D1.5 - Definition of framework, scenarios and requirements incl. KPIs & Baseline for 3rd cycle

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List of Abbreviations

TM .... *TeamMate*
V&V&E .... *verification, validation and evaluation*

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1 Executive summary

This deliverable D1.5 is an update of D1.1 and D1.3 focussing on framework, scenarios, requirements, KPIs, and Baseline for 3rd cycle.

The work on the TeamMate car concept & requirements is very important for the AutoMate project as it provides the ground work for the technology development in WP2-5 and the verification, validation and evaluation activities (V&V&E). The starting point was the definition of the TeamMate car concept, the scenario and use-case definition and requirements specification in D1.3. During the second project cycle some of these aspects have been further detailed, specified and clarified in order to be effectively used for project cycle 3, especially the scenario use-cases and the requirements.

In the scenario section of this document, you will find an update on the use-case descriptions, now focussing on the aspect of support that is provided (action or perception) and the direction of support (Human to Automation or Automation to Human). The refined use-cases foster the implementation of the use-cases in the actual demonstrators by covering multiple former use-cases with fewer total cases and integrating as many Enablers as possible.

The part dedicated to the V&V&E framework briefly reflects the terms verification, validation and evaluation within the AutoMate project and the overall framework to be used by the other work packages (WPs) which was already introduced in D1.3.

Concerning the requirements, some performance and privacy related requirements were added. For some enablers additional requirements were specified to address the vehicle integration and/or advances planned for the 3rd cycle. For all requirements further attributes were introduced.

Additionally, the demonstrator baselines and KPIs were updated based on D6.1 and the 2nd cycle evaluation experiments described in D6.2.

2 Introduction

This document describes the progress of the work in WP1 concerning the scenario and use case development (task 1.2) as well as the definition of requirements, KPIs and baseline car (task 1.3). In Section 3 scenarios and cases for the 3rd cycle are presented. Within the update for cycle 3 some new requirements attributes were defined, and the requirements themselves were updated. The overall framework for verification, validation and evaluation activities remained unchanged since cycle 2. The requirements and a brief description of the aforementioned framework are presented in Section 4. Finally, a conclusion is given in Section 5.

3 Scenarios and use case development

During the 2nd cycle of the project and the 3rd cycle of WP1 the scenario and use-cases descriptions were slightly changed. The demonstrator owners performed these updates in order to be more compliant with their objectives and to address more aspects of the TeamMate (TM) concept. During the 2nd cycle the amount of use cases was reduced by focussing only on the direction of support i.e. Human to Automation (H2A) and Automation to Human (A2H), and whether the support takes place during action or during perception. Further details can already be found in D6.1. In the following sections, the changes will be described in detail and afterwards the complete list of the current status of the use-cases is presented.

3.1 Peter scenario updates

The six use cases of the Peter scenario described in D1.3 were condensed in two use cases depending on the direction of support. Thus, for the 3rd cycle the uses cases of the Peter scenario are described as follows:

- **Use Case 1: H2A support in perception**

The TeamMate Car is driving in a narrow rural road in Automated Mode. The car, arriving behind a tractor, detects that the view is obstructed. Therefore, the vehicle is not confident of the available space sideways to overtake the tractor, which represents a limit in perception. Since the vehicle is not sure about the possibility to perform a safe overtaking manoeuvre*, it would follow the tractor either until the road is wider or the tractor changes direction. The*

TeamMate car asks Peter to check by himself if a safe overtake manoeuvre is possible, in order to support the automation. When Peter confirms there is enough space, the TeamMate car performs the overtaking manoeuvre in Automated Mode.

- **Use Case 2: A2H support in action**

Peter is driving on a narrow rural road in Manual Mode. He approaches a tractor causing limited visibility of the road and intends to overtake the tractor. Peter is in a hurry, so he decides to overtake. The TeamMate car detects a car approaching at the opposite lane. A collision is likely to occur. In order to avoid it, the TeamMate car takes the control of the vehicle and plans and executes a safe manoeuvre to drive the vehicle back to the original lane. At the same time, in order to let Peter understand its action, the TeamMate car shows the danger of the oncoming vehicle using an augmented reality HMI whose graphical elements appear to be directly on the road. When the situation is safe, the automation hands over the control to the driver (back to Manual Mode).

3.2 Martha scenario updates

The six use cases of the Martha scenario described in D1.3 were condensed into two use cases depending on the direction of support. Thus, for the 3rd cycle the uses cases of this scenario are described as follows:

- **Use case 1: H2A support in action**

The TeamMate car is driving in an extra-urban road in Automated Mode. Through the V2I communication, it detects road works one kilometre and *that the lanes are no longer visible. Since the TeamMate car knows that it will not be able to deal with this situation autonomously, it asks Martha for support in action: in particular, it asks Martha to handle the lateral control while the longitudinal control is kept by the TeamMate car. Martha is attentive, and she takes over the lateral control until the end of the roadworks, when the TeamMate car can shift back to Automated Mode.*

- **Use case 2: A2H support in perception and in action**

Martha is driving in an extra-urban road in Manual Mode. She receives an incoming call: the TeamMate car detects that she is distracted, so it informs her about the risk she is running. However, she does not care about the warning, and keeps talking animatedly on the phone. So, the TeamMate car informs her that it will take the control of the vehicle in a few seconds, and if Martha still does not take any actions, the automation takes over and switches into Automated Mode.

3.3 Eva scenario updates

The six use cases of the Eva scenario described in D1.3 were condensed in two use cases depending on the direction of support. Thus, for the 3rd cycle the uses cases of this scenario are described as follows:

- **Use case 1: H2A support in perception**

The TeamMate car is driving in Automated Mode. When it approaches a roundabout, it detects high amount of traffic within the roundabout which can affect the efficiency of the manoeuvre in Automated Mode. Thus, it might take some time to enter the roundabout or the automation might even be *unable to enter the roundabout on its own. To speed up the manoeuvre, the TeamMate car asks Eva for cooperation in perception, asking her to check the available space and to provide a trigger to start the manoeuvre. Eva checks the traffic and gives the confirmation when to enter the roundabout. The TeamMate car notifies the feedback and enters the roundabout in Automated Mode.*

- **Use case 2: H2A support in action (and perception)**

The TeamMate car is driving in Automated Mode. From information on maps, it knows about an upcoming roundabout which cannot be travelled through efficiently and safely (e.g. too much time required to enter the roundabout in Automated Mode or the lane markings are not present on the road). Therefore, the TeamMate car asks Eva for support in action and perception. In this way, Eva is responsible to decide when it is the right time to enter into the roundabout and, moreover, the vehicle control is shared between Eva and the TeamMate car: she takes care of the lateral driving task and the TeamMate car takes care of the longitudinal task. In this context, the precondition is that the driver is attentive (not-distracted), in such a way that when the cooperation is proposed, she is ready.

