RAINBOW

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Acronyms

Term	Explanation
C-V2X	Cellular Vehicle to Everything
CLI	Command Line Interface
CPA	Collision Prediction and Avoidance
CRUD	Create, Read, Update and Delete
DoA	Description of Action
FPS	Frames per Second
GCS	Ground Control Station
GUI	Graphical User Interface
IoT	Internet of things
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
IT	Information Technology
KPI	Key performance indicator
OPC UA	OPC Unified Architecture (OPC UA)
OPEX	Operational Expenditure
PLMC	Personnel Localization Motion Capturing
RMT	Robot Motion Tracking
SLO	Service Level Objective
SME	Small-Medium enterprise
UI	User Interface

Executive Summary

This deliverable serves as the final report on the evaluation of the RAINBOW platform, based on the final stages of the operation of the platform at the premises of the three demonstrators and the test scenarios performed there. It is In the months between the advanced release of the RAINBOW platform and the end of the project, as this is the proper timeslot where the RAINBOW platform had achieved sufficient maturity and had the required operational capacity, while the demonstrators had enough time to perform necessary testing activities which have been described as "final scenarios" and are documented in deliverables D6.3 "Human-Robot Collaboration Demonstrator – Final Release", D6.5 "Digital Transformation of Urban Mobility Demonstrator - Final Release", and D6.7"Power Line Surveillance Demonstrator - Final Release".

As is discussed in the document at hand, in the current advanced release of the RAINBOW platform, demonstrators have been able to deploy the RAINBOW platform at their premises without the help of technical counterparts and start executing the designed test cases. Thus, they have been able to measure certain metrics that relate to the anticipated impact as foreseen in the earlier deliverables of WP6 and the final results can be classified as positive for the benefits that the platform offers to the use cases selected by the project.

Continuing, the present deliverable documents the lessons learnt from the use cases, as well as some adoption guidelines, formulated with the ultimate goal of supporting wider adoption of the RAINBOW platform. Furthermore, this deliverable compares the current state of the RAINBOW platform with the previous one, so as to quantify and assess the improvements achieved between the two iteration cycles.

The adoption guidelines stem from the lessons learnt and provide further insight into the expectations of the industrial landscape. A significant amount of work of notable importance and exceptional quality has been done by the technical partners in the context of the RAINBOW platform. The developed platform is currently capable of supporting service graph descriptions and deployment, usage of highly heterogeneous devices as nodes of the same network, runtime monitoring, historic metric storage, streaming analytics and even service-level objective (SLO)-enabled runtime QoS assessment and the elicitation of custom app-level metrics. Lastly, this deliverable provides constructive feedback for additional future developments of the RAINBOW platform.

This deliverable is structured in a low-to-high abstraction manner: after an introduction to the deliverable, D6.9 engages in a high-level overview of the evaluation framework established in D6.1 "Evaluation Framework and Demonstrators Planning". Continuing, this deliverable outputs data regarding the validation of the RAINBOW platform, both at a technical and a business level. Next, the deliverable demonstrates the relationship between the various demonstrator-specific KPIs, the elicited business KPIs described in D6.1 and the RAINBOW impact KPIs, as documented in the project's DoA [5]. Lastly, the deliverable extracts valuable information regarding the experience of the demonstrators

with the currently available RAINBOW platform, formulating lessons learnt and various adoption guidelines for the wider applicability of the developed platform.

1 Introduction

This section provides the scope in which is the deliverable being developed along with its objectives and its relation to other tasks and deliverables of the RAINBOW project. This section also provides a "bird's eye" view of the rest of the deliverable's structure.

1.1 Scope and Objectives of the Deliverable

The purpose of this document is to provide a report on the final results of the RAINBOW demonstrators and to conduct an interim evaluation of the platform (in both technical and business perspectives), towards identifying weak and strong points of both the platform itself and the usage conducted by the demonstrators. In this context, the deliverable at hand follows the guidelines and procedures that have been devised in D6.1 - Evaluation Framework and Demonstrators Planning and aims to apply the evaluation methodology to the current release of the RAINBOW platform and to the final stages of the demonstrators. It needs to be noted that this deliverable has been compiled with the goal to provide to the consortium a holistic view on the developments of WP6 that will help the further development of the platform, the optimisation of various points and the refinement of the value proposition which can come out of the demonstrators achieving their KPIs and business impact. Lastly, a direct objective of this deliverable is to output lessons learnt from the three RAINBOW demonstrators (documented in Subsections 5.1, 5.2 and 5.3 with the ultimate goal of establishing adoption guidelines (documented in Subsection 5.4) for the wider applicability and usability of the RAINBOW platform targeting a greater industrial/research audience.

1.2 Relationship with other RAINBOW WPs, Tasks and Deliverables

This deliverable is directly linked with all other deliverables of WP6, which will document the demonstrators' implementation and platform evaluation results. Moreover, D6.9 also links the feedback collected from the demonstrators with the rest of the implementation WPs, based on the evaluation that will be performed in WP6. Figure 1 illustrates the relationship of the deliverable at hand to various tasks from WP1, namely Task 1.3 and the corresponding deliverable, and WP6, namely Tasks 6.1, 6.2, 6.3 and 6.4 and the three corresponding final-stage demonstrator deliverables: D6.3 "Human-Robot Collaboration Demonstrator - Final Release" [1], D6.5 "Digital Transformation of Urban Mobility Demonstrator - Final Release" [2], and D6.7 "Power Line Surveillance Demonstrator - Final Release" [3].

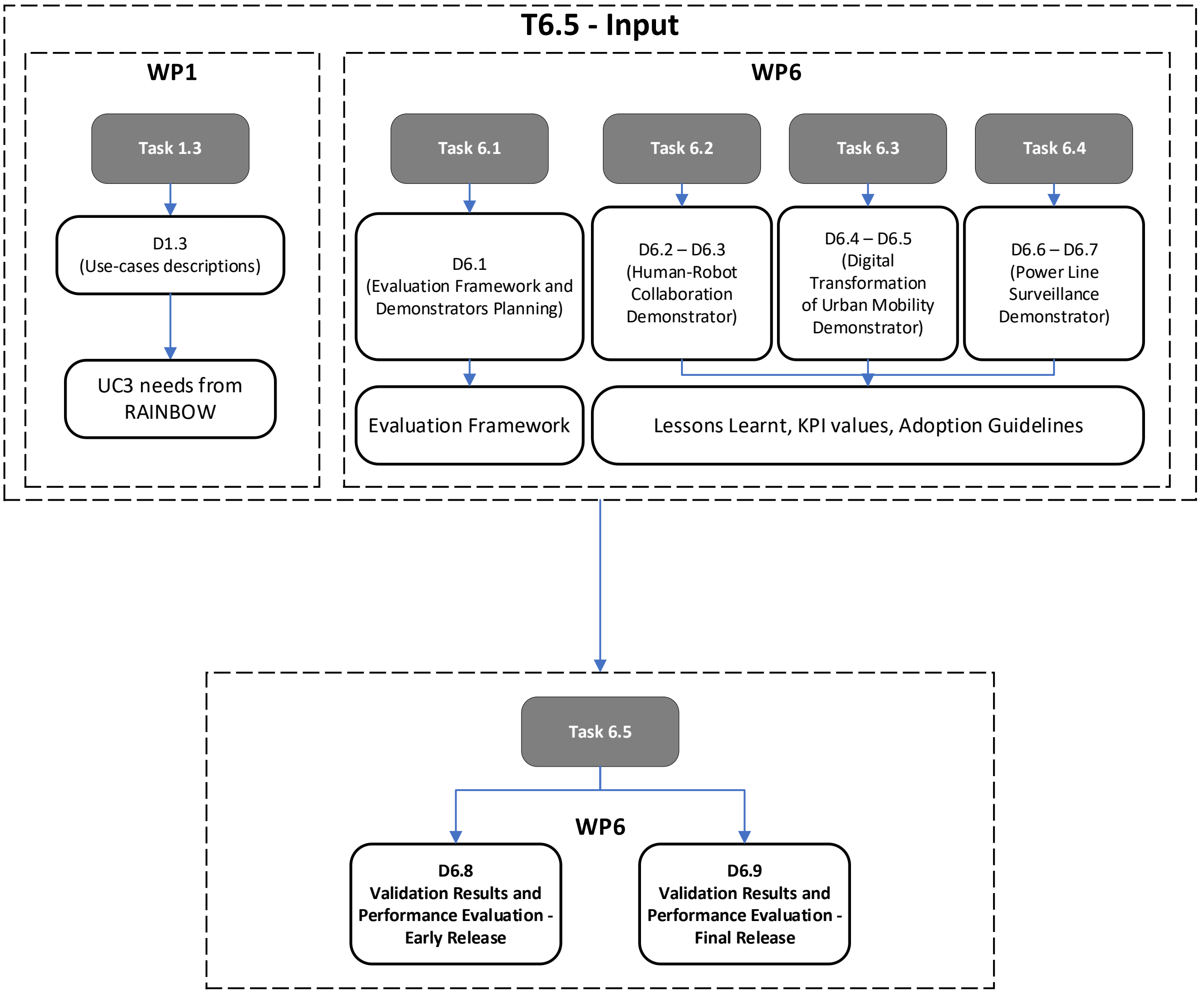

Figure 1: Inputs and outputs of this deliverable

1.3 Structure of the Deliverable

The deliverable is structured as follows:

- Section 1 "Introduction" is responsible for establishing a clear understanding of the objectives of this deliverable and the relationship it has to other RAINBOW WPs, Tasks, and Deliverables.
- Section 2 "The RAINBOW Evaluation Framework Overview" provides a short overview of the RAINBOW evaluation framework as already defined in D6.1 "Evaluation Framework and Demonstrators Planning" [4].
- Section 3 "RAINBOW Validation" serves as the main body of the deliverable, documenting the RAINBOW demonstrators' KPI measurements.
- Section 4 "RAINBOW Impact" constitutes an endeavour to map the corresponding use cases to the impacted RAINBOW components, whilst also mapping the Impact KPIs from the RAINBOW DoA [5] to the demonstrators' evaluation metrics.

