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D9.4 Tailored HF-RTP and Methodology Vs1.0 for the Automotive Domain

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Executive Summary

The following document describes the process of adaptation of the HF-RTP, which is being developed in the HoliDes project (WP1), to the automotive domain, with a special focus on the description of the AdCoS and toolchains developed by the partners. It is the follow up deliverable of D9.2. It is explained how the tailoring methodology provided by WP1 is applied in the Automotive Domain.

1 Introduction

This deliverable describes how the HF-RTP methodology Vs1.0and the HF-RTP, which are being developed in WP1, are applied and tailored in the automotive domain. In particular, it focuses on the application of the tailoring rules provided by WP1 and defined in D1.4.

1.1 Objective of the document

Deliverable D9.4 describes the results of the HF-RTP tailoring methodology applied to the automotive domain for the first project cycle.

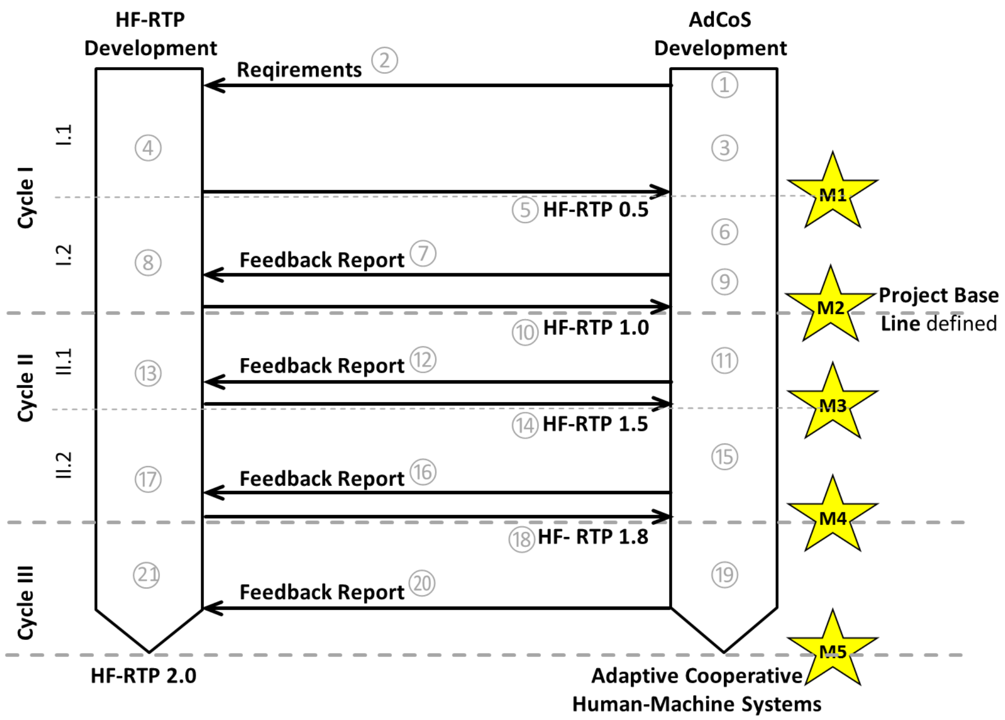

Figure 1: Overall workflow taken from the HoliDes proposal.

The HF-RTP and the tailoring methodology (version 1.0) developed in WP1 and delivered in D1.4 are applied to the AdCoS of the automotive domain. A starting point for the tailoring of the HF-RTP in WP9 has already been provided in D9.2, which was based on the HF-RTP version 0.5 (M1).

In the HoliDes context, D9.4 is the first application of the HF-RTP methodology to the automotive domain and the AdCoS developed in WP9.

1.2 Structure of the document

This document is divided into 5 chapters. After the introduction in Chapter 1, Chapter 2 summarizes the tailoring methodology provided by WP1. Chapter 3 defines detailed development workflows for each of the WP9 AdCoS, which are the basis for the deployment of the tailoring rules. Chapter 4 summarizes the conclusions of the tailoring process for the automotive domain and Chapter 5 gives an outlook for future activities.

1.3 Main results and achievements

The tailoring steps provided by WP1 partners are applied to the AdCoS of WP9. The main achievements of this deliverable are related to the first two tailoring steps which contain the identification of issues in the current development process, as well as the mapping of MTTs from the HF-RTP to the identified issues.
It will be shown that there are currently a lot of issues in the development process regarding human factors and how to design a cooperative system in an efficient way. The identification of those issues is an important step when selecting MTTs for the AdCoS. It could be achieved, that the AdCoS providers elaborated a number of tools as being useful for the AdCoS development during the tailoring process. Therefore the number of used MTTs from the HF-RTP was increased within WP9. For a number of MTTs, there is an interest to be integrated into the development process, since they probably will add benefit to the overall system.

2 HoliDes Reference technology platform (HF-RTP)

2.1 HF-RTP tailoring methodology

The tailoring methodology applied in this deliverable is the outcome of WP 1 in the first project cycle. The methodology has been reported in D1.4 and defines the following four tailoring steps:

1. Identification of the purpose of the project and the used tool chain
2. Selection of methods and tools
3. Definition of semantics and information mapping between methods and tools
4. Implementation of information models and connectors.