4 Overall verification, validation and evaluation framework

4.1 Review of previous cycles

At the beginning of the 1st cycle, a set of high level requirements have been defined, which were considered a qualitative description of the most relevant features of the enablers. During the further progression the requirements were refined to meet the standards defined by the OEMs (PSA and CRF). The resulting common process for the verification & validation (V&V) and the verification & validation & evaluation (V&V&E) framework including the process for the assessment of the achievement of the project objectives were already described in D1.3. Since the process and the framework proved to be useful during the 2nd cycle they are retained for the 3rd cycle.

4.2 Definition of verification, validation and evaluation

Verification, validation and evaluation (V&V&E) are fundamental activities for the deployment of reliable and acceptable autonomous systems. The definition for V&V&E for the second cycle was given in D1.3 and stays unchanged for the 3rd cycle.

From the software engineering point of view:

- Verification **checks** whether the system under development is well-engineered, error-free, works properly without crash, etc.
- Validation **measures** whether the system under development meets the posed requirements, so it defines the measurable threshold to assess if the quality of the system is acceptable for its intended use.

Therefore, the requirement and its metric are indivisible items (they must never be split apart).

- The evaluation **measures** the performance of a system against a predefined baseline to assess whether the new system is innovative (i.e. it can bring benefits to its intended target).

In the 3rd cycle of the Automate project, the V&V activities are expected to be performed in T2.5, T3.6 and T4.5, while the evaluation is conducted in T6.3 and T6.4.

4.3 Definition of assessment of project objectives

As shown in Figure 1, the objectives of the project are logically connected to the WPs that, in turn, are linked to their outputs, i.e. the enablers and the demonstrators. Therefore, the achievement of these objectives can be linked to the achievement of the expected results of the enablers and demonstrators. With regard to the enablers, these expected results have to be assessed against the requirements and metrics to validate their quality and degree of innovation. For the demonstrators, the expected results are linked to a set of key performance indicators (e.g. increase of safety, increase of trust, etc.). As a consequence, we plan to use the results of the V&V&E activities to progressively demonstrate the achievement of the project objectives linked to the enablers and the demonstrators.

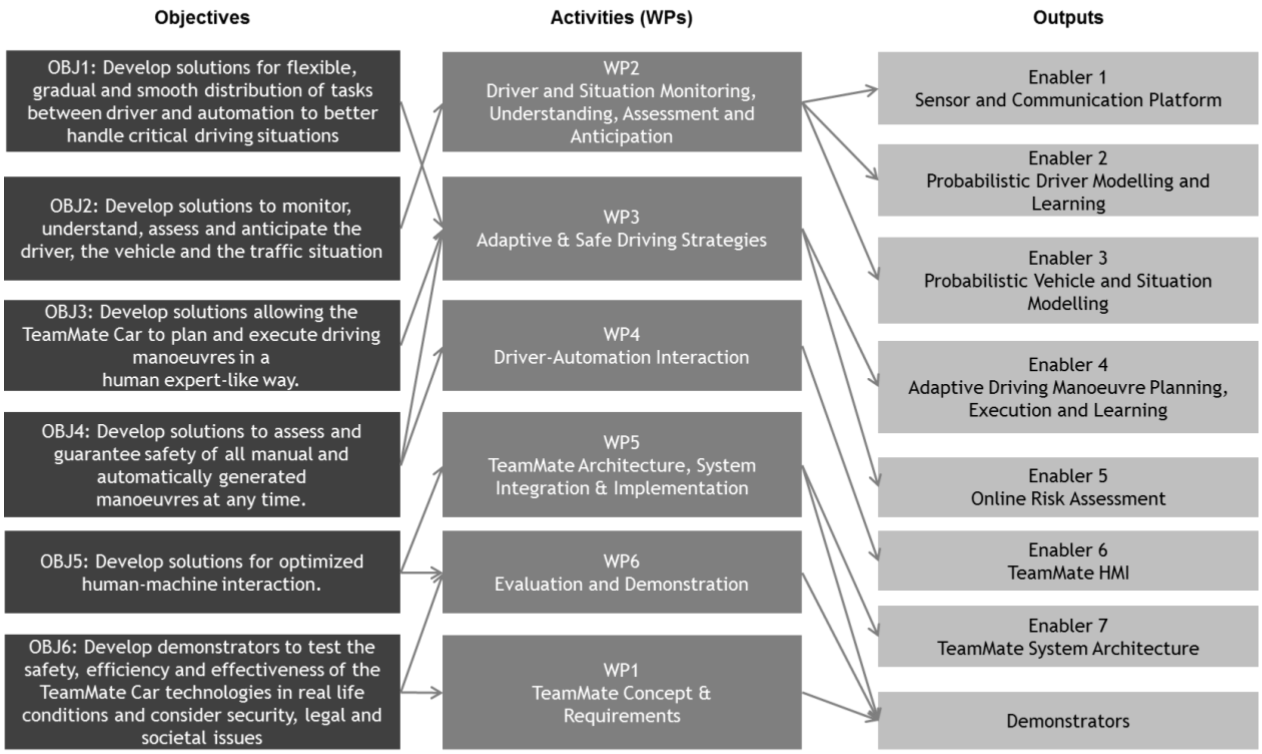

Figure 1: Schema to link the objectives to the enablers and the demonstrator

4.4 Impact on the other WPs and tasks

The overall V&V&E process has an impact on the activities of the other WPs and tasks that are expected to receive inputs from WP1. Since the requirements for the enablers are defined in T1.3 they should not be split apart from their metrics.