- Section 5 "Lessons Learnt and Adoption Guidelines" builds on the outputs of the previous version of this deliverable and further analyses obtained values of KPIs and data obtained from the hands-on experience of the three demonstrators with the second and final release of the RAINBOW platform. The three use cases provide detailed feedback related to the available services and capabilities, their experience on what can be improved and their views on what can be considered novel in the context of each demonstrator.

2 The RAINBOW Evaluation Framework Overview

This section is dedicated to the analysis of the methodology used for the elicitation of evaluation results, along with the technicalities regarding the provision of feedback on RAINBOW's functionality. The evaluation framework will help the project to demonstrate and evaluate the benefits generated for fog and edge devices by using the RAINBOW methodology. The overall Evaluation Framework, which is briefly discussed in this section has been developed to evaluate RAINBOW from at least two different perspectives:

1. The success of the platform is directly linked to the demonstrators. Taking such a demonstrator-specific perspective in the evaluation will assure that the expectations and requirements of the demonstrator-specific stakeholders are met. This is assured by modelling different scenarios within the demonstrators and involving the related stakeholders within evaluation in each demonstrator.
2. A more generalised perspective, which will assure that expectations and requirements of non-demonstrator-specific stakeholders are evenly met, too.

The following sub-sections present the evaluation approach and the framework that will be implemented and executed during the activities of WP6. The technical verification of the RAINBOW platform is performed in the technical development work packages, while the business evaluation and demonstrator-specific testing are implemented in the context of Task 6.5, which is also outputting the deliverable at hand. The second validation and verification of the platform are implemented in a two-step manner and begins in M26 of the project (February 2022), right after the finalisation of the first round of validation. The second iteration of the RAINBOW platform is finalised in M27 (March 2022) and documented in the present deliverable with the evaluation of the final-stage demonstrators. Continuing, the developments proceed and are documented in M36 (December 2022) in D6.9. Figure 2 demonstrates the overall flow of the RAINBOW evaluation through the early and advanced development and demonstrator stages.

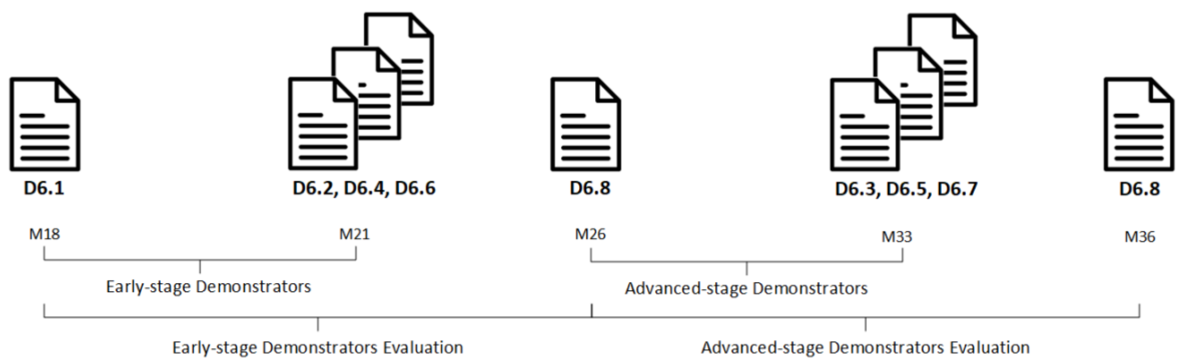

Figure 2: RAINBOW Evaluation timeline

The technical evaluation of RAINBOW also considers ISO 25010:2011 "Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - System and software quality models", as it encompasses a set of models that better address the evaluation of the software quality. As mentioned in D6.1, various perspectives are considered in this standard, namely (1) **Functional Suitability** (i.e., the degree to which the product provides functions that meet stated and implied needs when the product is used under specified conditions), (2) **Performance Efficiency** (i.e., the performance relative to the number of resources used under stated conditions), (3) **Compatibility** (i.e., the degree to which two or more systems or components can exchange information and/or perform their required functions while sharing the same hardware or software environment, (4) **Operability** (i.e., the degree to which the product has attributes that enable it to be understood, learned, used and attractive to the user, when used under specified conditions), (5) **Reliability** (i.e., the degree to which a system or component performs specified functions under specified conditions for a specified period), (6) **Security** (i.e., the degree of protection of information and data so that unauthorised persons or systems cannot read or modify them, and authorised persons or systems are not denied access to them), (7) **Maintainability** (i.e., the degree of effectiveness and efficiency with which the product can be modified, and lastly (8) **Portability** (i.e., the degree to which a system or component can be effectively and efficiently transferred from one hardware, software or other operational or usage environment to another).

Similarly, as mentioned the business evaluation of RAINBOW considers ISO 25010:2011 "Quality in Use" which considers the user's point of view to measure the perception of the quality of the system. This model considers (1) **Effectiveness** (i.e., the accuracy and completeness with which users achieve specified goals), (2) **Efficiency** (i.e., the resources expended concerning the accuracy and completeness with which users achieve goals), (3) **Satisfaction** (i.e., the degree to which users are satisfied with the experience of using a product in a specified context of use), (4) **Safety** (i.e., the degree to which a product or system mitigates the potential risk to economic status, human life, health, or the environment), and lastly (5) **Context coverage** (i.e., the degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in both specified contexts of use and contexts beyond those initially explicitly identified).

3 RAINBOW Validation

This section provides an overview of the technical and business validation of the RAINBOW platform, based on the metrics which have been selected in deliverable D6.1 [4] to showcase the smooth operation of the platform and its performance.

As it becomes obvious from Table 1, Table 2 and Table 3, the majority of the metrics which guarantee the technical excellence of the platform are already meeting the targets set, even though there is still much development effort left to release the full feature of the platform. It is important to maintain an understanding of the subsequent interconnections of the various RAINBOW use cases, and the corresponding components, as their outputs in terms of lessons learnt and adoption guidelines will be pivotal in optimising future developments of each component. With that in mind, we deduce that the technical success of the demonstrators is of utmost importance for the effective validation of the various RAINBOW components. Overall, the RAINBOW use cases have successfully demonstrated the platform's capacity in this wide spectrum of industrial applicability.

3.1 Technical Validation and Platform KPIs

This subsection is dedicated to the evaluation of RAINBOW 's technical KPIs and its overall performance on a low (i.e., networking and computing) level. The technical validation is demonstrator-specific. As such, a subsection is dedicated to each use case respective technical validation. The RAINBOW consortium has successfully identified a set of performance-indicating evaluation metrics.

3.1.1 RAINBOW Technical Evaluation in Human-Robot Collaboration in Industrial Ecosystems

The Human-Robot Collaboration in Industrial Ecosystems use case is focused on low-latency and physical personnel safety for optimal human-robot cooperation.

During the early release of the RAINBOW platform, some technical metrics (e.g., BIBA-KPI-01) were not possible to measure, as such measurements would be only achieved with a fully functional RAINBOW platform. Given the increased project maturity, the demonstrator is now capable of testing this metric, after testing the scalability of the application prior to the measurement of this metric.

Regarding the second technical metric of this use case, "BIBA-KPI-02", at the start of the project this KPI was included for the use case, but after discussion with technical partners, the demonstrator considers that it seems like the RAINBOW platform will not provide such features. Considering this, the second technical metric of this use case is no longer relevant to the RAINBOW project.

Regarding BIBA-KPI-01, the robots successfully stopped after latency metric is mocked to be over 500ms using an OPC Unified Architecture (OPC UA) SLO controller. Other metrics also provided the necessary OPC UA message after they are mocked (tests were performed on a local OPC UA server). While the KPI was met, during tests, it was observed that the delay for stopping, while measurable, can be reduced by modifying the SLO accordingly (such as reducing the average time) and modifying the analytics engine internal timings. This hints that RAINBOW can potentially further reduce system latency and increase responsiveness, by setting the respective objective accordingly.

For BIBA-KPI-03 through BIBA-KPI-08, it was observed that the SLO configuration yaml file was required to be manually updated using a command line interface. RAINBOW offers no support in its editor to upload SLO configuration yaml file.

In terms of conducting the necessary tests for BIBA-KPI-09, the application specific Metric collection is classified as “Passed”, while however application-specific metric visualization was failed . More specifically, the RAINBOW dashboard is not showing any of the graphs as of yet. This has minimal impact in the project and its overall capacity to accommodate the use case at hand, but is considered worth mentioning. The application specific parameters are monitored by the RAINBOW Monitoring internal logs, but a user of RAINBOW can't see any such logs on the dashboard.

Regarding BIBA-KPI-10 registering, user name and password credential evaluation was considered successful (pass). Nevertheless, data visualization on editor is deemed as failed, as the dashboard is not showing any of the graphs yet, as mentioned above.

BIBA-KPI-11 provides positive feedback as to how RAINBOW provides secure mesh overlay network out of the box, as no security incidents were reported. BIBA-KPI-12 showed that the collected metrics at the worker nodes were successfully sent to the master; this was tested using the web interface of the RAINBOW-storage through the data-transferring tool curl. Finally, BIBA-KPI-13 validated that a user can create limited queries through the analytics editor of the Dashboard, however queries for custom metrics cannot be created.

