D1.3 - Definition of framework, scenarios and requirements incl. KPIs & Baseline for 2nd cycle (Revised)

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Executive summary

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 initial definition of the TeamMate car concept, the scenario and use-case definition and requirements specification in D1.1. In this document you can find preliminary versions of all of these aspects. During the first project cycle some of these aspects have been further detailed, specified and clarified in order to be effectively used for project cycle 2, especially the technology development and the V&V&E activities.

Within this document, you will find an update on the use-case descriptions which mostly specify in more detail the aspects covered in the respective use-case. This is to help implement the use-cases in the actual demonstrators.

Furthermore, this document clarifies the terms verification, validation and evaluation within the AutoMate project and presents an overall framework to be used by the other work packages (WPs) for a coordinated and consistent V&V&E phase. This overall framework includes also a description of the assessment plan for the achievement of the project objectives, which will be linked to the results of the V&V&E activities linked to the enablers and the demonstrators.

Concerning the requirements, the process for the requirements definition and specification of metrics has been refined and improved. The outcome is a common approach for V&V of all enablers. Therefore, the preliminary versions of the requirements from D1.1 were further refined and matched to the enablers, in order to clearly identify measurable metrics to assess. WP1 also includes the definition of the baseline and key performance indicators (KPIs) for the evaluation phase. Therefore, in this document, preliminary versions of

all baselines of the demonstrators have been specified as well as a current set of KPIs for each demonstrator.

1 Introduction

This document describes the progress of the initial work in WP1 concerning the scenario and use case development (task 1.2) in section 2 and the definition of requirements, KPIs & Baseline car (task 1.3) in section 3. Within the update for cycle 2, some structural changes concerning the verification, validation and evaluation activities were performed, i.e. an overall approach was defined in WP1, task 1.3. Details of this framework are also presented in section 3 of this document. Finally, an outlook of the next steps in WP1 is given in section 4.

2 Scenarios and use case development

In the first cycle of WP1 some changes have been done to the scenario and use-cases descriptions. The car owners updated within their scenario their use-cases in order to be more compliant with their objectives and/or to give more details of the TeamMate (TM) car. 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. For a complete overview of all scenario and use-case descriptions, please refer to the excel-file in Annex A.

2.1 Peter scenario updates (ULM demonstrator)

There have been no changes for the Peter scenario.
The Peter scenario is described as follows: “On a rural road, Peter is driving in full automation mode when the automation cannot overtake a large vehicle in front of the ego car due to sensors’ limitations and needs Peter’s help”.
As a summary, please find in the following list the current description of all use cases for the Peter scenario:

- **Use case 1:** TM car is waiting for the indication to overtake from the driver. Then it executes the manoeuver. There is no traffic, and weather conditions are good.

- **Use case 2:** TM car is waiting for the indication to overtake from the driver. The indication from the driver to overtake is in contradiction with the traffic situation. When the driver initiates overtaking, the system drives to the left lane and sees that it is not safe to overtake. Therefore, it drives back into initial lane and informs the driver that there is oncoming traffic and it is not possible to overtake right now.
- **Use case 3:** There are bad weather conditions. Due to a lack of road markings or bad road markings, the system prompts the driver to be very attentive. Then the overtaking manoeuver starts.
- **Use case 4:** Due to a curved street and not enough sight for the driver, the system thinks the driver is not able to decide if it is safe to perform an overtaking manoeuver. When the driver instructs the system to overtake, it refuses and explains it to the driver.
- **Use case 5:** TM car helps the driver to make a decision. Due to a massive tractor, the driver hesitates and thinks the road is too narrow to overtake. The system will give him feedback that the space on the other lane is wide enough but still needs Peter's help to decide if there is oncoming traffic. Then the overtaking is initiated by the driver and conducted by the system.
- **Use case 6:** The truck blocks the road because of an accident, but it is not allowed to overtake by the regulation. The driver has to overtake manually and the system must learn from this particular situation.

2.2 Martha scenario updates (VEDECOM demonstrator)

There have been no major changes for the Martha scenario. Some more details have been added to the use-case descriptions in order to clarify possibly misunderstanding wording.

The Martha scenario is described as follows:

"The TeamMate Car is driven in manual mode by Martha on an urban road. Martha, receives a text message and starts reading through. TeamMate detects that the driver is distracted and not attentive to the forward roadway anymore, thus, proposes the driver to activate automated mode".