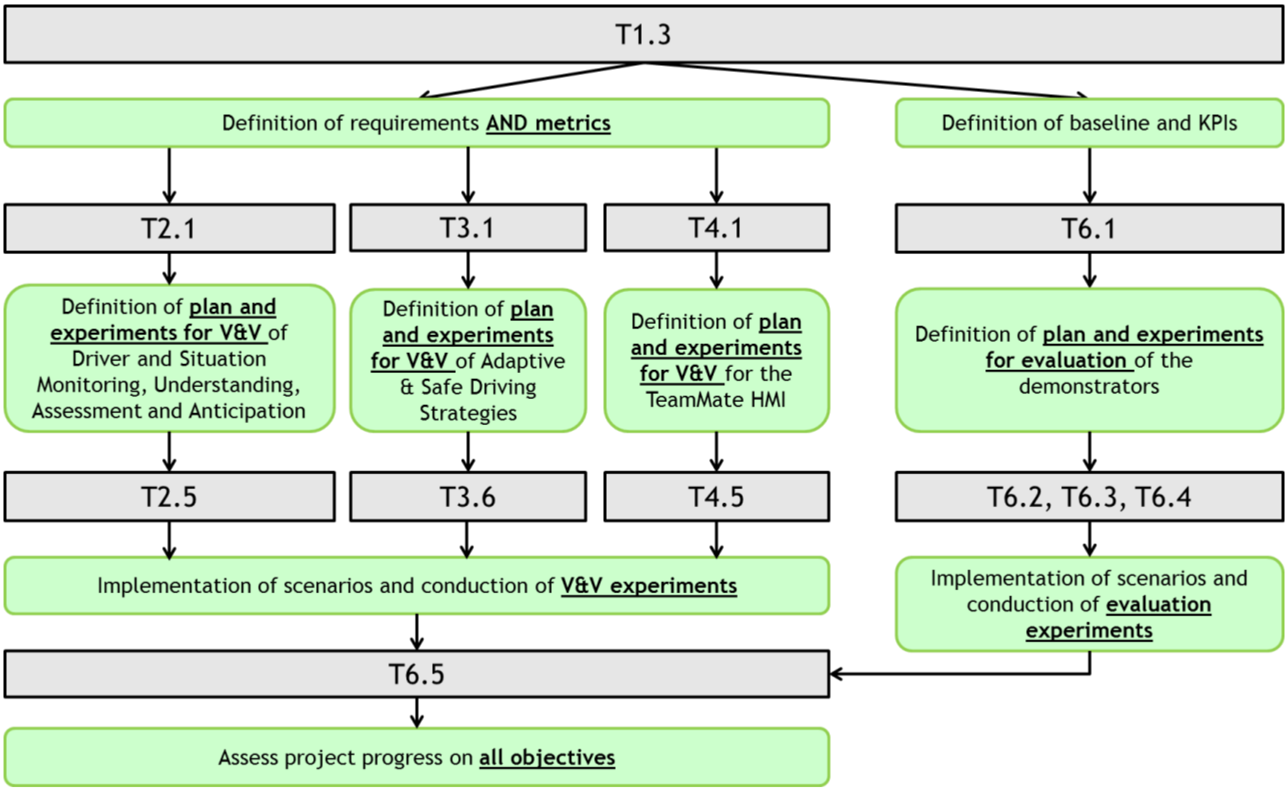

Figure 2: PERT to show the links between the WPs for the V&V&E activities and the achievement of the objectives

According to the schema shown in Figure 2, the following activities will be performed in the 3rd cycle in WP2-4 and WP6:

- T2.1, T3.1 and T4.1 will focus on the definition of plans and experiments for the V&V of the enablers that will be conducted in T2.5, T3.6 and T4.5 against the requirements and measurable metrics defined in T1.3.

- T6.1 will focus on the definition of plans and experiments for the evaluation of the demonstrators that will be conducted in T6.2, T6.3 and T6.4 against the baseline and KPIs defined in T1.3.
- T6.5 will collect the results of the V&V for the enablers and the preliminary evaluation for the demonstrators to assess the achievement of the progress on all project objectives.

These activities will have a clear impact on the corresponding deliverables in the 2nd cycle:

- D2.5, D3.6 and D4.5 will include a reference to the requirements, metrics and the V&V process as provided in this document, and then they will focus on the description of plans and experiments for the V&V of the enablers.
- D2.6, D3.7 and D4.6 will describe the results of the V&V activities for the enablers against the requirements and metrics defined in D1.5 and the plan and experiments described in D2.6, D3.7 and D4.6.
- D6.3 will describe the results of the evaluation of the demonstrators against the baseline and KPIs defined in D1.5.

4.5 Definition of requirements and metrics for the 3rd cycle

During the 2nd cycle and at the beginning of the 3rd cycle, requirements have been refined and improved, and metrics have been defined for them.

In order to collect the new requirements and to update the existing ones, the structure of the original Excel file has been revised as well. In particular the formerly used enabler Excel sheets contain now the columns described in Table 1.

Field	**Description**
Type of Enabler	Each enabler can be seen as a family of different solutions, i.e. tool, model, algorithm, sensor, HMI, etc.
Name	Name of the enabler the requirements refers to
Verification/validation	Requirement is used for verification or validation
Enabler Owner	The developer of the enabler the requirement refers to.
Req. Owner	The partner who created this requirement
ID	Unique ID of the requirement
Description	Brief description of the requirement
Demo Owner	The owner of the demonstrator who plans to integrate the related enabler
Use Cases	Uses cases for which the requirement is relevant
Metric	Measurable and quantifiable description of the success criteria to assess that the requirement has been met
Type	User or System requirement
Nature	Functional or non-functional requirement
Priority Level	*High* priority: the requirement must be fulfilled (mandatory) otherwise *Low* priority: the requirement should be fulfilled
TRL	For the targeted Technology Readiness Level this requirement must be fulfilled.

Table 1: Structure of the excel file for the requirement management (new attributes are bold)

The requirements table is filled in in two steps:

- 1st step: all fields, except "Demo owner", are filled in by the enabler owner who is in charge of the development of the requirement.
- 2nd step: the demo owners check all requirements and associate their names to show a commitment to integrate a specific enabler, which meets a specific requirement, into their demonstrator.

Therefore, the revised Excel file will include only those requirements which are developed by a certain partner and actually integrated into a specific demonstrator.

The following sub-sections include the list of all requirements and metrics defined at the end of the 2nd cycle and the beginning of the 3rd for each enabler. These requirements and metrics will be used by the enabler owners in T2.1, T3.1 and T4.1 to define the plan for the V&V activities, and in T6.5 to progressively quantify the achievement of the project objectives

4.5.1 Definition of requirements and metrics for Enabler 1.1

Name: Driver monitoring system

Enabler Type: Tool

Owner: CAF

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority Level	TRL
R_EN1_tool1.1	Validation	CRF	Driver monitoring tool must classify if the driver is visually distracted (states: distracted, not distracted)	CRF	Eva Martha	Correct Rate (CR) for classification of distraction: - 70% ≤ CR < 80% -> acceptable; -80% ≤ CR < 90% -> good - CR ≥ 90% -> excellent	System	functional	High	7
R_EN1_tool1.2	Validation	CRF	Driver monitoring tool must detect where the driver is looking (areas: road ahead, side mirrors, rear view mirror)	CRF	Eva Martha	Correct Rate (CR) for detection of the eye zone: - 70% ≤ CR < 80% -> acceptable; -80% ≤ CR < 90% -> good - CR ≥ 90% -> excellent	System	functional	Low	6
R_EN1_tool1.3	Verification	CRF	Driver monitoring tool must detect how long the driver is looking at a specific area (areas: road ahead, side mirrors, rear view mirror)	CRF	Eva Martha	Check: Y/N	System	functional	Low	6

4.5.2 Definition of requirements and metrics for Enabler 1.2

Name: V2X

Enabler Type: Tool

Owner: BIT

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority Level	TRL
R_EN1_tool2.1	Validation	VED	Traffic monitoring tool must communicate with surrounding vehicles (10 m range) within 100ms	VED	Martha	reliability of communication 99% of the messages must be correctly and timely received	system	functional	Low	7
R_EN1_tool2.2	Verification	VED	Traffic monitoring tool must use V2x technology with the surrounding vehicles and roadside units	VED	Martha	Check: Y/N	system	functional	Low	7
R_EN1_tool2.3	Validation	VED	Traffic monitoring tool must detect moving and static objects (i.e. vehicles and obstacles) in a 200m range by using other vehicles' sensors	VED	Martha	reliability of detection 99% of the vehicles in a 200m range must be correctly detected 99% of the vehicles in a 200m range must be detected within 1 s	system	functional	Low	7