Table 1: RAINBOW technical achievements applicable to Demonstrator #1

KPI ID	KPI Title	Baseline Value	Value after RAINBOW		
			Expected	Obtained (Early stage)	Obtained (Final stage)
BIBA-KPI-01	Deterministic System Latency for collision prediction and avoidance	System Latency is not deterministic with in the tolerance of Metric#1 > 500ms OR Metric#2 > 200ms OR Metric#3 > 10% Additional information *Metric#1: Network Latency between Fog Device and Gateway* *Metric#2: Network Jitter between Fog Device and Gateway* *Metric#3: Packet Loss Percentage*	Condition check#1 Stop Robot when If Metric#1 > 500ms OR Metric#2 > 200ms OR Metric#3 > 10% Result Condition check#1 need to be meet for the test. Type: Pass/Fail Additional information *Metric#1: Network Latency between Fog Device and Gateway* *Metric#2: Network Jitter between Fog Device and Gateway* *Metric#3: Packet Loss Percentage between Fog Device and Gateway*	N/A	Pass

KPI ID	KPI Title	Baseline Value	Value after RAINBOW Expected	Obtained (Early stage)	Obtained (Final stage)
		between Fog Device and Gateway			
BIBA-KPI-03	Horizontal scale-out of PLMC services	Not supported.	<u>Condition check#1</u> Maintain at least one instance of PLMC at any given time instance <u>Condition check#2</u> PLMC Service scales out horizontally If (Metric#1 > Metric#2) for 10 seconds AND Metric#3 is greater than 60% <u>Result</u> Condition check #1 **AND** Condition check #2 need to be meet for the test. Type: Pass/Fail <u>Additional information</u> *Metric#1: Message publish rate in RabbitMQ Queue Name: "generator_*	Pass	Pass

KPI ID	KPI Title	Baseline Value	Expected	Value after RAINBOW Obtained (Early stage)	Obtained (Final stage)
			personnel_rk" *Metric#2: Message delivery rate in RabbitMQ Queue Name: "generator_ personnel_rk"* *Metric#3: CPU Utilization*		
BIBA-KPI-04	Horizontal scale-in of PLMC services	Not supported.	<u>Condition check#1</u> Maintain at least one instance of PLMC at any given time instance <u>Conditional check#2</u> PLMC Service scales-in If (Metric#1 < Metric#2) for 10 seconds AND Count (PLMC instance) > 1. <u>Result</u> Condition check #1 **AND** Condition check #2 need to be meet for the test. Type: Pass/Fail	Pass	Pass

KPI ID	KPI Title	Baseline Value	Expected	Value after RAINBOW Obtained (Early stage)	Obtained (Final stage)
			<u>Additional information</u> *Metric#1: Message publish rate in RabbitMQ Queue Name: "generator_ personnel_rk"* *Metric#2: Message delivery rate in RabbitMQ Queue Name: "generator_ personnel_rk"* *Metric#3: CPU Utilization*		

BIBA-KPI-05	Horizontal scale-out of CPA services	Not supported.	<u>Condition check#1</u>
			Maintain at least one instance of CPA at any given time instance
			
			<u>Conditional check#2</u>
			If (Metric#1 > Metric#2) for 10 seconds
			OR
			If (Metric#3 > Metric#4) for 10 seconds
			AND
				Pass	Pass

KPI ID	KPI Title	Baseline Value	Value after RAINBOW Expected	Obtained (Early stage)	Obtained (Final stage)
			Metric#5 greater than 60% <u>Result</u> Condition check #1 **AND** Condition check #2 need to be meet for the test. Type: Pass/Fail <u>Additional information</u> *Metric#1: Message publish rate in RabbitMQ Queue Name: "rmt_robot_rk"* *Metric#2: Message delivery rate in RabbitMQ Queue Name: "rmt_robot_rk"* *Metric#3: Message publish rate in RabbitMQ Queue Name: "plm_walker_rk"*		

KPI ID	KPI Title	Baseline Value	Expected	Value after RAINBOW Obtained (Early stage)	Obtained (Final stage)
			Metric#4: Message delivery rate in RabbitMQ Queue Name: "plm_walker_rk" *Metric#5: CPU Utilization*		

BIBA-KPI-06	Horizontal scale-in of CPA services	Not supported.	<u>Condition check#1</u>
			Maintain at least one instance of CPA at any given time instance
			
			<u>Conditional check#2</u>
			If (Metric#1 < Metric#2) for 10 seconds
			OR
			If (Metric#3 < Metric#4) for 10 seconds
			AND
			Count (CPA instance) > 1.
			
			<u>Result</u>
			Condition check #1 **AND** Condition check #2 need to be meet for the test.
			
			Type: Pass/Fail
				Pass	Pass

KPI ID	KPI Title	Baseline Value	Expected	Value after RAINBOW Obtained (Early stage)	Obtained (Final stage)
			Additional information *Metric#1: Message publish rate in RabbitMQ Queue Name: "rmt_robot_rk"* *Metric#2: Message delivery rate in RabbitMQ Queue Name: "rmt_robot_rk"* *Metric#3: Message publish rate in RabbitMQ Queue Name: "plm_walker_rk"* *Metric#4: Message delivery rate in RabbitMQ Queue Name: "plm_walker_rk"* *Metric#5: CPU Utilization*		
BIBA-KPI-07	Horizontal scale-out of RMT services	Not supported.	Condition check#1 Maintain at least one instance of RMT at any given time instance Condition check#2	Pass	Pass

KPI ID	KPI Title	Baseline Value	Expected	Value after RAINBOW Obtained (Early stage)	Obtained (Final stage)
			RMT Service scales out horizontally If (Metric#1 > Metric#2) for 10 seconds AND Metric#3 is greater than 60% <u>Result</u> Condition check #1 **AND** Condition check #2 need to be meet for the test. Type: Pass/Fail <u>Additional information</u> *Metric#1: Message publish rate in RabbitMQ Queue Name: "generator_ robot_rk"* *Metric#2: Message delivery rate in RabbitMQ Queue Name: "generator_ robot_rk"*		

KPI ID	KPI Title	Baseline Value	Value after RAINBOW Expected	Obtained (Early stage)	Obtained (Final stage)
			Metric#3: CPU Utilization		
BIBA-KPI-08	Horizontal scale-in of RMT services	Not supported.	<u>Condition check#1</u> Maintain at least one instance of RMT at any given time instance <u>Conditional check#2</u> RMT Service scales-in If (Metric#1 < Metric#2) for 10 seconds AND Count (RMT instance) > 1. <u>Result</u> Condition check #1 **AND** Condition check #2 need to be meet for the test. Type: Pass/Fail <u>Additional information</u> *Metric#1: Message publish rate in RabbitMQ Queue Name: "generator_ robot_rk"*	Pass	Pass (conditional, see above for explanation)

KPI ID	KPI Title	Baseline Value	Value after RAINBOW Expected	Obtained (Early stage)	Obtained (Final stage)
			Metric#2: Message delivery rate in RabbitMQ Queue Name: "generator_ robot_rk" *Metric#3: CPU Utilization*		
BIBA-KPI-09	Monitoring and evaluation of SLOs.	Not supported	<u>Condition check #1</u> Application specific metrics like message publish rates on RabbitMQ queues, memory statistics of RedisDatabase etc must be monitored <u>Condition check #2</u> Rainbow specific metrics like CPU, memory usage etc must be monitored Result: Condition check #1 and Condition check #2 must be supported Type: Pass/Fail	Pass	Pass (conditional, see above for explanation)

KPI ID	KPI Title	Baseline Value	Value after RAINBOW Expected	Obtained (Early stage)	Obtained (Final stage)
BIBA-KPI-10	Data sharing	Not supported	Condition check#1 Only Users registered using valid credentials and access permission are allowed to access data and other RAINBOW platform specific features Result: Condition check #1 and Condition check #2 must be supported Type: Pass/Fail	Pass	Pass
BIBA-KPI-11	Security and Attestation	Not supported	Condition check#1 On-boarding of new fog device must adhere to attestation policies set by the service operator. Result: Condition check #1 and must be supported Type: Pass/Fail	N/A	Pass

KPI ID	KPI Title	Baseline Value	Value after RAINBOW Expected	Obtained (Early stage)	Obtained (Final stage)
BIBA-KPI-12	Data Synchronization	Not supported	Condition check#1 Periodically Synchronize data from all distributed databases present in each of the Fog with Central database Result: Condition check #1 and must be supported Type: Pass/Fail	N/A	Pass
BIBA-KPI-13	Analytical query	Not supported	Condition check#1 Support CRUD operations for database using Analytical editor of RAINBOW platform to fetch data from Distributed database across Fog device mesh network. Result: Condition check #1 and must be supported Type: Pass/Fail	N/A	Pass (conditional, see above for explanation)

3.1.2 RAINBOW Technical Evaluation in Digital Transformation of Urban Mobility

The Digital Transformation of Urban Mobility use case is focused on low-latency and overall system reliability and trust-enabling at the node level. For the early release of the RAINBOW platform, only the first two metrics (AHED-KPI-01 and AHED-KPI-02) were measured and the other metrics were deemed measurable in the final release of the Validation, Performance Evaluation & Adoption Guidelines deliverable.

Thus, the corresponding values have been successfully measured and the outputs indeed demonstrate a tangible improvement in terms of handling high-responsiveness communications. Moreover, regarding the second technical KPI of this use case, the consortium was now capable of reproducing a scenario in which the network latency was under control since the underlying RAINBOW components are now able to control the connection between the edge node and fog node. Concluding, the technical partners manage to not only measure all defined KPIs but also demonstrate measurable improvements in the two previously measured metrics (AHED-KPI-01, AHED-KPI-02).

Regarding AHED-KPI-1, the average fog node execution power consumption was computed to be approximately 30W. Correspondingly, edge node execution average power consumption was calculated at approximately 5W. Average power consumption was less than 10W, which is not only in line with the expectations but significantly exceeds them.

Continuing, AHED-KPI-02 and AHED-KPI-04 were computed in a binary manner (pass/fail), since the nature of those technical metrics was reliant on a pass/fail mechanism. Measuring the service orchestration bandwidth occupancy, RAINBOW achieved to keep the fps value between 10 and 30, as expected – it is important to note that initially, this value was not guaranteed. Lastly, AHED-KPI-03 demonstrates that RAINBOW managed to keep alerts delivery latency at 300ms, calculating it between an edge note and a vehicle.