As a summary, please find in the following list the current description of all use cases for the Martha scenario:

- **Use case 1:** In the first use case, Martha immediately confirms TeamMate's suggestion and activates the automated mode. After a while, TeamMate detects that the end of the automated driving zone is approaching via GPS. TeamMate sends a takeover request to Martha informing her that the end of the automated driving zone is approaching sufficiently in advance. Martha takes over manual control of the vehicle.
- **Use case 2:** Martha initially refuses TeamMate's suggestion to activate the automated mode. TeamMate detects via connectivity that there is a dangerous zone (roadwork) ahead. Thus, it repeats its suggestion to activate the automated mode with an explanation of the upcoming situation. Martha activates the automated mode.
- **Use case 3:** Martha rejects TeamMate's proposition to activate the automated mode and remains busy with her mobile phone. TeamMate has learned Martha's habitual driving behavior throughout her vehicle use. Eventually, it detects that Martha's driving behavior deviates from her normative driving style, such as driving close to the lane line and varying speed maintenance. Therefore, it proposes to switch to automated driving mode for a second time. Martha rejects TeamMate's suggestion for a second time and remains in manual control of the vehicle. TeamMate registers this response and does not make further

proposals.

- **Use case 4:** After refusing TM's proposition to switch to automated mode, Martha continues her text message and starts deviating from her habitual driving style. TeamMate repeats its proposition for a second time. Martha then complies with TeamMate’s suggestion, activates automated driving mode, and carries out her side activity. Upon finishing her side activity, she communicates to TeamMate that she wants to take over manual control. TeamMate verifies that the distracting situation is over and that Martha is attentive to the forward roadway again. TeamMate gives control back to Martha.
- **Use case 5:** TeamMate issues a takeover request as it approaches the end of the automated driving zone. However, it detects via the driver monitoring system that Martha is not attentive to the forward roadway. It, then, issues a warning indicating that she is distracted to drive safely in manual mode and proposes relevant information.
- **Use case 6:** Martha activates the automated mode while she is busy replying her text message and remains in automated mode afterwards. TeamMate detects via GPS that the end of the automated driving zone is approaching, thus, issues a takeover request to Martha sufficiently in advance. Martha does not take over manual control for a certain time (to be decided). The vehicle, thus, initiates a minimum risk manoeuvre (MRM) and informs Martha about its decision.

2.3 Eva scenario updates (CRF demonstrator)

The Eva scenario is described as follows:
“A TeamMate Car is driving through a complex roundabout with different traffic and driving status conditions”.
Regarding this scenario, several use-case changes have been done concerning

the details of descriptions, which are listed in the following section:

- **Use case 1:** is now more precise.

For example, the description for the TeamMate behavior was "Driver wants, System executes" and this has been changed to "Driver wants, system can execute, but driver is requested for supervision"

- **Use case 2:** was previously use case 3.

There are some minor changes in the description of the use-case and also in the scenario pictogram.

- **Use case 3:** was use case 5.

Here again, the order of the use-case was changed and some minor descriptions were changed.

- **Use case 4:** was use case 6.

The lane width was changed from normal to narrow and pedestrians are no longer considered in this use case. This is due to the fact that it is not clear whether this use-case can be implemented in the driving simulator.

- **Use case 5:** was use case 4.

No addition to this use case, just a minor simplification in the TeamMate behavior description.

- **Use case 6:** is added.

It replaces the previous use-case which was deleted. It was deleted since it didn't seem to have enough relevance for the project. This was the old use-case: "The TeamMate car is approaching the roundabout, but the system is not able to deal with the situation. It requires Eva's intervention." This use-cases was replaced by the following new description: "Driver is performing manually the roundabout, system (learns and) support him/her, monitoring the status and the environment (e.g. a pedestrian crossing the road ahead the TM car)".

As a summary, please find in the following list the current description of all use cases for the Eva scenario:

- **Use case 1:** “TM car is approaching the roundabout, and the system is able to deal with the situation. Eva does not need to intervene, but - due to the complexity of the situation - she is asked to supervise.”
- **Use case 2:** “TM car is approaching the roundabout, but the system is not able to deal with the situation (e.g. high traffic flow density). It requires Eva's intervention and she responds.”
- **Use case 3**: “TM car is approaching the roundabout, but there are road-blocks and it requires that Eva intervenes. However, she is distracted and the system needs to perform a recovery action to take her back the into the control loop.”
- **Use case 4:** “Eva is in "manual" mode and approaches a roundabout. She receives an incoming call and answers. TM car can deal with the situation and offers to take over the control”.
- **Use case 5:** “TM car is approaching the roundabout, but there are road-blocks and it requires that Eva intervenes. She starts changing lanes, but the system “sees” that it is not safe now, so it drives back into initial lane”.
- **Use case 6:** “Eva is driving manually and approaching the roundabout, the system (learns and) supports her, monitors her status and the environment (e.g. a pedestrian crossing the road ahead the TM car)”.