R_EN1_tool2.4	Validation	VED	At each moment the vehicle must have an accurate global localisation or at least lane shift information in the lane recognition, and human behaviour assessment and prediction.	VED	Martha	lateral accuracy < 0,30 m on highway lateral accuracy < 0,15 m in city	system	functional	High	5
R_EN1_tool2.5	Validation	VED	The tool must have an accurate estimation of ego-lane	VED	Martha	CR for accuracy level - >90% acceptable	system	functional	High	5

4.5.3 Definition of requirements and metrics for Enabler 2.1

Name: Driver Intention Recognition

Enabler Type: Model

Owner: OFF

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority Level	TRL
R_EN2_model2.1	Verification	OFF	The driver model must provide a unified interface to be integrable in the TeamMate architecture	ULM	Eva Peter-A2H	Check: Y/N	system	non-functional	high	4
R_EN2_model2.2	Validation	HMT	The driver model for intention recognition must allow an effective recalibration of the parameters of the driver model on the basis of the data obtained during runtime	ULM	Eva Peter-A2H	Check: Y/N	system	non-functional	high	4
R_EN2_model2.4	Validation	HMT	The driver model for intention recognition must recognize the overtaking intention of the driver	ULM	Eva Peter-A2H	CR of the classification: - ≥80% acceptable	system	functional	high	4
R_EN2_model2.5	Verification	HMT	The driver model for intention recognition must provide the overtaking intention of the driver	ULM	Eva Peter-A2H	Check: Y/N	system	functional	high	4
R_EN2_model2.6	Verification	HMT	The driver model for intention recognition must run on the demonstrator hardware or, if it runs on ist own HW, it should be possible to connect it to the Demonstrator	ULM	Eva Peter-A2H	Check: Y/N	system	non-functional	high	4

R_EN2_model2.7	Verification	HMT	The driver model for intention recognition must not safe any personal data in an not anonymized way.	ULM	Eva Peter-A2H	Check: Y/N	user	non-functional	high	4

4.5.4 Definition of requirements and metrics for Enabler 3.1

Name: Integrated vehicle and Situation Model

Enabler Type: Model

Owner: DLR, OFF

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority Level	TRL
R_EN3_model1.1	Verification	DLR	The integrated model must combine data-, object- and sensor-fusion with probabilistic modelling techniques to represent the spatial relations and physical states of the vehicle and all objects in the environment	ULM	Peter-A2H	Check: Y/N	system	functional	high	4
R_EN3_model1.2	Validation	DLR	The integrated model must estimate the spatial relationship of the vehicle from all objects in the environment with probabilistic modelling techniques	ULM	Peter-A2H	CR of the estimation: - >90% acceptable	system	functional	high	4
R_EN3_model1.3	Validation	DLR	The integrated model must predict possible evolutions of the traffic situation in respect to potential interventions of the driver	ULM	Peter-A2H	CR of the prediction - >90% acceptable	system	functional	low	4
R_EN3_model1.4	Validation	DLR	The integrated model must predict possible evolutions of the traffic situation in respect to potential interventions of the automation	ULM	Peter-A2H	CR of the prediction - >90% acceptable	system	functional	low	4

R_EN3_model1.5	Verification	ULM	The integrated model must represent possible evolutions of the traffic situation in respect to potential interventions of the driver	ULM	Peter-A2H	Check: Y/N	system	functional	low	4
R_EN3_model1.6	Verification	DLR	The integrated model must represent possible evolutions of the traffic situation in respect to potential interventions of the automation	ULM	Peter-A2H	Check: Y/N	system	functional	low	4

4.5.5 Definition of requirements and metrics for Enabler 3.2

Name: Road Boundary based Safety Corridor

Enabler Type: Algorithm

Owner: DLR

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority Level	TRL
R_EN5_alg1.1	Verification	OFF	The algorithm must be able to provide a set of safety corridors, indicating areas in which the probability of collision with a single other object is below a user-defined threshold	ULM, VED, CRF	Peter-A2H	Check: Y/N	system	functional	high	4
R_EN5_alg1.3	Verification	OFF	The algorithm must be able to return a safety corridor with a fixed frequency required and guaranteed by the demonstrator owner.	ULM, VED, CRF	Peter-A2H	Check: Y/N	system	non-functional	high	4

4.5.6 Definition of requirements and metrics for Enabler 4.1

Name: Planning and execution of safe manoeuvre

Enabler Type: Model

Owner: ULM

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority Level	TRL
R_EN4_model1.1	Verification	OFF	The model must be able to provide corridors which are safe, trackable by vehicle controller, and comfortable.	ULM, VED	Martha Peter-A2H	Acceleration < 5m/s^2	system	functional	high	4
R_EN4_model1.10	Validation	ULM	The planning time of the algorithm must be less than 500ms, since Literature, experiment and experience show that 50-500ms are acceptable to react to environment changes.	ULM, VED	Martha Peter-A2H	Planning time <= 500ms	system	functional	high	4
R_EN4_model1.11	Validation	ULM	Trajectory planning must be able to plan an overtaking trajectory	ULM	Peter-A2H	Collision free AND planning time <= 500ms	system	functional	high	4

4.5.7 Definition of requirements and metrics for Enabler 4.2

Name: Learning of intention from the driver

Enabler Type: Model

Owner: HMT

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority Level	TRL
R_EN4_model2.2	Validation	HMT	The model must be able to learn (online) the driver's preferred decisions in specific situations	ULM	Eva Peter-A2H	CR of the recalibration >= CR of the initial model	system	functional	high	4
R_EN4_model2.3	Verification	HMT	The model must be able to modify/update the parameters of driver model	ULM	Eva Peter-A2H	Check: Y/N	system	functional	high	4
R_EN4_model2.4	Validation	HMT	The model must only learn from safe driving behaviour and decisions	ULM	Eva Peter-A2H	CR for the recognize: - < 90% not acceptable - >90% acceptable	system	non-functional	low	4
R_EN4_model2.5	Verification	HMT	The model must only learn from safe driving behaviour and decisions	ULM	Eva Peter-A2H	Check: Y/N	system	non-functional	low	4
R_EN4_model2.6	Verification	HMT	Online Learner should implement an interface to the Online Risk Assessment	ULM	Eva Peter-A2H	Check: Y/N	system	non-functional	low	4

R_EN4_model2.7	Verification	HMT	The online learning module must not safe any personal data in an not anonymized way.	ULM	Eva Peter-A2H	Check: Y/N	user	non-functional	high	4
R_EN4_model2.8	Verification	HMT	The model must be integrable in the demonstrators	ULM	Eva Peter-A2H	Check: Y/N	system	non-functional	high	4
R_EN4_model2.9	validation	HMT	The update procedure must be sufficiently fast	ULM	Eva Peter-A2H	time required for update < 500ms	system	non-functional	low	4