Table 2: RAI0NBOW technical achievements applicable to Demonstrator #2

KPI ID	KPI Title	Baseline Value	Value after RAINBOW		
			Expected	Obtained (Early stage)	Obtained (Final stage)
AHED-KPI-01	AHED service orchestration power consumption	Average power consumption: ~30W	Average power consumption: 15W (Estimation) Average power consumption: <30W (Expected)	Pass	Fog node execution average power consumption: ~30W Edge node execution average power consumption: ~5W Average power consumption (proportionally to the running time) < 10W
AHED-KPI-02	AHED service orchestration bandwidth occupancy	fps not under control 0 < fps < 30	fps under control 10 < fps < 30	Pass	Pass
AHED-KPI-03	AHED C-V2X Alerts delivery latency	300 milliseconds between the RSU and the vehicle	Less or equal to 300 ms	N/A	From Edge node: ~300ms
AHED-KPI-04	AHED Number of C-V2X Events managed	V2X exchange messages broadcasted at a frequency between 1 and 10 Hz.	Less or equal to 10 Hz	N/A	Pass

3.1.3 RAINBOW Technical Evaluation in Power Line Surveillance via Swarm of Drones

The Power Line Surveillance via Swarm of Drones use case is focused on automatic deployment, trust-enabling at the node level and extending current system capabilities at a technical level. Already while using the early release of the RAINBOW platform, all metrics except that of MSP-KPI-04 "Reduction of overlaps between individual flight routes" were measured. The aforementioned metric was reliant on the Mission Guidance service (which is documented in detail since the early-stage demonstrator description in D6.6 [3]). As this service is the main component responsible for generating tasks (mission plans) for particular drones, the respective KPI was impossible to measure (since the reduction in overlaps could not be quantified). This issue has been successfully resolved in the current version and the corresponding functionalities have been properly implemented.

Regarding the values obtained in the final stage demonstrator, we observe a tangible increase in performance in nearly all cases. Firstly, for MSP-KPI-01, the time to pass the control over the drone from one GCS to another GCS was 3s, as was the case during the first version of RAINBOW; this is due to the fact that the component responsible for such handovers was already fully developed and successfully deployed from the first stage; RAINBOW helps by providing the network fabric through which cross-node optimisations are made. Continuing, MSP-KPI-02 demonstrates an increase in productive flight time to 100%, compared to 74.7% which was obtained in the first stage. Overall improvement in the from the early release to the advanced RAINBOW release is thus 25.3%, effectively doubling the expected value (50%). MSP-KPI-03 "Reduction of data acquisition time per kilometre of power line" was now measured to be 61.2%, compared to 28.2% in the early release. The expected value for this metric was 50%, and consequently highlights the technical partners' and RAINBOW's overachievement in this regard; this was achieved through allowing a group of services to share data to automatically plan drone operations. MSP-KPI-04 quantifies the Reduction of overlaps between individual flight routes; RAINBOW achieved a reduction of 83.33% on average, surpassing the expected value of a 75% reduction. Lastly, a significant feat achieved in this use case is demonstrated by MSP-KPI-05 "Efficiency of battery usage for a productive phase of the drone flight"; in this case, the value obtained in the final release was 167.2%, significantly improving the previous value of 74.5%. This is achieved thanks to RAINBOW allowing GCS nodes to implement the drone handover in an individual fashion over unreliable network links, which allows for shorter returns paths - drones can now land at the nearest GCS node.

Table 3: RAINBOW technical achievements applicable to Demonstrator #3

KPI ID	KPI Title	Baseline Value	Value after RAINBOW Expected:	Obtained (Early stage)	Obtained (Final stage)
MSP-KPI-01	Time to pass the control over the drone from one GCS to another GCS	Not supported.	4 sec	3 sec	3 sec
MSP-KPI-02	Increase of productive flight distance per drone	0%	50%	74,7 %	100%
MSP-KPI-03	Reduction of data acquisition time per kilometre of power line.	0%	50%	28,2 %	61,2%
MSP-KPI-04	Reduction of overlaps between individual flight routes	0%	-75%	N/A	-83,33%
MSP-KPI-05	Efficiency of battery usage for a productive phase of the drone flight	0%	55%	74,7 %	167,2%

3.2 Business Validation and Platform KPIs

This subsection is dedicated to the evaluation of RAINBOW in terms of business KPIs achievement and overall user satisfaction with the functionalities of the platform. As is the case with the technical validation in the previous subsection, this investigation is demonstrator-specific and thus, a subsection is dedicated to the respective business validation of each use case.

Moreover, in the context of Task 6.5, the consortium conducted a survey using the questionnaire described in D6.1 [4]. The questionnaire concerns the RAINBOW platform business stakeholders, as well as the corresponding demonstrator software teams. The end goal of this survey is to find a tangible and quantifiable correlation between the users' characteristics and RAINBOW's offerings. This approach can help the project identify its strengths, weaknesses and better target its industrial and business audience. The questionnaire itself, as well as the responses received are included in the Annex of this deliverable.

3.2.1 RAINBOW Business Evaluation in Human-Robot Collaboration in Industrial Ecosystems

This subsection elaborates on the business validation KPIs of D6.1 and is responsible for documenting its results in the Human-Robot Collaboration in Industrial Ecosystems use case. In the first use case, Deployment time (RAINBOW-KPI-01), achieved a significant decrease from both the baseline and the expected values, measuring a total of 90s for complete deployment. Security incidents per year (RAINBOW-KPI-03) also shows that the current stage of the platform can support a secure high-value deployment, demonstrating 0 security incidents per year, as of the time of measurement. Service Availability (RAINBOW-KPI-04) also demonstrates that RAINBOW allows for 100% service availability thanks to efficient orchestration and load balancing. Lastly, user satisfaction (RAINBOW-KPI-08), is approximately 90%, surpassing the expectation of 70%.

Table 4: RAINBOW Business KPIs applicable to Demonstrator #1

ID	KPI	Baseline Value	Value After RAINBOW		
			Expected	Obtained (Early stage)	Obtained (Final stage)
RAINBOW-KPI-01	Deployment Time	N/A	< 120 sec	90 sec (average)	90 sec (average)
RAINBOW-KPI-03	Security Incidents	N/A	< 1 / year	N/A	0
RAINBOW-KPI-04	Service Availability	N/A	> 99%	N/A	100%
RAINBOW-KPI-08	User Satisfaction	N/A	>70%	N/A	90%

3.2.2 RAINBOW Business Evaluation in Digital Transformation of Urban Mobility

This subsection elaborates on the business validation KPIs of D6.1 and is responsible for documenting its results in the Digital Transformation of Urban Mobility use case. In the second use case, deployment time (RAINBOW-KPI-01) was measured at approximately 10 seconds, while the expected value was 1 minute, and the previously achieved value was approximately 20 seconds. The observed software delivery cycle (RAINBOW-KPI-02) 10 secnds on average, while the expected value was 1 min. Continuing, security incidents (RAINBOW-KPI-03) measured in the timeframe of the demonstrator were 0, while the expected number was approximately 10. Service availability (RAINBOW-KPI-04) also significantly benefits from RAINBOW, with its value being 100%, and its expected value about 99%. This value was also achieved in the first deployment stage. User satisfaction (RAINBOW-KPI-08) was projected to be approximately 70%; the eventually achieved value is 80%, showing great success, accompanied by some room for improvement. Lastly, Investments for developing fog computing services (RAINBOW-KPI-09) achieved a value of 1PM, exceeding the previously obtained value of 1.7PMs. This hints that the final release of RAINBOW does indeed reduce overhead and offers a more business-friendly set of services.

Table 5: RAINBOW Business KPIs applicable to Demonstrator #2

ID	KPI	Baseline Value	Value After RAINBOW		
			Expected	Obtained (Early stage)	Obtained (Final stage)
RAINBOW-KPI-01	Deployment Time	N/A	< 1 min	20 sec (average)	10 sec (average)
RAINBOW-KPI-02	Software Delivery Cycle		<1 min	N/A	10 sec (average)
RAINBOW-KPI-03	Security Incidents		<10	N/A	0
RAINBOW-KPI-04	Service Availability	N/A	> 99%	100%	100%
RAINBOW-KPI-08	User Satisfaction	N/A	>70%	N/A	80%
RAINBOW-KPI-09	Investments for developing fog computing services	N/A	< 1 PM	1.7 PM	1 PM

3.2.3 RAINBOW Business Evaluation in Power Line Surveillance via Swarm of Drones

This subsection elaborates on the business validation KPIs of D6.1 and is responsible for documenting its results in the Power Line Surveillance via Swarm of Drones use case. In the third use case, deployment time (RAINBOW-KPI-01) was measured at 10 seconds, reducing the corresponding value to one fifth of that observed in the first stage (50 seconds). Continuing, security incidents (RAINBOW-KPI-03) measured in the timeframe of the demonstrator were 0, while the expected number was approximately 0.3 per hour of active deployment. As was the case with the previous two demonstrators, service availability (RAINBOW-KPI-04) also significantly benefits from RAINBOW, with its value being 100%, and its expected value about 99%. Concluding, user satisfaction (RAINBOW-KPI-08) reached 80%, whereas the expected value was at 70%.

Table 6: RAINBOW Business KPIs applicable to Demonstrator #3

ID	KPI	Baseline Value	Value After RAINBOW		
			Expected	Obtained (Early stage)	Obtained (Final stage)
RAINBOW-KPI-01	Deployment Time	5 min	< 2 sec	50 sec	10 sec
RAINBOW-KPI-03	Security Incidents	0.3/hour	< 1 / year	N/A	0
RAINBOW-KPI-04	Service Availability	13%	> 99%	N/A	100%
RAINBOW-KPI-08	User Satisfaction	N/A	> 70%	N/A	80%

4 RAINBOW Impact

This section summarizes the technical achievements and the high-level business-oriented achievements in the three RAINBOW use cases as a function of the metrics defined in D6.1 [4]. Additionally, this section provides values for the impact KPIs presented in the project's DoA [5]. The method of measurement of KPIs specified in the Description of Action (DoA) can be described as follows: KPIs from the DoA have been mapped to metrics defined in D6.1 and rendered measurable via the values collected during demonstrators' testing activities, as seen in Table 7. More specifically, the various metrics from D6.1 were taken into consideration conjointly, with their values being weighted to deduce an accurate mean representative value for each respective KPI from the DoA. Table 8 receives the abovementioned mapping as an input, along with measurements in the corresponding Technical and Business KPIs, and provides us with values for the Impact KPIs, visualising the projected contribution of RAINBOW towards facilitating its initially-defined goals for the industry and the overall business landscape.

As stated in the previous version of this deliverable, due to their nature and overall definition, KPI.02 "Improved interoperability of cloud-based services used in fog and edge execution environment (compared to other state-of-the-art approaches)" and KPI.03 "Contribution to open source initiatives and standardisation groups dealing with cloud, fog and edge computing paradigms", it was deemed irrelevant to collect measurements and devise values in the context of WP6.