3 Overall verification, validation and evaluation framework

3.1 First cycle review

At the beginning of the 1st cycle, a set of high level requirements have been defined. They were meant to drive the initial concept and design of the enablers, thus they described how the enablers were expected to work in order to address the main issues of the development of the TM car. At that stage, the requirements were considered as a qualitative description of the most relevant features of the enablers.

However, during the further progression of the 1st cycle, the partners working in WP2-4 on the enablers started refining the requirements, in order to clearly identify measurable (i.e. quantitative) metrics to assess whether the enablers actually met the quality standards defined by the OEMs (PSA and CRF). During this refinement, the Risk Mitigation Plan defined in the Grant Agreement has been taken into consideration to define "strict rules for deriving metrics from requirements in terms of reliability and validity". Therefore, the overall process for the management of the requirements and the definition of measurable metrics has been refined and improved, and a common process for the Verification & Validation (V&V) of all enablers has been proposed. Moreover, since WP1, especially task 1.3, also includes the definition of the baseline and KPIs to evaluate the innovation of the demonstrators, the evaluation plan has been clearly defined as well, in order to provide the project partners with a complete and consistent verification & validation & valuation (V&V&E) framework. Finally, the process for the assessment of the achievement of the project objectives has been reviewed as well, and it has been included as a consistent part of the V&V&E.

3.2 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.

If the verification can be seen as the task of determining that the system is built according to its specifications, validation is the process of assessing its quality and determining that it actually fulfils the purpose for which it has been intended. Finally, the evaluation reflects the improvement of its performance against a baseline (i.e. the state of the art).

From the software engineering point of view:

- Verification **checks** whether the system under development is well-engineered, error-free, no 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 that the new system is innovative (i.e. it can bring benefits to its intended target).

In 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.