4.5.8 Definition of requirements and metrics for Enabler 5.1

Name: Online Risk Assessment

Enabler Type: Algorithm

Owner: OFF, DLR

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority Level	TRL
R_EN5_alg1.2	Validation	OFF	The difference between the probability of collision guaranteed by the safety corridors and the real probability of collision is below a threshold	ULM, VED, CRF	Eva Martha Peter-A2H	Difference: - < 5 * prediction horizon in seconds % acceptable	system	non-functional	low	4
R_EN5_alg1.4	Verification	OFF	The online risk assessment must provide a unified interface to be integrable in the TeamMate architecture	ULM, VED, CRF	Eva Martha Peter-A2H	Check: Y/N	system	non-functional	high	4
R_EN5_alg1.5	Validation	OFF	The online risk assessment must determine the safety level of a planned trajectory based on a set of pre-defined metrics	ULM, VED, CRF	Eva Martha Peter-A2H	CR for safe trajectory - >90% safe	system	functional	high	4
R_EN5_alg1.6	Verification	OFF	The online risk assessment must be able to assess the safety of a planned trajectory based on a set of pre-defined metrics	ULM, VED, CRF	Eva Martha Peter-A2H	Check: Y/N	system	functional	high	4

R_EN5_alg1.7	Verification	OFF	The online risk assessment must not safe any personal data in a not anonymized way.	ULM, VED, CRF	Eva Martha Peter-A2H	Check: Y/N	user	non-functional	high	4

4.5.9 Definition of requirements and metrics for Enabler 6.1

Name: TeamMate HMI

Enabler Type: HMI

Owner: ULM, REL

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority level	TRL
R_EN6_HMI1.1	Verification	ULM	The ambient light must clarify the driving mode (e.g. the takeover requests)	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.2	Verification	ULM	The interaction strategy should be usable according to ISO 9241-11	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	non-functional	low	5
R_EN6_HMI1.3	Verification	ULM	The most efficient channels of communications should be included according to the mode	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	non-functional	low	4
R_EN6_HMI1.4	Verification	REL	The HMI must have different states for each automation mode	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.5	Verification	REL	The HMI must show the Take Over Request on the cluster and mirror it on the Central Stack Display and the HUD	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6

R_EN6_HMI1.6	Verification	REL	The overall HMI concept must include a strategy to modify the ambient lights to improve the driver awareness on the automation state	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.7	Verification	REL	The HMI must have 3 visual displays: - an instrument cluster - a Central Stack Display - a Head Up Display	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.8	Verification	REL	In TeamMate mode the HMI must show the possibility to interact with it through vocal interaction	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	low	6
R_EN6_HMI1.9	Verification	REL	Navigation info and surrounding view must be visible on the instrument cluster both in automatic and manual mode	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.10	Verification	REL	In MtoA transition mode, the Instrument cluster must show the correct handover through a popup that informs the driver of the current transition	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.11	Verification	REL	Infotainment features must be mirrored on the instrument cluster only in Automatic Mode	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	low	6
R_EN6_HMI1.12	Verification	REL	In TeamMate mode, the HMI must show the suggested manoeuvre through animated features	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6

R_EN6_HMI1.13	Verification	REL	In Manual mode, the Central Stack Display must show redundant information on navigation and surrounding situation	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.14	Verification	REL	In Automatic mode, the Central Stack Display must allow to reach all the features of the NIT navigation menu	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.15	Verification	REL	In Manual mode, in MtoA transition mode and in emergency mode the Central Stack Display must allow to reach only some features of the navigation menu (e.g. it should not be possible to reach the "Messages", "Web" and "Settings" items)	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	low	6
R_EN6_HMI1.16	Verification	REL	In Automatic to Manual transition mode (TOR activated) the Central Stack Display shouldn't allow to navigate the menu	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.17	Verification	REL	In manual mode, the HUD must provide crucial information on navigation (e.g. current speed, navigation info, speed limit)	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.18	Verification	REL	A HUD must be provided for Manual mode and for Automatic to Manual transition mode	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6

R_EN6_HMI1.19	Verification	REL	The HMI must integrate all relevant information on traffic, driver and automation	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	5
R_EN6_HMI1.21	Verification	REL	NCDC must display when the automated driving mode is switched on/off	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.22	Verification	REL	The HMI must clarify driver's and system's responsibility in order to prevent mode confusion	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.23	Verification	REL	NCDC must display the information on lateral vehicle control and the longitudinal vehicle control	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	5
R_EN6_HMI1.24	Validation	BIT	NCDC must display different map representations (short term as well as long term) to intuitively show imminent risks	ULM,VED, CRF,REL	Eva Peter Martha	Correct rate of recognition of imminent risks CR > 90% acceptable	user	functional	low	4
R_EN6_HMI1.25	Verification	ULM	The HMI should offer different actions on a manoeuvre level to the driver	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.26	Validation	ULM	The HMI must be understood by the driver when shows the different actions on a manoeuvre level	ULM,VED, CRF,REL	Eva Peter Martha	CR for understanding level - >90% acceptable	user	Non-functional	high	6

R_EN6_HMI1.27	Verification	REL	The HMI should select the right channel of communication at the right moment depending on the driver and traffic situation	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.28	Verification	REL	The HMI must always make the driver aware on how to intervene	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	non-functional	high	6
R_EN6_HMI1.29	Verification	REL	More than one channel of communication should be provided to the driver other than visual UI, including acoustic feedbacks (i.e. speech recognition, microphones, cameras, haptic feedbacks, speakers)	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.30	Verification	REL	Driver must be alerted of possible dangers by using stimuli of different modalities	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.31	Validation	REL	The performance of human-automation interaction must be evaluated by measuring: - attention allocation efficiency - mission effectiveness - driver physical comfort and fatigue trust in the system - user acceptance	ULM,VED, CRF,REL	Eva Peter Martha	CR for mission effectiveness - >90% acceptable	user	non-functional	low	6

R_EN6_HMI1.36	Validation	REL	The different HMI modes visualized in the driving cluster must be recognized by the driver.	ULM,VED, CRF,REL	Eva Peter Martha	CR for understanding level Situation Awareness	user	non-functional	high	6
R_EN6_HMI1.37	Validation	VED	The crucial ambient light modes must be understood by the driver (automated mode, emergency mode)	ULM,VED, CRF,REL	Eva Peter Martha	CR for understanding level < 90% not acceptable >90% acceptable	user	non-functional	high	6
R_EN6_HMI1.38	Validation	ULM	The takeover transition time from automated to manual mode must be long enough to rebuild attention of the driver and to bring him in the loop.	ULM,VED, CRF,REL	Eva Peter Martha	Take Over Success < 90% not acceptable >90% acceptable Driver Workload, Reaction time	user	non-functional	high	6
R_EN6_HMI1.39	Verification	ULM	The system must provide a way of intervention by the driver in non-crucial situations.	ULM,VED, CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.40	Validation	ULM	The system must distinguish between intentional and unintentional intervention.	ULM,VED, CRF,REL	Eva Peter Martha	Threshold for steering wheel angle (e.g. 2 degrees) or braking pedal position	user	non-functional	high	6