It should be noted that the consortium was not able to quantify KPI.08 "Lowering access barrier for SMEs for to the usage of advanced technologies for the development, management, security and orchestration of services, made available to SMEs". This KPI is of a qualitative nature, however the specific required business KPIs could not be practically measured. Nevertheless, the consortium was able to accurately document how the advanced release of the RAINBOW platform has proven capacity in helping SMEs in. This is clearly described in Section 3 of D7.10 [8], entitled "Contribution to Strategic Impacts of Objective ICT-15-2019". More specifically, RAINBOW succeeds in creating new opportunities to encourage EU-based SMEs to develop and offer cloud-based services based on highly advanced technologies; RAINBOW's internal components expose open and user-friendly APIs in order to provide more advanced technologies and be relevant in the industry.

Table 7: Mapping of DoA Impact KPIs to Business/Technical KPIs from D6.1

Impact KPIs (from DoA)	Description	D6.1 Business KPIs	D6.1 Technical KPIs
KPI.1	Decrease in effort and investments for developing and managing the lifecycle of fog computing services and increase software delivery cycles speed (compared to other state-of-the-art approaches)	RAINBOW-KPI-01	Technical KPI mapping not applicable. This impact KPI is a direct function of the three RAINBOW Business KPIs described to the left.
		RAINBOW-KPI-02	
		RAINBOW-KPI-09	
KPI.4	Improved efficiency and performance of fog nodes (infrastructure) due to more efficient service development and orchestration (compared to other state-of-the-art approaches)	RAINBOW-KPI-04	BIBA-KPI-12
			BIBA-KPI-13
			AHED-KPI-02
			AHED-KPI-03
KPI.5	Increased productivity of business applications which rely on, or can be developed based on fog computing services (compared to the current status)	RAINBOW-KPI-08	BIBA-KPI-03
			BIBA-KPI-04
			BIBA-KPI-05
			BIBA-KPI-06
			BIBA-KPI-07
			BIBA-KPI-08
			BIBA-KPI-09
			AHED-KPI-04
			MSP-KPI-02
			MSP-KPI-03
			MSP-KPI-04
KPI.6	Increased trust feeling of data and services relying on fog-based services and IoT infrastructure in general and improved security and privacy	RAINBOW-KPI-03	BIBA-KPI-01
			BIBA-KPI-02
			BIBA-KPI-10

Impact KPIs (from DoA)	Description	D6.1 Business KPIs	D6.1 Technical KPIs
	guarantees (compared to other state-of-the-art approaches)		BIBA-KPI-11
			MSP-KPI-01
KPI.7	Decrease in the energy footprint of fog nodes and edge devices (compared to other state-of-the-art approaches)	RAINBOW-KPI-07	AHED-KPI-01
			MSP-KPI-05
KPI.8	Lowering access barrier for SMEs for to the usage of advanced technologies for the development, management, security and orchestration of services, made available to SMEs	RAINBOW-KPI-05	Technical KPI mapping not applicable. This impact KPI is a direct function of the two RAINBOW Business KPIs described to the left.
		RAINBOW-KPI-06	

Table 8: Measuring values of DoA Impact KPIs

DoA KPIs	KPI	Target Value	Measurement (Early stage)	Measurement (Final stage)
KPI.1	Decrease in effort and investments for developing and managing the lifecycle of fog computing services and increase software delivery cycles speed (compared to other state-of-the-art approaches)	20%	16.7%	23.2%
KPI.4	Improved efficiency and performance of fog nodes (infrastructure) due to more efficient service development and orchestration (compared to other state-of-the-art approaches)	25%	13.3%	25%

DoA KPIs	KPI	Target Value	Measurement (Early stage)	Measurement (Final stage)
KPI.5	Increased productivity of business applications which rely on, or can be developed based on fog computing services (compared to the current status)	25%	20%	28.8%
KPI.6	Increased trust feeling of data and services relying on fog-based services and IoT infrastructure in general and improved security and privacy guarantees (compared to other state-of-the-art approaches)	30%	20%	30%
KPI.7	Decrease in the energy footprint of fog nodes and edge devices (compared to other state-of-the-art approaches)	30%	17%	30%

5 Lessons Learnt and Adoption Guidelines

This section is dedicated to the elicitation of useful lessons learnt as well as an updated, final version of adoption guidelines for the RAINBOW platform. The target is to support the wide adaptability of the RAINBOW platform at a European level, effectively supporting the modernisation and the increase of efficiency of the involved (industrial) stakeholders' desired outputs, considering the corresponding stakeholder requirements, as identified and documented in D1.1 [7]. Invaluable information from three diverse and cutting-edge use cases will be used as input to formulate the adoption guidelines and help align the RAINBOW platform's development with the expectations of the demonstrators' respective industries.

5.1 Improvements and Lessons Learnt from Human-Robot Collaboration in Industrial Ecosystems

The first RAINBOW use case has been deployed and executed successfully, contributing with valuable information towards the technical team regarding issues that arose during the deployment of RAINBOW and their implemented solutions, the overall experience of the demonstrator, including weak and strong points, and points regarding the potential improvements which can or should be implemented in the next version of the RAINBOW platform and will be validated through the implementation of advanced demonstration of the respective use case. Data obtained in both stages of the development cycle has been interpolated, in order to draw conclusions on possible improvements and eventually output adoption guidelines.

During the previous (early) deployment stage, the demonstrator reported that there existed no automated scripts capable of facilitating the deployment of the RAINBOW platform at the use case's infrastructure in a zero-touch manner. For the early release of the RAINBOW platform, end-users had to rely on either pre-existing highly technical knowledge or need to be assisted by a more technical counterpart during the deployment process. Additionally, another reported issue was the lack of documentation for the respective use case partner to understand how the deployment of the components would look like on a container level; this made it difficult to notice issues and debug them appropriately, prior to the expression of their effects.

Summarising, as documented in the previous version of this deliverable, it was identified that there currently exists no support for volume mounts/config maps making it hard to upload application-specific configurations. Additionally, it was noted that the RAINBOW UI does not provide sufficiently detailed logs and does not allow direct SLO configuration updates. Lack of sufficiently detailed logs causes issues related to debugging, while lack of direct SLO configurability means that the end-user has to engage in such modifications manually using the command-line interface (CLI) in the respective virtual machines on which the services at hand are running. Lastly, the current version of the RAINBOW platform still requires a considerable amount of hands-on interaction with the servers to troubleshoot potential problems arising during deployment.

Currently, in the final development and deployment stage, the demonstrators identified the weakness of missing support for creation of SLOs using the custom metrics of the applications through the web UI. This constitutes a weakness of the RAINBOW platform as it necessitates more technical knowledge, as well as the usage of yaml files to instantiate and configure the SLOs. Continuing, attempting to deploy an application out of order or in a random fashion, may result in errors and subsequently lead to unsuccessful deployment. For example, assuming the deployment requirements of the first RAINBOW use case, the rabbitmq and redis services should deploy before other pods. Additionally, currently RAINBOW offers no support for using of volumes for the containers. This significantly limits the interaction and configuration opportunities with the deployed pods, which is highly used for containerized workloads. Many RAINBOW artifacts are deployed using "Network Mode Host" option; this option has proved to enable more access than necessary or desired to the overall server, which may potentially raise security concerns.

To address the corresponding issues, during both development stages, the technical team of the demonstrator engaged in extensive documentation of all issues faced throughout the deployment process in GitLab, which was pivotal in resolving issues and tracking their process and sharing solutions/guidelines and best practices amongst the involved partners. Some strong points of the RAINBOW platform observed in the early stage include the fact that the RAINBOW user interface (UI) does indeed make deployment significantly simplified, as the end-user did not have to actually write, configure and re-edit YAML files for successful deployment. Furthermore, the RAINBOW platform demonstrated the capability to provide service graphs that indicate interdependencies often useful to visualise complex application deployments.

Currently, in the final stage of development, most of the positive points highlighted during the early stage are enhanced; as for the shortcomings, several of the above-mentioned points have been resolved while some still linger. As of the final stage, the strong points include the deployment of the RAINBOW platform now being much simpler with the help of convenient and easy-to-use scripts, reducing the efforts and time significantly. This is pivotal for enabling a zero-overhead process which was lacking in the first stage. Moreover, using RAINBOW increases ease and speed of deployment of the use case application through intuitive web UI. Continuing, RAINBOW now provides secure communication between the components by integration of CJDNS to RAINBOW ecosystem. Lastly, the RAINBOW platform now supports the creation of SLOs for out-of-the-box metrics (for example *cpu*_ptc) through the web UI, even though custom metrics are yet not supported.

Key takeaways from the lessons learnt from the final development stage of the first use case include the highlighted success of the RAINBOW platform to simplify the deployment of intricate applications, as well as the visualisation of such deployments via the RAINBOW UI. Additionally, the newly provided automation scripts have significantly reduced overhead compared to the measurements taken at the first stage. Configurability has increased, yet there is still room for improvement in this direction, while the platform now requires less amount of hands-on interaction. Concluding, although the deployment process is much simpler now, the demonstrator still encountered some debugging issues (i.e., not an inherent design flaw) that required remote assistance from technical partners.

5.2 Improvements and Lessons Learnt from Digital Transformation of Urban Mobility

The final development stage of the second RAINBOW use case has been successfully deployed and executed. All testing iterations have produced valuable insights concerning the demonstrator's general experience, the onboarding experience of applications to the containerised RAINBOW environment and helped discover potential improvement points for the RAINBOW platform.

Previously, this use case noted that similarly to the first use case, lack of a fully automated installation script somewhat hindered the deployment of this demonstrator's application. This issue has partially been addressed through a simpler deployment of the RAINBOW platform with the help of automated scripts. Initially, the most important and hindering issue reported by the second RAINBOW use case demonstrator was the additional complexity introduced by the need to be able to migrate a set of services between nodes with ARM64 and AMD64 processors. This issue is now addressed in the final release of the RAIBNOW platform, introducing the new capability to migrate services between nodes with ARM64 and AMD64 processors through the inherent use of multi-architecture container image manifest lists. This proved to be of particular value for the demonstrator and supported the use case in valuable ways.