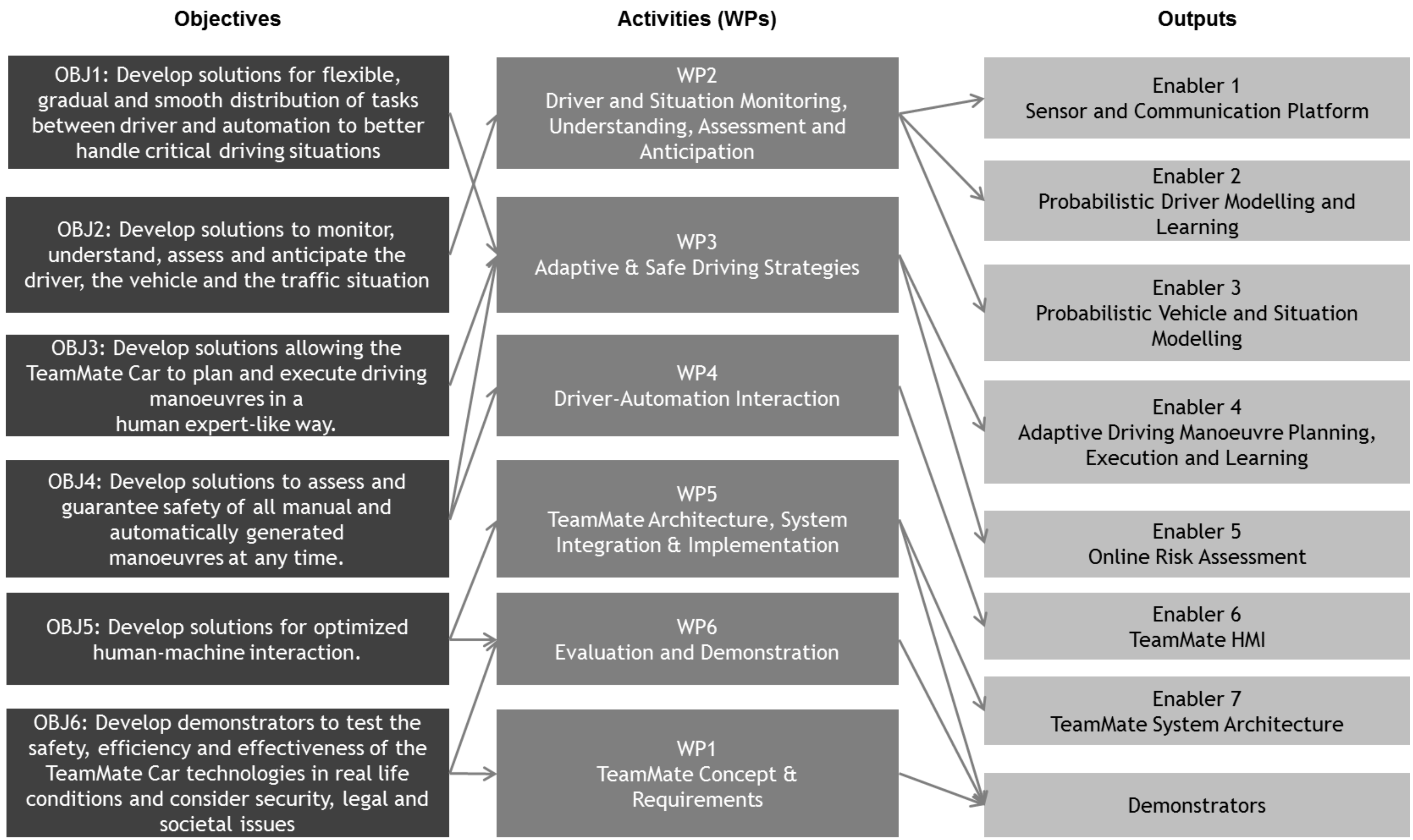

Figure 1 Schema to link the objectives to the enablers and the demonstrator

3.3 Definition of assessment of project objectives

As shown in Figure 1, the objectives 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 the project objectives can be linked to the achievement of the expected results of the enablers and demonstrators. With regard to the enablers, these expected results are the requirements and metrics to validate their quality and innovation. For the demonstrators, the expected results are linked to a set of target performance (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.

3.4 Impact on the other WPs and tasks

The refinement of the overall V&V&E process has also an impact on the activities of the other WPs and tasks that are expected to receive inputs from WP1. As shown in Figure 2, since the requirements are defined in T1.3 and they cannot be split apart from their metrics, from now on, all requirements and metrics for the enablers will be defined in T1.3, while T2.1, T3.1 and T4.1 will focus on the definition of the plan and the experiments for the V&V activities. Moreover, T6.5 will be also fed with the results of the V&V activities of the enablers (in addition to the iterative results of the evaluation of the demonstrators).