R_EN6_HMI1.43	Validation	REL	The use of multimodal elements in the HMI must increase the level of situation awareness	REL	Eva Peter Martha	SA (SAGAT) > 0	user	functional	high	6
R_EN6_HMI1.44	Validation	REL	The HMI must make the driver able to predict the relation among the HMI states (e.g. stable and transition)	REL	Eva Peter Martha	Correct rate: > 90%	user	functional	high	6
R_EN6_HMI1.45	Validation	REL	The user should always be aware of the automation state	REL	Eva Peter Martha	Correct rate: > 90%	user	functional	high	6
R_EN6_HMI1.46	Validation	REL	When a limit occurs, the user should be aware of the agent that has a limit	REL	Eva Peter Martha	Correct rate: > 90%	user	functional	high	6
R_EN6_HMI1.47	Validation	REL	When a support is needed, the user should be aware of the type of expected cooperation	REL	Eva Peter Martha	Correct rate: > 90%	user	functional	high	6
R_EN6_HMI1.48	Validation	REL	The user should be able to understand the message communicated by the driver	REL	Eva Peter Martha	Correct rate: > 90%	user	functional	high	6
R_EN6_HMI1.49	Validation	REL	The user should be able to predict in which HMI mode will be after the support	REL	Eva Peter Martha	Correct rate: > 90%	user	functional	high	6
R_EN6_HMI1.50	Validation	REL	The H2A support in perception should be less demanding then the H2A support in action	REL	Eva Peter Martha	NASA TLX Support in perception < support in action	user	functional	high	6

4.5.10 Definition of requirements and metrics for Enabler 6.2

Name: Augmented Reality HMI

Enabler Type: HMI

Owner: HMT

ID	Verification/ validation	Req. Owner	Description	Demo Owner	Use Cases	Metric	Type	Nature	Priority level	TRL
R_EN6_HMI1.20	Verification	REL	The HMI must show safe driving corridors and constraints on these corridors using graphical means	ULM,VED,CRF,REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.33	Verification	REL	In manual mode augmented reality (AR) elements should be reduced to a minimum and not distract the driver.	ULM, REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.34	Verification	REL	In automated mode, augmented reality elements can be used to enhance the situation awareness.	ULM, REL	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.35	Validation	REL	In automated mode, the manoeuvres performed by the vehicle must be comprehensible for the driver through graphical visualizations.	ULM, REL	Eva Peter Martha	CR for understanding level >90%	user	functional	high	6

R_EN6_HMI1.41	Validation	HMT	The HMI should communicate to the driver why the automation is acting in a certain manner in an understandable way.	ULM,REL	Eva Peter Martha	Situation awareness	user	non-functional	high	6
R_EN6_HMI1.42	Validation	HMT	The driver needs to understand the meaning of the overtaking corridor visualized through AR.	ULM,REL	Eva Peter Martha	CR for understanding level	user	non-functional	high	6
R_EN6_HMI1.51	Validation	HMT	The HMI must show safe driving corridors and constraints on these corridors using graphical means	ULM	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.52	Validation	HMT	In manual mode, augmented reality (AR) elements should be reduced to a minimum to not distract the driver.	ULM	Eva Peter Martha	Check: Y/N	user	functional	high	6
R_EN6_HMI1.53	Validation	HMT	In automated mode, augmented reality elements can be used to enhance the situation awareness.	ULM	Eva Peter Martha	CR for understanding level >90%	user	non-functional	high	6
R_EN6_HMI1.54	Validation	HMT	In automated mode, the manoeuvres performed by the vehicle must be comprehensible for the driver through graphical visualizations.	ULM	Eva Peter Martha	CR for understanding level >90%	user	functional	high	6

R_EN6_HMI1.55	Validation	HMT	The HMI should communicate to the driver why the automation is acting in a certain manner in an understandable way.	ULM	Eva Peter Martha	CR for understanding level >90%	user	non-functional	high	6
R_EN6_HMI1.56	Validation	HMT	The driver needs to understand the meaning of the overtaking corridor visualized through AR.	ULM	Eva Peter Martha	CR for understanding level	user	non-functional	high	6

4.5.11 Definition of requirements and metrics for Enabler7

Enabler 7, the TeamMate system architecture can be interpreted as an aggregation of all other enablers. Requirements will be described in deliverable D5.4.

4.6 Definition of baseline car and key performance indicators

This section provides a description of the baseline and key performance indicators (KPIs) for each demonstrator. In particular, it includes:

- The description of the baseline that each demonstrator owner plans to use for the evaluation experiments in WP6.
- The high-level description of the key performance indicators, which are used to demonstrate TeamMate concept against the baseline.
- The description of the detailed KPIs used to measure the aforementioned performances.

This information is exploited in WP6 (T6.1) to define and plan experiments to actually conduct the evaluation of the demonstrators against their baseline.

In this context simulators and vehicles are considered as demonstrators. In this way, it is possible to evaluate different features and solutions developed in the AutoMate project in different scenarios, e.g. with different grades of automation.

Moreover, it seems clear that some KPIs can’t be evaluated in real traffic conditions. For example, it wouldn’t be possible to evaluate safety-related KPIs in real vehicles: therefore, some of these KPIs (e.g. number of accidents) will be evaluated in driving simulators. The tools and models (i.e. the enablers) developed in AutoMate will be implemented in both types of demonstrators. In the 3rd cycle, the evaluation process will be conducted in the simulators and real vehicles.

So, it will be possible to assess the solutions developed in the AutoMate context against their baseline, in order to highlight the progress of these features beyond the state of the art.

The KPIs and KPI categories have been refined in D6.1 to evaluate different aspects of the TeamMate car concept and in order deal with different directions of cooperation (H2A and A2H).

KPI category	KPI name	KPI Description
Safety	number of accidents	number of accidents that the vehicle got involved in during the experiment
Safety	number of second thoughts	number times the driver attempts an overtake but then drives the car back to the original lane
Safety	Driver's reaction time in H2A support	time between the HMI has provided the information of request of support to the driver and the start of reaction
Safety	time to enter roundabout	how long the vehicle takes to enter the roundabout
Safety	time to start the overtaking	how long the vehicle takes to start the overtaking
Trust	trust in automation	questionnaire described in the Foundations for an empirically determined scale of trust in automated systems
Acceptance	Acceptance	determine acceptance based on Technology Acceptance Mode
Acceptance	Workload and frustration	measure the workload and frustration of the driver, by using the NASA-TLX questionnaire
User Experience	Usability	measured by the standard SUS questionnaire
Willingness to buy	Willingness to buy	questionnaire with 2 5-point Likert questions about the willingness to buy of the TeamMate car and a fully autonomous vehicle

Table 2: KPIs overview

4.6.1 Baseline and KPIs for the ULM demonstrator

The baseline for the ULM Demonstrator is a car defined as a highly automated vehicle SAE level 3, without any TeamMate features. This baseline will be used for evaluation against the TeamMate car features, which will be implemented in a simulator and a real vehicle. This allows the testing of various developments, e.g. HMI-versions, which can all be implemented in the simulator and only partly in the vehicle due to hardware restrictions. Therefore, in the following sections we divide into the simulator and vehicle implementations.

4.6.1.1 ULM simulator baseline implementation and KPIs

As mentioned in D6.1 the ULM simulator demonstrator will be evaluated by considering the PETER scenario, use-case 1: H2A support in perception and use-case 2: A2H support in action.