Regarding the previous stage, most of the issues faced were possible to resolve through extensive work and support from the technical partners, a process that flowed smoothly and continuously. For example, an issue associated with an excessive number of SLO queries issue was (at first) manually resolved through the manual deletion of the queries. Currently, these observed weaknesses have been addressed and fixes have been incorporated within the RAINBOW platform.

As for the weak points identified in the final stage, the single remaining point observed in the second RAINBOW use case is the act that error messages appear to be somewhat generic and don't offer much insight to the underlying issue. It is thus important to improve the error message management feature, as the current one is too generic and often it has been necessary for the second use case demonstrators to contact the technical partners to resolve potential issues. Lastly the documentation can be improved to support the development and debugging process, in order to not consume additional resources in remote assistance.

When it comes to the strong points of the RAINBOW platform, this use case identified several strong points in both stages of the development cycle. Firstly, the process of component and application creation with the RAINBOW user UI greatly simplifies the deployment of the application with respect to pure Kubernetes deployment, thanks to a higher-level approach that does not require any knowledge about Kubernetes and its technical files for successful deployment, as it serves as an abstraction layer between the user and all Kubernetes-specific details. Continuing, the RAINBOW platform provides a service graph which is a very useful method to visualise service dependencies and the whole deployment architecture. It is noteworthy that the demonstrator considers that RAINBOW's monitoring framework allows exposing and monitoring arbitrary, application-specific metrics. RAINBOW's SLO framework allows specifying complex SLOs that can be used in conjunction with multiple elasticity strategies to adapt deployments at runtime. The RAINBOW's monitoring framework it is another strength of the platform and implementing the same logic for a migration with application-level metrics without rainbow would have been difficult or completely impossible. Lastly, arguably the most important specific improvement for this use case has proved to be the capability to migrate services between nodes with ARM64 and AMD64 processors.

Several constructive improvement points for the RAINBOW platform have been identified in this use case. Firstly, this use case considers that external volumes binding can drastically speed up and improve the RAINBOW experience since it would allow dynamic configuration parameter changes on the fly, while the host network mode should not be mandatory, since it may create security issues in production deployments. Lastly, the user interface could be extended to enable the end user to effortlessly edit the SLOs.

Key takeaways from the lessons learnt from the second use case include the measurable simplification of deployment processes thanks to RAINBOW, which was even more highlighted in the advanced release of RAINBOW. It is important to note that the platform now has the capability to migrate services between nodes with ARM64 and AMD64 processors. Moreover, error messages and documentation are still in need of improvement, in order to make them more descriptive. Considering the remarks above, this use case has identified several improvement points for the RAINBOW platform. Key takeaways from the lessons learnt from the final demonstrator include the simplification of deployment processes and the benefits from the monitoring framework very useful in the orchestration dynamics.

5.3 Improvements and Lessons Learnt from Power Line Surveillance via Swarm of Drones

The third RAINBOW use case was deployed and executed successfully through both the first and the second phases, contributing valuable information towards the technical team related to the perceived demonstrator's experience with the RAINBOW platform, potential issues, shortcomings and positive aspects of the overall design.

Valuable feedback and potential improvements are indicated, to help better align the RAINBOW platform with the industry's needs and expectations, given the project's current maturity.

Thanks to high degrees of compartmentalisation on the demonstrator's end, and timely actions on behalf of the technical partners, no blocking issues were identified in the context of this use case. However, during the first stage some minor issues due to the maturity of the previous release of RAINBOW were found. For instance, some deployment attempts for our service graph failed even if the underlying nodes had the proper resources. The latter issue is easily solvable from the user perspective by resubmitting the deployment. As for resolving more potential issues, since no blocking problems were identified for this use case, the resolution of all observed issues falls within the domain of qualitative improvements.

During the first deployment stage, this use case has identified several strong points regarding the RAINBOW platform. For example, tests confirmed that RAINBOW, by enabling the direct use of distributed services, allows for more efficient operations without the efforts of developing and implementing them in order to change the existing centralized services. This is even more pronounced in the advanced release of the RAINBOW platform, thanks to the successful coordination of the ground control stations enabled by RAINBOW. Furthermore, during the first stage it was noted that the usage of SLOs allows for a simpler physical topology of the system. Thanks to the usage of SLOs, there is no need to have different types of nodes (i.e., all hardware can be uniform), so operators can focus on the application layer of their tasks without being concerned with the condition of the system and proper placement of hardware. The orchestrator automatically assigns services to proper nodes and makes sure that this allocation is optimal while nodes are added and removed from the system; this is pivotal to the demonstrator and showcases directly applicable added value for the demonstrator.

During the developments of the final stage, most of the abovementioned strong points have been enhanced, and additional ones have been introduced. Firstly, several conducted tests of use case three, revealed a noticeable increase in the efficiency of the drone system missions; this is attributed to the good coordination of the work of the GCS station, enabled by the underlying RAINBOW components. After the enhancements and improvements undergone, the installation and instantiation of the use case scenarios is more straightforward. For all intents and purposes, all deployment-related activities are now completely automated by the provided scripts. It is also important to note that SLOs can now be used to adjust system performance and also to make system deployment adapt automatically to the available hardware. This feature is of utmost importance or this use case, as its success is directly dependent on the flawless cooperation between networked elements of varying hardware typologies and resource availability. Concluding, the presence of RAINBOW's security and attestation features are valuable for the security of operations in the context of the use case.

Nevertheless, this use case also identified some weak points of the RAINBOW platform in this final stage of development. To begin with the weak points, Further development is required that will simplify or enhance or just enable some processes. Moreover, it is advisable for more widespread industrial adoption for RAINBOW partners to develop a tool that will allow users to assess the state of RAINBOW cluster, so as to check whether installation has succeeded and whether all components are working as expected with just a single command. Additionally, this use case hints that installation of the analytic stack requires tweaking of configuration files and the documentation does not state clearly whether IPv6 or IPv4 addresses should be used; this is not as much a functional issue as much a documentation shortcoming. Continuing, it would significantly reduce overhead if the installation script for the master node would output configuration parameters in a form that can be directly pasted into installation script for worker nodes (or as a configuration file that this script reads). Another hint outputted by this use case is that a declarative approach to installation should be considered (for example Ansible), to allow for an easier and more application-focused deployment process. Although RAINBOW now supports custom metrics, they cannot yet be treated the same way as those built-in; this could be addressed to allow for a more application-aware service instantiation. Lastly, when a horizontal SLO scales up a service deployment, the client services still use only the previously running instances; when that is the case, it would be very beneficial for the users if they could detect in some easy way that there is a new instance available and they should reconnect, so that the load is spread also across the new instance

Considering all the above-mentioned remarks, this demonstrator has identified several improvement points for the RAINBOW platform. Firstly, this use case would significantly benefit from a dedicated feature allowing end-users to evaluate and appraise the state of RAINBOW cluster. This is envisaged to allow stakeholders to use a simple command to monitor the state of the installation and deployment processes, as well as to judge whether or not all components are working as expected. Secondly, documentation and installation guides should be somewhat enhanced in order to clarify the typology of expected user input (as was the case with IPv4 and IPv6 addresses). Thirdly, configurability would significantly ease deployment if it were possible for configuration parameters to be passed into the automatic installation script; as of the time of writing this deliverable, this is done manually. Thirdly, the deployment process would benefit if, when a horizontal SLO scales up a deployment the respective client services were able to detect the fact that a new instance is available; this would allow the computational load to more easily and evenly spread across the newly instantiated continuum.

Key takeaways from the lessons learnt from the final stage of the third use case hint that operation efficiency has increased even more when compared to that which was achieved during the early development phase. As was observed in the first version of this deliverable, usage of SLOs measurably simplifies the system's topology. To that end, it would be a positive addition if client services could be made aware of horizontal SLO alterations. The observation that the RAINBOW orchestrator is more than capable of assigning services to the proper network node is still valid and highlighted in this final development stage. Concluding, some additional points which showed significant improvement compared to the previous stage include the new zero-overhead installation method leveraging automated scripts, and the fact that SLOs can now be used to make a deployment adapt automatically to the available hardware.

5.4 Adoption Guidelines

Successes and failures coming for testing the early version of the platform at the premise of the three use cases resulted in a spectrum of valuable validation results, lessons learnt, improvement points, as well as data concerning the overall experience of the demonstrators with the current version of the RAINBOW platform. Considering the above remarks, outputs and potential improvement points, the consortium has identified some adoption guidelines. In this subsection, matters concerning implementation, operation and execution of the demonstrators are formulated as methodological adoption guidelines for the further exploitation, effective utilisation and further developments towards the advanced release of the RAINBOW platform.

Taking into account the "stepping-stone" adoption outlines outputted by the first version of this deliverable (D6.8), the consortium has composed a set of newly elicited and more mature guidelines. The following paragraphs describe a set of more mature adoption guidelines serving as action points for the consortium pivoting relevant developments.

For example, an iimportant note and comment from the use case partners during the early stage was include the automation of deployment processes and the disengagement of human operators from the deployment and virtual infrastructure management process. This was envisaged to better align RAINBOW with the stakeholders' expectations. Enabling this functionality proved to indeed be a pivotal enhancement, and raised yet another desire, namely the configurability of the automated deployment via dedicated config files.

Guidelines elicited from what end users value about RAINBOW:

1. Automation of containerised application deployments is a strong point, highlighted by all three demonstrators. Throughout both development stages, end users noted the added value offered by the fact that RAINBOW made it measurably easier to deploy highly complex services without having to deal with low-level configurations. This eliminates knowledge barriers and enables relevant stakeholders to act more independently. Especially during the final stage, RAINBOW allowed for a completely automated installation process using convenient scripts, which boosted this observed advantage.

2. RAINBOW effectively creates an abstraction layer between the infrastructure and the end-user through the RAINBOW dashboard. The provided dashboard significantly simplifies service deployment and component creation. RAINBOW manages to conceal the Kubernetes details and the service graph which is appreciated by the end users for managing the dependencies and the whole deployment architecture. Further pursuing the separation of the control and user planes seems to be highly desired for enabling wide market adoption.
3. Automatically adjusting performance and adapting to available hardware proved to be highly desired. Highlighting the newly introduced configurability and overall elasticity of RAINBOW is the fact that it now supports migration from and to nodes with different processor architectures. As such, this adoption guideline incorporates configurability and hardware-agnosticism to steer RAINBOW into a more adaptable direction, due to its capacity to remove overhead from end-users and support a more business-centric approach.