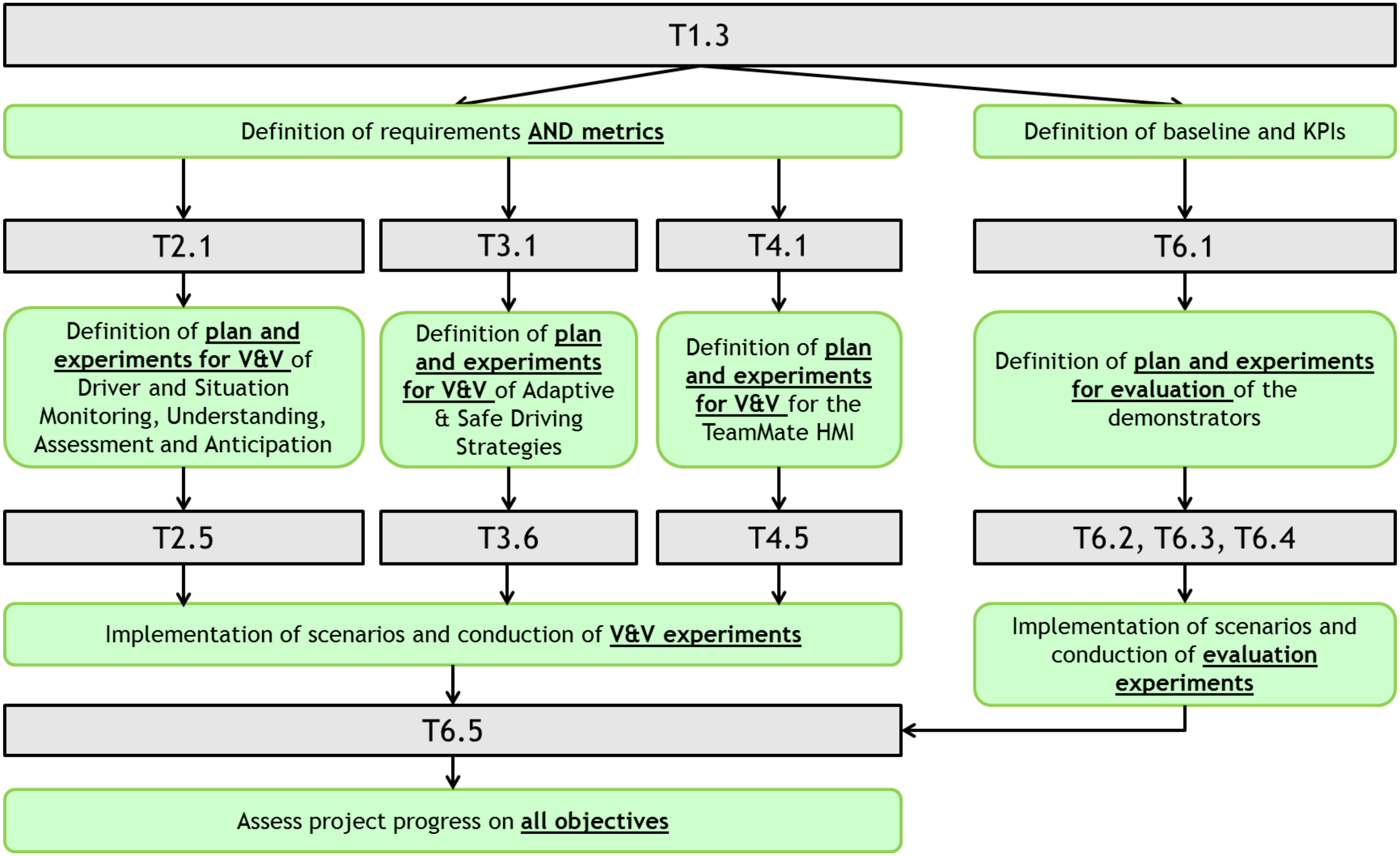

Figure 2 PERT to show the links between the WPs for the V&V&E activities and the achievement of the objectives

According to the schema shown in Figure 2, the following activities will be performed in the 2nd 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.

Moreover, these activities will have a clear impact on the corresponding deliverables in the 2nd cycle:

- D2.3, D3.4 and D4.3 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.
- D2.4, D3.5 and D4.4 will describe the results of the V&V activities for the enablers against the requirements and metrics defined in D1.3 and the plan and experiments described in D2.3, D3.4 and D4.3.
- D6.1 will include a reference to the baseline and KPIs as provided in this document and then it will focus on the description of plan and experiments for the evaluation of the demonstrators.
- D6.2 will describe the results of the evaluation of the demonstrators against the baseline and KPIs defined in D1.3 and the plan and experiments described in D6.1.

3.5 Definition of requirements and metrics for the 2nd cycle

During the 1st cycle, the high-level requirements have been refined and improved, and measurable metrics have been defined for all of them.
In order to collect the new improved requirements, the structure of the original excel file has been revised as well. In particular, a sheet has been created for each enabler, including the fields described in Table 1.

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 excel file is filled in in 2 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, that meets a specific requirement, into their demonstrator.

Therefore, the revised excel file will only include requirements whose development is related to a partner AND that will be actually integrated in a demonstrator.

The section 3.5 includes the list of all requirements and metrics defined at the end of the 1st cycle 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.

3.5.1 Definition of high level requirements for privacy and security

The recent General Data Protection Regulation (GDPR) has defined high level requirements for privacy and security that will be taken into consideration in Automate:

- Personal data shall be:
  a) processed lawfully, fairly and in a transparent manner in relation to the data subject ('lawfulness, fairness and transparency');
  b) collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes;
  c) adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed ('data minimisation');
  d) accurate and, where necessary, kept up to date;

e) kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed;
f) processed in a manner that ensures appropriate security of the personal data

- Requirements for the data management:
  a) the controller shall implement appropriate technical and organisational measures to ensure and to be able to demonstrate that processing is performed in accordance with this Regulation.
  b) the controller shall implement appropriate technical and organisational measures, such as pseudonymisation, which are designed to implement data-protection principles, such as data minimisation, in an effective manner and to integrate the necessary safeguards into the processing in order to meet the requirements of this Regulation
  c) The controller shall implement appropriate technical and organisational measures for ensuring that, by default, only personal data which are necessary for each specific purpose of the processing are processed

- Security requirements:
  the controller and the processor shall implement appropriate technical and organisational measures to ensure a level of security appropriate to the risk, including inter alia as appropriate:
  a) the pseudonymisation and encryption of personal data;
  b) the ability to ensure the ongoing confidentiality, integrity, availability and resilience of processing systems and services;
  c) the ability to restore the availability and access to personal data in a timely manner in the event of a physical or technical incident;
  d) a process for regularly testing, assessing and evaluating the effectiveness of technical and organisational measures for ensuring the security of the processing.

3.5.2 Definition of requirements and metrics for Enabler1

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

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

3.5.3 Definition of requirements and metrics for Enabler 2

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

3.5.4 Definition of requirements and metrics for Enabler 3

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

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

3.5.5 Definition of requirements and metrics for Enabler 4

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

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

3.5.6 Definition of requirements and metrics for Enabler 5

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

3.5.7 Definition of requirements and metrics for Enabler 6

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_HMI1.4 6	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	functiona l	high	6
R_EN6_HMI1.4 7	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	functiona l	high	6
R_EN6_HMI1.4 8	Validation	REL	The user should be able to understand the message communicated by the driver	REL	Eva Peter Martha	Correct rate: > 90%	user	functiona l	high	6
R_EN6_HMI1.4 9	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	functiona l	high	6
R_EN6_HMI1.5 0	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	functiona l	high	6

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

3.5.8 Definition of requirements and metrics for Enabler7

For the enabler 7 TeamMate system architecture, no requirements have been defined in this cycle. The requirements for this enabler will be defined in the next cycle, when the system architecture will be defined and the other enablers will be integrated. For the requirements management, the same table will be used.