Thus, two different baselines for the evaluation were defined:

1. H2A use case: aimed at demonstrating the added value of the driver, thus the baseline is the autonomous driving without any intervention of the driver
2. A2H use case: aimed at demonstrating the role of the automation to immediately and efficiently address safety-critical conditions, thus the baseline is manual driving without support of the automation.

For the H2A use case, the TeamMate system should able to improve the following aspects, compared to the baseline:

- comfort,

- the efficiency of the manoeuvre,
- usability,
- trust and the acceptance of the systems. In addition, time to focus attention back on the roadway and reaction time to take over lateral control, and number of accidents during the overtaking manoeuvre are important KPIs with regard to safety.

For the A2H use case the TeamMate system should improve the safety of the manoeuvre.

Thus, the KPIs for the PETER scenario are linked to the efficiency, the comfort, the acceptance and the trust, as well as the safety.

Scenario	Direction and type of support	Baseline	Aim of the evaluation	KPI category	KPI	KPI ID
PETER	H2A in perception	Autonomous driving	Measure the added value of the support of the driver to the automation to improve the efficiency as well as the comfort (and, as a consequence, the trust and acceptance) overtaking the tractor	Efficiency	Time to start the overtaking	KPI1
				Trust	Trust in automation	KPI2
				Acceptance	Acceptance	KPI3
					Workload and frustration	KPI4

	A2H in action	Manual driving	Quantify the added value of the support of the automation to improve the safety of the driver	Safety	Number of accidents (with vehicles in the opposite direction)	KPI5
					Number of second thoughts	KPI6

Table 3: KPIs of the ULM simulator

According to the different scenarios and use cases, the following KPIs, which cannot be used for the baseline, will be also considered in order to collect important information on the performance of the TeamMate car:

- Usability
- Driver's reaction time in H2A support
- Intention to buy

4.6.1.2 ULM vehicle baseline implementation and KPIs

As described in D6.1, for the ULM vehicle the PETER scenario is representative of a limit of the automation: in a rural road, the automation may not be able to overtake a tractor.

In order to improve the efficiency of the manoeuvre, the automation can ask for support from the driver (either in perception or in action).

In cycle 3 the use case 2 "H2A support in perception" will be evaluated. The evaluation is aimed at demonstrating the added value of the driver, thus the baseline is the driverless approach (i.e. the autonomous driving without any intervention of the driver).

The KPIs selected for this scenario are the same as the ones identified for the H2A support of the ULM simulator demonstrator, linked to the efficiency, the acceptance and the trust (as shown in Table 7).

Scenario	Direction and type of support	Baseline	Aim of the evaluation	KPI category	KPI	KPI ID
PETER	H2A in perception	Autonomous driving	Measure the added value of the support of the driver to the automation to improve the efficiency as well as the comfort (and, as a consequence, the trust and acceptance) overtaking of the tractor.	Efficiency	Time to start the overtaking	KPI1
				Trust	Trust in automation	KPI2
				Acceptance	Acceptance	KPI3
					Workload and frustration	KPI4

Table 4: KPIs of the ULM vehicle

According to the different scenarios and use cases, the following KPIs, which cannot be used for the baseline, will be also considered in order to collect important information on the performance of the TeamMate car:

- Usability

- Driver's reaction time in H2A support
- Intention to buy

4.6.2 Baseline and KPIs for the VED demonstrator

The baseline for the VEDECOM Demonstrator is a car without any TeamMate features. This baseline will be used for evaluation against the TeamMate car features in a simulator and a real vehicle. Both demonstrators will be evaluated by considering the MARTHA scenario.

4.6.2.1 VED simulator baseline implementation and KPIs

Use case for the support of the driver to the automation (H2A in action) and the use case for the support of the automation to the driver (A2H in perception and in action) have been selected to evaluate the added value of the TeamMate approach (i.e. the cooperation).

This requires the definition of two different baselines for the evaluation:

1. H2A use case: the evaluation is aimed at demonstrating the added value of the driver, thus the baseline is the driverless approach (i.e. the autonomous driving without any intervention of the driver)
2. A2H use case: the evaluation is aimed at demonstrating the role of the automation to promptly and efficiently address safety-critical conditions, thus the baseline is the manual driving (i.e. when there is no support of the automation)

The VED demonstrator aims to demonstrate that the TeamMate car improves the driving experience compared to a baseline car with respect to:

- Safety of the driver
- Acceptance and trust in vehicle’s decisions and behaviours (i.e. in automation).

The KPIs that will be used to measure the added value of the H2A support in action concern mainly safety, acceptance, efficiency and trust.

On the other hand, the A2H support is mainly provided to improve the safety of the driver. So, for the A2H use case, the aim of the evaluation is to measure how the TeamMate system is able to improve the safety of the manoeuvre. Moreover, TeamMate’s decision to activate Automated Mode is based on the fact that the driver is distracted, and does not change his risky behaviour with the warning. Therefore, trust is fundamental in the driver’s decision to accept the support in action of the automation, instead of wrestling for control with the TeamMate car. The earlier the Automated Mode is activated in this use-case, the safer and more efficient the specific driving situation would be.

The KPIs selected for the MARTHA scenario are thus linked both to the efficiency, the acceptance and the trust, as well as the safety (as shown in Table 5).

Scenario	Direction and type of support	Baseline	Aim of the evaluation	KPI category	KPI	KPI ID
MARTHA	H2A in perception	Autonomous driving	Measure the added value of the support of the driver to the automation to improve the efficiency as well as the comfort (and, as a consequence, the trust and acceptance)	Efficiency	Time to start the lane change to avoid the roadworks	KPI1
				Trust	Trust in automation	KPI2
				Acceptance	Acceptance	KPI3
					Workload and frustration	KPI4
	A2H in action	Manual driving	Quantify the added value of the support of the automation to improve the safety of the driver	Safety	Number of accidents	KPI5
					Number of disengagements or safe manoeuvre	KPI6

Table 5: KPIs of the VED simulator

The evaluation process foresees a comparison between the same KPIs for the baseline and the demonstrator. Therefore, some KPIs that are relevant to measure the specific performances of the TeamMate car have not been selected because they cannot be used for the baseline.

According to the different scenarios and use cases, the following KPIs will also be considered in order to collect important information on the performance of the TeamMate car:

- Usability
- Driver's reaction time in H2A support
- Intention to buy

4.6.2.2 VED vehicle baseline implementation and KPIs

The MARTHA scenario is considered a representative test case for a specific limitation of the automation: in case of roadworks, the automation may not be able to *detect the lanes* to safely drive in Automated Mode.

As a consequence, the automated vehicle may unexpectedly handover the control to the driver (the so called "disengagement") and this situation represents a safety critical condition for the driver (as already explained in the previous sections).

In order to improve the efficiency of the manoeuvre, and especially to avoid the safety critical disengagement, the automation can ask for support of the driver (H2A in action).

