs of wealthy entities.

4 Conclusions

This document has presented a thorough update of all the (five-dimensions structured) KPIs of the project. In this deliverable, technical KPIs have been mainly enhanced in terms of detail, procedures and early evaluation results. Although some measurements have been able to be tackled, the work in WP4, WP5 and WP6 is still on-going and only partial results have been obtained. The results are looking good so far, and now that integration in a common "lab" infrastructure is close to be finalised, data about performance, technical connection between elements and other aspects are closer to be settled.

With regards to pilot evaluation (for what concerns analysing the results of the trials in WP7), the KPIs have been improved in terms of description and measurement means. WP7 is now at an intense stage of devotion (trials being executed right now), thus no results can be measured yet. This deliverable has paved the way to allow a final evaluation of those during the last months of the project (to be documented in D8.3). Remarkably almost all KPIs that were identified in D8.1 have remained valid and are still expected to reach their targeted values.

Finally, process evaluation KPIs are also in pace to be evaluated in D8.3. Some of those (such as dissemination or communication target numbers) are continuously measured, therefore values are depicted in this document. Others (e.g., formal letters of support) are still being tackled under the works of WP8, thus only an update of more precise measurement means specification is provided.

All in all, the document meets the goal of establishing an intermediate control point of the advance on KPIs evaluation and the most substantial part of such assessment will be conducted and reported during the next months of the project.

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 1 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.4.7.5	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