Considering the above remarks as metrics for the establishment of adoption guidelines, RAINBOW has proven to have been successfully pivoted by the technical partners towards the direction set by the previously elicited adoption guidelines, namely: being **business-oriented** and **user-friendly**, offering **simplified deployment of complex applications** and easy-to-understand **visualisations of interdependencies and application architectures**.

Building on the above-mentioned adoption guidelines, the consortium defined a set of new and more mature adoption guidelines to push adoptability even further, namely: enabling **complete deployment automation** whilst ensuring **easy configurability**, supporting the creation of an **abstraction layer between user and infrastructure**, ensuring **elasticity and adaptability** in terms of hardware and node typologies.

Guidelines elicited from what end users would like to see from RAINBOW:

1. Handling and managing error messages is in need of improvement, along with the corresponding documentation which appeared to be lacking in terms of supporting the debugging process and clarifying expected user input. Tests by the industrial partners seemed to hint that a more instruction-based approach could reduce the need for technical partners to intervene in the case of debugging-related issues.
2. End users value the possibility to easily assess the state of the RAINBOW cluster being used. As a guideline for additional developments, enabling end users to easily and timely receive feedback on the status of undergoing deployment processes.
3. Stakeholders appreciate the possibility to use custom metrics for the creation of SLOs, but would like to see such metrics receive the same "treatment" as those inherently contained within RAINBOW. It would lead to wider adoption

of the RAINBOW platform if it were possible to use the web user interface to create SLOs from custom metrics and not necessarily rely on modifying configuration files.

Considering what RAINBOW has already achieved in terms of configurability and ease of use, the above-mentioned remarks serve as additional adoption guideline establishment metrics. Overall, RAINBOW will ensure even further market penetration and industrial adoptability through **support for user-defined metrics for SLOs, monitoring capabilities,** and **clear documentation.**

6 Conclusions

The objective of the present deliverable was to document the evaluation procedure of the three demonstrators of the RAINBOW project, on a technical and business level. This deliverable aims to contribute towards the successful integration of the RAINBOW solution with demonstrator-specific applications, serving the ultimate goal of ensuring wide applicability and diversification of the project's impact. Since its early release, RAINBOW demonstrated high levels of maturity. This is even more highlighted in the current, final release of the RAINBOW platform.

From the early release of the platform, it was shown that the capability to create an abstraction layer serving the end-user in the deployment, securing and management of their applications is invaluable to the industry. In the final version, it was shown that adhering to the guidelines established in the first version of this deliverable tangibly increased the business value of RAINBOW, following a more user-friendly approach by enabling significantly simplified deployment of complex applications, as well as offering solid visualisations capabilities in regards to managing software interdependencies and intricate application architectures.

Comparing the current and the previous versions of RAINBOW's offering, this deliverable defines a set of new aims and aspirations for the consortium to satisfy, moving on to further industrial adoption. The industrial stakeholders appreciate complete deployment automation, especially combined with easy configurability, as this ensures platform-wide adaptability and zero-overhead deployment management.

Continuing, this RAINBOW deliverable has performed a business validation, following the adopted evaluation methodology. The RAINBOW evaluation framework has been specified as consecutive flows of validation and evaluation processes spanning from technical to business validation and further to performance evaluation on the basis of specific KPIs of RAINBOW specific functions and the whole solution. Following an iterative development and testing processes scheme, it has been ensured that the appropriate KPIs have been met, the strengths of the platform have been enhanced, and the weaknesses which were initially identified have been addressed. Virtually all stakeholders' clarifications/suggestions/changes have been addressed in the final version of the RAINBOW platform, considering the lessons learnt and the adoption guidelines outputted by the RAINBOW demonstrators. Lastly, the lessons learnt, the calculated technical and business KPIs, as well as the responses to the business validation questionnaire provide constructive feedback for the continuous improvement and long-term advancement of RAINBOW.

In terms of technical validation of the platform, the different tests that have been conducted showcase the excellence of the platform, as the majority of the technical performance targets are already met by the system. Regarding the business value of the platform, the different users (as part of the demonstrating partners) showcased that the RAINBOW in its final developmental stage has a clearly positive impact on their operations and their development and deployment processes, especially in regards to deployment time and overall ease of use. This is also highlighted by the responses in the business validation questionnaire (annexed in this deliverable). Overall, the business stakeholders validated that RAINBOW reduces development effort, while some accessibility-related features can be enhanced. Moreover, the pivotal points of the demonstrators'' appreciation of the RAINBOW platform are noted, and optimisations necessary for further industrial adoption will take place accordingly

The business validation questionnaire responses indicate that for RAINBOW use cases 1 and 3, the responses indicate a high degree of success in virtually all regards, while the responses for use case 2 indicate a set of identified weaknesses and room for improvement. This hints that the RAINBOW platform has been more successful in the first and third use cases, where user satisfaction is the highest.

Lessons learnt indicate that the RAINBOW platform has achieved major milestones in regards to providing a solid business-oriented technical tool. Overall, the questionnaires and achieved KPI values indicate that the platform is indeed headed in the right direction in terms of wide industrial adoption. There have also been identified some improvement points, mainly concern accessibility and the addition of some useful functionalities aimed at further enhancing RAINBOW's capabilities.

References

[1] RAINBOW Consortium (2021) Deliverable D6.2 "Human-Robot Collaboration Demonstrator - Early Release"
[2] RAINBOW Consortium (2021) Deliverable D6.4 "Digital Transformation of Urban Mobility Demonstrator - Early Release"
[3] RAINBOW Consortium (2021) Deliverable D6.6 "Power Line Surveillance Demonstrator - Early Release"
[4] RAINBOW Consortium (2021) Deliverable D6.1 "Evaluation Framework and Demonstrators Planning"
[5] RAINBOW Consortium (2020) Description of Action.
[6] RAINBOW Consortium (2021) Deliverable D1.3 "RAINBOW Use-Cases Descriptions"
[7] RAINBOW Consortium (2021) Deliverable D1.1 "RAINBOW Stakeholders Requirements Analysis"
[8] RAINBOW Consortium (2022) Deliverable D7.10 "Project Impact Assessment"

Annex I - Impact KPI calculation formulas

Impact KPI calculation formulas:

KPI.1 = x[avg(RAINBOW-KPI-01)]+ y*[avg(RAINBOW-KPI-02)] + z*[avg(RAINBOW-KPI-09)]*

KPI.4 = x[avg(RAINBOW-KPI-04)] + y*(BIBA-KPI-12) + z*BIBA-KPI-13) + j*(AHED-KPI-02) +k*(AHED-KPI-03)*

KPI.5 = x[avg(RAINBOW-KPI-08)] + y*(BIBA-KPI-03) + z*(BIBA-KPI-04) + j*(BIBA-KPI-05) +k*(BIBA-KPI-06) + p*(BIBA-KPI-07) + r*(BIBA-KPI-08) + d*(BIBA-KPI-09) + u*(AHED-KPI-04) + s*(MSP-KPI-02) + w*(MSP-KPI-03) + q*(MSP-KPI-04)*

KPI.6 = x[avg(RAINBOW-KPI-03)] + y*(BIBA-KPI-01) + z*(BIBA-KPI-02) + j*(BIBA-KPI-10) + k*(BIBA-KPI-11) +p*(MSP-KPI-01)*

KPI.7 = x[avg(RAINBOW-KPI-07)] + y*(AHED-KPI-01) + z*(MSP-KPI-05)*

Annex II - Business Validation Questionnaire Responses

Human-Robot Collaboration in Industrial Ecosystems – Questionnaire Response:
Business Validation - Evaluation Metrics selected for the RAINBOW Demonstrators Operation

Sub-characteristics	Related Questions	Response
Effectiveness		
Effectiveness	**Do you think that RAINBOW platform increases the productivity of your business applications compared to the current status?** *Scale 1-5*	5
	Do you think it is easier to have access to the usage of more advanced technologies via the RAINBOW platform compared to the current status? *Scale 1-5*	5
Efficiency		
Efficiency	**Do you think the RAINBOW platform covers its advertised purpose?** *Scale 1-5*	5
Satisfaction		
Usefulness	**Can you easily complete your business goals using the RAINBOW platform?** *Scale 1-5 (e.g. not at all / partially / most of them /almost all / all of them)*	5
Trust	**Do you trust the data and services (e.g. analytics results) relying on the RAINBOW platform?** *Scale 1-5*	5
Pleasure	**Do you use the RAINBOW platform with pleasure?** *Scale 1-5*	5
Comfort	**Do you feel that the UI and workflow of the RAINBOW platform are friendly to the user?** *Scale 1-5*	5
Safety		
Privacy guarantees	**How solid do you feel that your data and services relying on the RAINBOW platform are protected?** *Scale 1-5*	5
Trust feeling	**Do you believe that services based on the RAINBOW framework are trustworthy?** *Scale 1-5*	5
Usability		
Learnability	**How easy it was for you to learn how to use basic functionalities of the RAINBOW platform?** *Scale 1-5*	4

Sub-characteristics	Related Questions	Response
Flexibility	**How much do you believe that the RAINBOW platform can be used for applications other than the demonstrator ones?** *Scale 1-5*	5
Accessibility	**Do you believe that the RAINBOW platform can be accessed by disabled users (e.g. visual or hearing impairment)?** *Scale 1-5*	4
Business Value		
Clarity	**How clear it was to you what RAINBOW is about before engaging with the platform?** *Scale 1-5*	5
Value	**How much do you feel that use of the RAINBOW platform increases the value of the product of your business?** *Scale 1-5*	5
Need Level	**How important is for your organisation the business need that the RAINBOW platform covers for you?** *Scale 1-5*	4
Urgency	**How soon after the end of the project do you expect RAINBOW to be fully functional?** *Scale 1-5*	5
Need Coverage	**In which degree does RAINBOW covers your need?** *Scale 1-5*	4
Innovation/Uniqueness	**How innovative do you find the idea of RAINBOW?** *Scale 1-5*	5
Virality	**How probable is it for you to recommend the use of RAINBOW platform to someone you know who works in the same domain as you?** *Scale 1-5*	4
Cost efficiency	**How much has cost-effectiveness increased after the integration of RAINBOW to your application?** *Scale 1-5*	4
Software Delivery Cycle	**To what extend does RAINBOW help reduce software delivery overhead and hasten delivery cycles?** *Scale 1-5*	5
Energy Consumption Costs	**How much did RAINBOW assist in reducing energy demands for your application?** *Scale 1-5*	4