3.6 Definition of baseline car and key performance indicators (KPIs)

This section provides a description of the baseline and 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 indicator of the demonstrator (that are used to demonstrate its innovation against the baseline).
- The description of the detailed KPIs used to measure the aforementioned performances.

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

In this framework, both simulators and vehicles will be considered as demonstrators. In this way, it will be possible to evaluate different features and solutions developed in 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: some of these KPIs (e.g. number of accidents) will be therefore 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 2nd cycle, the evaluation process will be conducted in the simulators; in the 3rd cycle it will be conducted in real vehicles.

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

3.6.1 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.

3.6.1.1 ULM simulator baseline implementation and KPIs

For the evaluation of the TeamMate car features, the baseline will be implemented in the ULM driving simulator using. The driver will be able to interact with the system through a central touch panel. This GUI allows the user to choose between different actions via touch buttons on a very simple GUI in the central stack.

The baseline will be implemented in the ULM driving simulator with the SILAB driving simulation engine. The simulator is a mock-up that represents a real car (as shown in Figure 3) with a driver and a passenger seat. Additionally, there are several features in the driving simulator:

- steering wheel (force-feedback)
- pedals
- indicators
- central touch panel
- displayed rear mirrors (central, left, right)
- Smart-eye camera (static eye tracking system)

It also includes three high definition beamers that project the simulated environment onto a projection screen in front of the driver to create an immersive driving environment (as shown in Figure 4).

Figure 3 ULM driving simulator

Figure 4 ULM car Mock-up inside projection screen

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

- increase the safety,
- increase usability of the HMI,
- increase acceptance and trust.

Table 2 provides a preliminary set of KPIs that will be used in WP6 to evaluate the ULM demonstrator against its baseline in empirical experiments that will involve real drivers in simulated environments.

©	KPI ID	KPI name	KPI Description
Safety	KPI1	# of accidents	Number of accidents occurred during the experiment.
Acceptance and trust	KPI2	# of disengagements	The number of disengagements measures how often the driver takes over the control. Thus, it represents the acceptance of the system.
Safety	KPI3	Time for take over	Time the driver needs to take over when the vehicle is not able to deal with the current situation.
Acceptance	KPI4	attitudes toward using	Measure of the desirability of using the TeamMate car.
Acceptance	KPI5	Intention to use	Measure of the likelihood of the participants to use the system.
Acceptance	KPI6	Actual use	Measure of actual use of the system.
Safety	KPI7	Reaction time	How fast did the driver interact/react with the system (e.g. in a safety critical situation)?
Usability	KPI8	Usability	Usability measures to show that the new interface is more usable than the baseline interface and that there are no major usability fails.
Safety	KPI9	Situation assessment	How attentive was the driver in several situations (how many of the objects in the environment did the driver fixate)?
Safety	KPI10	Willingness of risk taking	Time to collision (TTC) in overtaking situations.

Safety	KPI11	#of failures while shifting control from the car to the driver	The driver has to overtake in a specified time to assure driving safety. This KPI measures in how many cases he is able to do so in the given time.
Safety	KPI12	Time to focus	Time that the driver needs to focus safety relevant objects (e.g. lane, traffic).
Safety	KPI13	Distraction time	How long is the driver distracted (via eye tracking)

Table 2: KPIs of the ULM demonstrator (simulator)

3.6.1.2 ULM vehicle baseline implementation and KPIs

The baseline will be additionally implemented in an automated car, as shown in Figure 5) with several advanced driver assistance systems (ADAS), such as Lane Keeping and Cruise Control.

Figure 5 ULM demonstrator (vehicle)

The aim of the vehicle implementation is to demonstrate the benefit of the TeamMate car features compared to an automated vehicle SAE level 3 with the following aims:

- increase safety,
- increase the number of events the vehicle can handle,
- increase comfort of the driver,
- increase acceptance,
- increase usability.

Table 3 provides a preliminary set of KPIs that will be used in WP6 to evaluate the ULM demonstrator against its baseline in empirical experiments that will involve real drivers.

Performance measured with the KPI	**KPI ID**	**KPI name**	**KPI Description**
Safety	KPI1	Feeling of safety	Subjective feeling of safety while driving the vehicle.
Acceptance and trust	KPI2	# of disengagements	The number of disengagements measures how often the driver takes over the control. Thus, it represents the acceptance of the system.
Comfort	KPI3	Feeling of comfort	Subjective measure of the comfort of the driver.
Acceptance	KPI4	Acceptability	Measure of the acceptability of the automated vehicle.
Usability	KPI5	Usability	Measure of the usability of the overall vehicle.