For this H2A use case, the evaluation is aimed at demonstrating the added value of the driver, thus the baseline is the driverless approach (i.e. the autonomous driving without any intervention of the driver)

VED demonstrator aims to demonstrate that the TeamMate car improves the driving performance / experience compared to a baseline car with respect to:

- reaction time
- acceptance and trust in vehicle's decisions and behaviours (i.e. in automation).

The KPIs that will be used to measure the added value of the H2A support in action concern mainly safety, acceptance, efficiency and trust (as shown in Table 6). For the KPIs used to measure the safety, only the number of disengagements has been considered in the real environment (while in the VED simulator also the number of accidents and near misses has been taken into consideration).

Scenario	Direction and type of support	Baseline	Aim of the evaluation	KPI category	KPI	KPI ID
MARTHA	H2A in action	Autonomous driving	Measure the added value of the support of the driver to the automation to improve the efficiency as well as the safety (and, as a consequence, the trust and acceptance)	Efficiency	Time to start the lane change to avoid the roadworks	KPI1
				Trust	Trust in automation	KPI2
				Acceptance	Acceptance	KPI3
				Safety	Number of disengagements or safe manoeuvre	KPI4

Table 6: KPIs of the VED vehicle

The evaluation process foresees a comparison between the same KPIs for the baseline and the demonstrator. Therefore, some KPIs that are relevant to measure the specific performances of the TeamMate car have not been selected because they cannot be used for the baseline.

According to the different scenarios and use cases, the following KPIs will also be considered in order to collect important information on the performance of the TeamMate car:

- Usability
- Driver's reaction time in H2A support
- Intention to buy

4.6.3 Baseline and KPIs for the REL and the CRF demonstrators

In this section, the baselines for REL and CRF demonstrators are illustrated, which are a driving simulator and a real vehicle, respectively.

Both the REL and CRF demonstrator will be evaluated using the EVA scenario, which has been identified as a representative test case for a specific limitation of the automation: as already discussed in previous deliverables, entering a roundabout is a well-known issue for the autonomous driving [[2]] in terms of efficiency and comfort.

The dense traffic conditions near the roundabout and the different directions of the other vehicles can dramatically affect the time to enter the roundabout which in turn can create frustration and reduce the acceptance of the driver.

[2] http://theconversation.com/budget-2017-uks-driverless-cars-stuck-on-testing-roundabout-87805

4.6.3.1 REL simulator baseline implementation and KPIs

Since the demonstrator is aimed to show the value of the driver to support the automation, the baseline is represented by an autonomous driving condition where the driver has no role in the cooperation (i.e. the so called "driverless" approach). The potential drawback of the baseline is the inefficient manoeuvre execution, since the driver cannot support the automation.

In order to improve the efficiency of the manoeuvre, the automation of the TeamMate car requests support from the driver (either in perception or in action).

Therefore, the use case for the H2A support in perception and action has been selected to evaluate the added value of the cooperative TeamMate approach in the REL demonstrator.

In this use case, the automation is in charge of the vehicle control, while the driver perceives the traffic in the roundabout. If the driver confirms that there is enough room to enter the roundabout, the TeamMate car performs the entering manoeuvre autonomously. Additionally the car asks for the activation of the Shared Control, since there are no lane markings on the road. The car waits until the support in action is given and the driver takes the lateral control.

The aim of the REL demonstrator is to demonstrate the benefit of the TeamMate car compared to the baseline, in particular to:

- increase the manoeuvre efficiency,

- high levels of acceptance and trust (in order to foster its adoption and have a real impact on road safety).

The KPIs selected for this scenario are mainly linked to the efficiency, the comfort, the acceptance and the trust (as shown in Table 7).

Scenario	Direction and type of support	Baseline	Aim of the evaluation	KPI category	KPI	KPI ID
Eva	H2A in perception and action	Autonomous driving	Measure the added value of the support of the driver to the automation to improve the efficiency as well as the comfort (and, as a consequence, the trust and acceptance) entering the roundabout.	Efficiency	Time to enter the roundabout	KPI1
				Trust	Trust in automation	KPI2
				Acceptance	Acceptance	KPI3

Table 7: KPIs of the REL demonstrator

The evaluation process foresees a comparison between the same KPIs for the baseline and the demonstrator. Therefore, some KPIs that are relevant to measure the specific performances of the TeamMate car have not been selected because they cannot be used for the baseline.

According to the different scenarios and use cases, the following KPIs will also be considered in order to collect important information on the performance of the TeamMate car:

- Usability
- Driver’s reaction time in H2A support
- Workload
- Frustration
- Willingness to buy

4.6.3.2 CRF vehicle baseline implementation and KPIs

The baseline for the CRF demonstrator is an automated car, where the automation is in charge of driving until specific environment / scenario conditions which cannot be handled by the automation trigger a take-over request. This solution is affected by the issue called “the paradox”, or “the irony”, of the automation[3]. The problem is that the designer/engineer who tries to eliminate the operator, still leaves the operator to do the tasks which the designer cannot think how to automate, or that the automation is not able to solve. In addition, in the full automation approach, the communication of the system to the driver is still done in old ADAS perspective: the system tells the driver what s/he can do/do not and when.

The added value expected by the use of the TeamMate car is that the driver and automation are members of the same team, which have a common framework of reference, taking into account the respective status, the dynamic state of the vehicle and the condition of the environment.

The aim of the CRF prototype vehicle is to demonstrate the benefit of the TeamMate car compared to the baseline with regard to:

- Safety of the driver,
- High levels of acceptance and trust.

[3] L. Bainbridge. Ironies of automation. Automatica, vol. 19, no. 6, pp. 775-779, 1983.

The aim of the evaluation is to measure how the TeamMate car is able to improve the safety, trust and acceptance. Therefore, the KPIs for this scenario are listed in the following table:

Scenario	Direction and type of support	Baseline	Aim of the evaluation	KPI category	KPI	KPI ID
Eva	H2A in perception and in action	Autonomous driving, with basic HMI with ADAS perspective (system always tells what to do and when)	Measure the added value of the support of the driver to the automation to improve the safety and the efficiency, as well as the comfort, when entering the roundabout.	Safety	Number of TOR satisfied; number of Emergency Stop / Override actions	KPI1
				Trust	Trust in automation	KPI2
				Acceptance	Acceptance	KPI3

Table 8: KPIs of the CRF demonstrator

The evaluation process foresees a comparison between the same KPIs for the baseline and the demonstrator. According to the different scenarios and use cases, other KPIs can be taken into account during the tests execution.

5 Conclusion

WP1 has no planned activities until the end of the 3rd cycle. However, according to the PERT schema shown in Figure 2Figure 2, the activities of WP1 have the following impact on the other WPs in the 3rd cycle:

- T2.1, T3.1 and T4.1 will focus on the definition of plans and experiments for the V&V of the enablers that will be conducted in T2.5, T3.6 and T4.5 against the requirements and measurable metrics defined in T1.3.
- T6.1 will focus on the definition of plans and experiments for the evaluation of the demonstrators that will be conducted in T6.2, T6.3 and T6.4 against the baseline and KPIs defined in T1.3.
- T6.5 will collect the V&V results for the enablers and the preliminary evaluation for the demonstrators to assess the achievement of the progress on all project objectives.