Sub-characteristics	Related Questions	Response
Security Incidents	**How much do you feel that RAINBOW helped increase security for your application?** *Scale 1-5*	5

Digital Transformation of Urban Mobility – Questionnaire Response

Business Validation - Evaluation Metrics selected for the RAINBOW Demonstrators Operation

Sub-characteristics	Related Questions	Response
Effectiveness		
Effectiveness	**Do you think that RAINBOW platform increases the productivity of your business applications compared to the current status?** *Scale 1-5*	3
	Do you think it is easier to have access to the usage of more advanced technologies via the RAINBOW platform compared to the current status? *Scale 1-5*	2
Efficiency		
Efficiency	**Do you think the RAINBOW platform covers its advertised purpose?** *Scale 1-5*	4
Satisfaction		
Usefulness	**Can you easily complete your business goals using the RAINBOW platform?** *Scale 1-5 (e.g. not at all / partially / most of them /almost all / all of them)*	2
Trust	**Do you trust the data and services (e.g. analytics results) relying on the RAINBOW platform?** *Scale 1-5*	N/A
Pleasure	**Do you use the RAINBOW platform with pleasure?** *Scale 1-5*	4
Comfort	**Do you feel that the UI and workflow of the RAINBOW platform are friendly to the user?** *Scale 1-5*	4
Safety		
Privacy guarantees	**How solid do you feel that your data and services relying on the RAINBOW platform are protected?** *Scale 1-5*	N/A
Trust feeling	**Do you believe that services based on the RAINBOW framework are trustworthy?** *Scale 1-5*	N/A
Usability		

Sub-characteristics	Related Questions	Response
Learnability	**How easy it was for you to learn how to use basic functionalities of the RAINBOW platform?** *Scale 1-5*	4
Flexibility	**How much do you believe that the RAINBOW platform can be used for applications other than the demonstrator ones?** *Scale 1-5*	2
Accessibility	**Do you believe that the RAINBOW platform can be accessed by disabled users (e.g. visual or hearing impairment)?** *Scale 1-5*	2
Business Value		
Clarity	**How clear it was to you what RAINBOW is about before engaging with the platform?** *Scale 1-5*	3
Value	**How much do you feel that use of the RAINBOW platform increases the value of the product of your business?** *Scale 1-5*	3
Need Level	**How important is for your organisation the business need that the RAINBOW platform covers for you?** *Scale 1-5*	2
Urgency	**How soon after the end of the project do you expect RAINBOW to be fully functional?** *Scale 1-5*	2
Need Coverage	**In which degree does RAINBOW covers your need?** *Scale 1-5*	2
Innovation/Uniqueness	**How innovative do you find the idea of RAINBOW?** *Scale 1-5*	4
Virality	**How probable is it for you to recommend the use of RAINBOW platform to someone you know who works in the same domain as you?** *Scale 1-5*	4
Cost efficiency	**How much has cost-effectiveness increased after the integration of RAINBOW to your application?** *Scale 1-5*	3
Software Delivery Cycle	**To what extend does RAINBOW help reduce software delivery overhead and hasten delivery cycles?** *Scale 1-5*	2

Sub-characteristics	Related Questions	Response
Energy Consumption Costs	**How much did RAINBOW assist in reducing energy demands for your application?** *Scale 1-5*	**N/A**
Security Incidents	**How much do you feel that RAINBOW helped increase security for your application?** *Scale 1-5*	**N/A**

Sub-characteristics	Related Questions	Response
Effectiveness		
Effectiveness	**Do you think that RAINBOW platform increases the productivity of your business applications compared to the current status?** *Scale 1-5*	**2**
	Do you think it is easier to have access to the usage of more advanced technologies via the RAINBOW platform compared to the current status? *Scale 1-5*	**N/A**
Efficiency		
Efficiency	**Do you think the RAINBOW platform covers its advertised purpose?** *Scale 1-5*	**4**
Satisfaction		
Usefulness	**Can you easily complete your business goals using the RAINBOW platform?** *Scale 1-5 (e.g. not at all / partially / most of them /almost all / all of them)*	**2**
Trust	**Do you trust the data and services (e.g. analytics results) relying on the RAINBOW platform?** *Scale 1-5*	**N/A**
Pleasure	**Do you use the RAINBOW platform with pleasure?** *Scale 1-5*	**N/A**
Comfort	**Do you feel that the UI and workflow of the RAINBOW platform are friendly to the user?** *Scale 1-5*	**3**
Safety		
Privacy guarantees	**How solid do you feel that your data and services relying on the RAINBOW platform are protected?** *Scale 1-5*	**N/A**
Trust feeling	**Do you believe that services based on the RAINBOW framework are trustworthy?** *Scale 1-5*	**N/A**

Sub-characteristics	Related Questions	Response
Usability		
Learnability	**How easy it was for you to learn how to use basic functionalities of the RAINBOW platform?** *Scale 1-5*	3
Flexibility	**How much do you believe that the RAINBOW platform can be used for applications other than the demonstrator ones?** *Scale 1-5*	3
Accessibility	**Do you believe that the RAINBOW platform can be accessed by disabled users (e.g. visual or hearing impairment)?** *Scale 1-5*	1
Business Value		
Clarity	**How clear it was to you what RAINBOW is about before engaging with the platform?** *Scale 1-5*	3
Value	**How much do you feel that use of the RAINBOW platform increases the value of the product of your business?** *Scale 1-5*	2
Need Level	**How important is for your organisation the business need that the RAINBOW platform covers for you?** *Scale 1-5*	2
Urgency	**How soon after the end of the project do you expect RAINBOW to be fully functional?** *Scale 1-5*	2
Need Coverage	**In which degree does RAINBOW covers your need?** *Scale 1-5*	2
Innovation/Uniqueness	**How innovative do you find the idea of RAINBOW?** *Scale 1-5*	5
Virality	**How probable is it for you to recommend the use of RAINBOW platform to someone you know who works in the same domain as you?** *Scale 1-5*	3
Cost efficiency	**How much has cost-effectiveness increased after the integration of RAINBOW to your application?** *Scale 1-5*	3
Software Delivery Cycle	**To what extend does RAINBOW help reduce software delivery overhead and hasten delivery cycles?**	2

Sub-characteristics	Related Questions	Response
	Scale 1-5	
Energy Consumption Costs	**How much did RAINBOW assist in reducing energy demands for your application?** *Scale 1-5*	**N/A**
Security Incidents	**How much do you feel that RAINBOW helped increase security for your application?** *Scale 1-5*	**N/A**

Power Line Surveillance via Swarm of Drones – Questionnaire Response

Business Validation - Evaluation Metrics selected for the RAINBOW Demonstrators Operation

Sub-characteristics	Related Questions	Response
Effectiveness		
Effectiveness	**Do you think that RAINBOW platform increases the productivity of your business applications compared to the current status?** *Scale 1-5*	4
	Do you think it is easier to have access to the usage of more advanced technologies via the RAINBOW platform compared to the current status? *Scale 1-5*	4
Efficiency		
Efficiency	**Do you think the RAINBOW platform covers its advertised purpose?** *Scale 1-5*	4
Satisfaction		
Usefulness	**Can you easily complete your business goals using the RAINBOW platform?** *Scale 1-5 (e.g. not at all / partially / most of them /almost all / all of them)*	4
Trust	**Do you trust the data and services (e.g. analytics results) relying on the RAINBOW platform?** *Scale 1-5*	4
Pleasure	**Do you use the RAINBOW platform with pleasure?** *Scale 1-5*	4
Comfort	**Do you feel that the UI and workflow of the RAINBOW platform are friendly to the user?** *Scale 1-5*	4
Safety		
Privacy guarantees	**How solid do you feel that your data and services relying on the RAINBOW platform are protected?** *Scale 1-5*	4
Trust feeling	**Do you believe that services based on the RAINBOW framework are trustworthy?** *Scale 1-5*	4
Usability		

Sub-characteristics	Related Questions	Response
Learnability	**How easy it was for you to learn how to use basic functionalities of the RAINBOW platform?** *Scale 1-5*	4
Flexibility	**How much do you believe that the RAINBOW platform can be used for applications other than the demonstrator ones?** *Scale 1-5*	5
Accessibility	**Do you believe that the RAINBOW platform can be accessed by disabled users (e.g. visual or hearing impairment)?** *Scale 1-5*	5
Business Value		
Clarity	**How clear it was to you what RAINBOW is about before engaging with the platform?** *Scale 1-5*	4
Value	**How much do you feel that use of the RAINBOW platform increases the value of the product of your business?** *Scale 1-5*	4
Need Level	**How important is for your organisation the business need that the RAINBOW platform covers for you?** *Scale 1-5*	3
Urgency	**How soon after the end of the project do you expect RAINBOW to be fully functional?** *Scale 1-5*	3
Need Coverage	**In which degree does RAINBOW covers your need?** *Scale 1-5*	3
Innovation/Uniqueness	**How innovative do you find the idea of RAINBOW?** *Scale 1-5*	4
Virality	**How probable is it for you to recommend the use of RAINBOW platform to someone you know who works in the same domain as you?** *Scale 1-5*	4
Cost efficiency	**How much has cost-effectiveness increased after the integration of RAINBOW to your application?** *Scale 1-5*	3
Software Delivery Cycle	**To what extend does RAINBOW help reduce software delivery overhead and hasten delivery cycles?** *Scale 1-5*	3
Energy Consumption Costs	**How much did RAINBOW assist in reducing energy demands for your application?** *Scale 1-5*	3
Security Incidents	**How much do you feel that RAINBOW helped increase security for your application?** *Scale 1-5*	3