Table 3: KPIs for ULM demonstrator (vehicle)

3.6.2 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.

3.6.2.1 VED simulator baseline implementation and KPIs

The baseline will be implemented in the VED simulator with no automation (SAE level 0) where the driver is responsible for carrying out the dynamic driving task and monitoring the driving environment.

VED has a static driving simulator composed of four 32" screens displaying a total of 120° of horizontal field of view (as shown in Figure 6 while rear view is displayed by using three other screens. The driving simulator runs on Oktal's SCANeRTM studio software.

Figure 6 VED driving simulator

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

- improving safety of the driver,
- improving acceptance and trust in vehicle's decisions and behaviours (i.e. in automation).

A preliminary set of KPIs have been identified in order to evaluate the performance of the VED demonstrator in WP6 against its baseline in terms of safety, acceptance and trust in automation (as shown in Table 4).

Performance measured with the KPI	KPI ID	KPI name	KPI Description
Safety	KPI1	# of accidents	Number of accidents occurred during the experiment.
Acceptance and trust	KPI2	# of disengagements	The number of disengagements measures how often the driver had to take over because the vehicle is not able to deal with the current situation.
Safety	KPI3	Time for take over	Time the driver needs to take over when the vehicle is not able to deal with the current situation.
Safety	KPI4	Time-exposed-time-to-collision (TETTC)	Percentage of travel time during which time-to-collision is below a certain threshold (to be defined according to the specificities of the final use cases).
Trust	KPI5	Trust	Measure of trust in the TeamMate car.
Acceptance	KPI6	Intention to buy	Measure of consumer choice and willingness to buy the TeamMate car.

Table 4: KPIs of the VED demonstrator (simulator)

3.6.2.2 VED vehicle baseline implementation and KPIs

The VEDECOM vehicle baseline implementation is an automated vehicle built based on a Renault ZOE platform. The vehicle has two driving modes:

- Standard manual driving (SAE level 0)
- SAE level 4 “high driving automation” mode

In manual driving mode, the performance of the vehicle remains compatible with that of a standard vehicle, with added access to the connectivity services of Cooperative ITSs (standardised V2X messaging). Access to these services is guaranteed by the on-board platform, which includes several communication media, such as 802.11n standard WiFi, 802.11p vehicular WiFi and 3G/4G cellular network.

For the evaluation of the TeamMate car, the baseline will be the SAE level 4 high driving automation mode enabled by:

- 360° perception around the vehicle (as shown in Figure 7)
- Localisation systems
- Supervision system
- Connectivity platform

Figure 7 Perception sensors (lasers, radar and cameras)

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

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

A preliminary set of KPIs have been identified in order to evaluate the performance of the VED demonstrator in WP6 against its baseline in terms of safety, acceptance and trust in automation (as shown in Table 5).

Performance measured with the KPI	KPI ID	KPI name	KPI Description
Acceptance and trust	KPI1	# of disengagements	The number of disengagements measures how often the driver had to take over because the vehicle is not able to deal with the current situation.
Safety	KPI2	Time for take over	Time the driver needs to take over when the vehicle is not able to deal with the current situation.
Safety	KPI3	Time of stabilization	Time the driver needs to stabilize the car in the lane after taking over from TeamMate
Trust	KPI4	Trust	Measure of trust in the TeamMate car.
Acceptance	KPI5	Intention to buy	Measure of consumer choice and willingness to buy the TeamMate car.

Table 5: KPIs of the VED demonstrator (vehicle)

3.6.3 Baseline and KPIs for the CRF/REL demonstrators

The baseline for the CRF/REL demonstrator is a non-automated car (SAE level 0), where the human driver is in charge of driving as well as monitoring the driving environment. This baseline will be used for evaluation against the TeamMate Car features in a simulator and a real vehicle.

3.6.3.1 Baseline and KPIs for the REL simulator

The baseline will be implemented in the driving simulator of REL based on a SCANeR II driving simulation engine. It is a 1-driver front passenger simulator with real controls and automotive parts:

- steering wheel

- pedals
- ergonomic seat

It also includes a 50" wide-screen monitor to create an immersive driving environment (as shown in Figure 8).

Figure 8 CRF/REL driving simulator

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

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

Several KPIs have been identified in order to empirically evaluate the performances of REL demonstrator against its baseline in terms of expected increase of safety and acceptance (as shown in Table 6).

Performance measured with the KPI	KPI ID	KPI name	KPI Description
Safety	KPI1	# of accidents	Number of accidents occurred during the experiment.
Acceptance and trust	KPI2	# of disengagem ents	The number of disengagements measures how often the driver had to take over because the vehicle is not able to deal with the current situations
Safety	KPI3	Time for take over	Time the driver needs to take over when the vehicle is not able to deal with the current situations
Acceptance	KPI4	Time for hand over	Time the vehicle needs to take over when the driver starts the hand overs
Acceptance	KPI5	attitudes toward using	Measure of the desirability of using the TeamMate car
Acceptance	KPI6	intention to use	Measure of the likelihood of the participants to use the systems

Table 6: KPIs of the REL demonstrator (simulator)

3.6.3.2 Baseline and KPIs for the CRF vehicle

The baseline for the CRF demonstrator is an automated car with a basic HMI with ADAS perspective (system always tells what to do and when), 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.

For the evaluation of the TeamMate car, the baseline is sketched in the following figure ("normal driving" with ADAS), with the following sensors configuration:

- Frontal Mid-range Radar
- Front Camera
- Side Ultrasound system

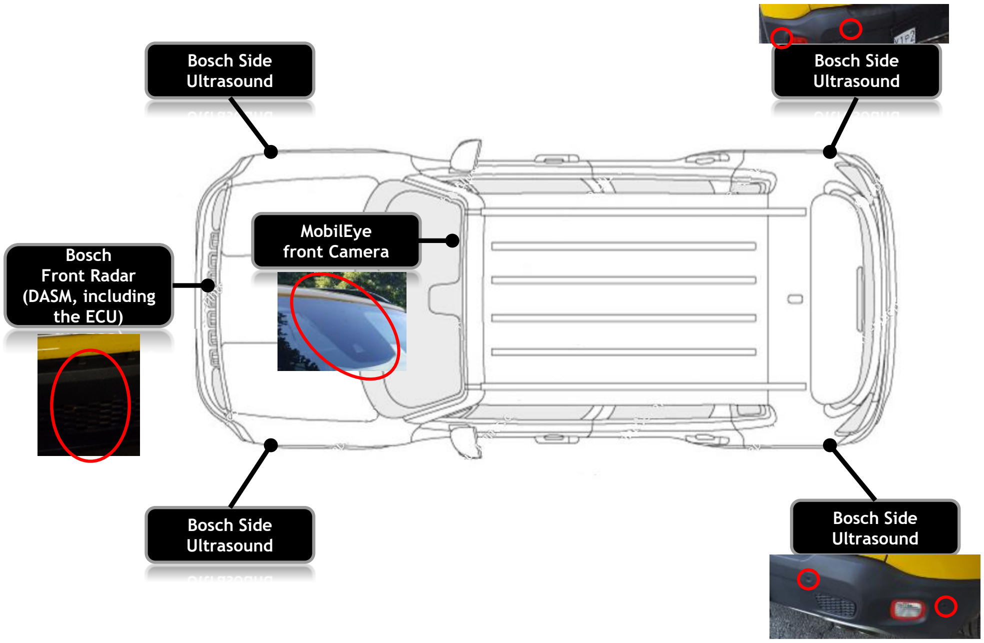

Figure 9: Perception sensors (ultra-sounds, radar and camera).

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.

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:

Performance measured with the KPI	**KPI ID**	**KPI name**	**KPI Description**
Safety	KPI1	# of accidents	Number of accidents occurred during the experiment.
Acceptance and trust	KPI2	# of disengagements	The number of disengagements measures how often the driver had to take over because the vehicle is not able to deal with the current situations

Safety	KPI3	Time for take over	Time the driver needs to take over when the vehicle is not able to deal with the current situations
Acceptance	KPI4	Time for hand over	Time the vehicle needs to take over when the driver starts the hand overs
Acceptance	KPI5	attitudes toward using	Measure of the desirability of using the TeamMate car
Acceptance	KPI6	intention to use	Measure of the likelihood of the participants to use the systems

Table 7: KPIs of the CRF demonstrator (vehicle), current proposal.

4 Conclusion and future work of WP1

WP1 has no planned activities until the end of the 2nd cycle (M23-24). However, according to the schema shown in Figure 2, the activities of WP1 in the 1st cycle have the following impact on the other WPs in the 2nd 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 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.

Additionally, for the 3rd project cycle, there will be further modifications concerning task 1.1 – the TeamMate car framework, based on the experiments and their outcomes. Furthermore, for task 1.2, CRF and Re:LAB plan to finish and adapt the flow diagrams, especially for the changed use-cases 4 and 6. The final decision, on which use-cases will actually be implemented in the demonstrator, is made during project cycle 2. In task 1.3, further modifications of the requirements, the definition of the baseline car and the KPIs might be necessary during project cycle 3.