By actually tailoring the HF-RTP on the real needs of the AdCoS owners, we discussed with the partners in WP1 in order to slightly rephrase the steps. The new version of the methodology, as a result of the collaboration of the AdCoS owners (WP6-WP9) with the partners in WP1, includes the following steps:

1. Identification of issues in the existing development process
2. Selection of methods and tools (MTTs)
3. Integration and interfaces between existing development process and MTTs
4. Implementation of information models and connectors.

So, in practice, what is the difference between tailored and non tailored tools?

There is a subtle but important difference between a tool being classed as part of the RTP and tailored in the RTP. To say that a tool is part of the RTP represents a commitment to say that a tool should share resources in compliance with the HoliDes IOS (i.e Tools will share data using RDF XML which is compliant to a HoliDes metal model and made available through a Restful interface).

Moreover, a tool is tailored in the HoliDes RTP if it can exchange information with other tools in the RTP in accordance to the IOS to satisfy a specific use case. One tool is making its data available as RDF XML and is considered to be an OSLC provider. The second tool is asking for the data and it is considered to be a consumer. In essence if a tool is tailored it ‘understands’ how to use that IOS compliant data.

Please refer to D1.5 for further details on this.

2.1.1 Tailoring Step 1 – Development process and issues

The first step provides the description of the overall purpose of the RTP within the development process to be supported.
Concretely, it defines the specific development process of each AdCoS, and describes the issue faced by the AdCoS owners in the development of the adaptive system, mainly in terms of Human Factors and adaptivity.

2.1.2 Tailoring Step 2 – Selection

By starting from the development process and relevant issues defined in step1, in step2 MTTs are selected to fit the needs of the project purpose (in terms of issues described in the first step). A detailed rationale is given for each of the selected MTTs which will be included in the workflow.

The definition of step2 in D1.4 also covers some issues about OSLC compliance of selected tools, which can be achieved for some tools during the project, but is not available yet.

2.1.3 Tailoring Step 3 – Integration and interfaces

Step 3 of the tailoring methodology is about the integration of the MTTs into the actual tool chain that is part of the development process of each AdCoS.

In particular, the mapping step describes the interfaces that defines which and how information is exchanged between MTTs and existing tools. Interfaces with the HF-RTP are also defined when needed (e.g. for sharing data that could be reused by other AdCoS's, such as datasets to create models).

This step relies on the definition of domain specific OSLC standard and use case specific meta models (which have been developing in WP1) in order to allow an MTT to share resources in compliance with the HoliDes IOS through a restful interface.
The WP9 AdCoS owners could not actually adapt the RTP MTTs to the specific workflows (based on the domain specific OSLC standard and a use case specific meta model).

2.1.4 Tailoring Step 4 – Implementation

Step 4 is the implementation of the mappings defined in step 3 (i.e. implementation of parsers to allow the tools to correctly interpret the information receive according to a predefined communication protocol).

The actual implementation of the communication protocols and parsers for the sharing of data among tools and with the RTP relies on the definition of the information to be shared (still in progress in collaboration with WP1). Therefore, this activity will be completed in the next versions of the tailoring of the HF-RTP.

The application of step 1, 2 and 3 will be provided for each AdCoS in chapter 3.

3 Deployment of the HF-RTP tailoring rules

The tailoring steps defined in D1.4 and outlined in chapter 2 will be deployed to all WP9 AdCoS in this chapter. A list of the AdCoS can be found in the table below.

AdCoS	Partners involved	AdCoS Description
Vehicle 1 (CRF) – Adapted Assistance	**CRF,** REL, SNV, INT, UTO, OFF.	Lane-Change Assistant (LCA), which is composed of two main functions: Forward collision Warning (FCW) and Overtaking Support (OS). LCA is adaptive based on driver's state (visual distraction) and intention (LC manoeuvre).
Vehicle 2 (IAS) – Adapted Automation	**IAS,** TWT, DLR	Highly automated vehicle which adapts the driving style to the human driver preferences identified by a driver model. Distraction of the operator may also lead to adaption of the driving style.
Simulator 1 - Virtual HCD Platform	**IFS,** INT, CVT, EAD-FR, ENA	Virtual AdCoS in charge to monitor car drivers' visual distraction risks and to assist them for collision avoidance (rear, lateral, and front) and lane change maneuvers. This AdCoS will be virtually designed, prototyped and evaluated with a Virtual Human Centered Design platform (V-HCD Demonstrator), to be also developed by the partners during the project.
Simulator 2 - Adaptive HMI	**TAK,** OFF, INT, TWT	Adaptive HMI that will be implemented in the simulator. The HMI is adaptive to driver state (i.e. visual and cognitive distraction), driver intention (overtaking wish or not), environment (presence or absence of potentially conflicting cars) and automation level. The automation will be implemented as automated overtaking assistance (level 2 or 3 of automation according to the BASt-definition [4]).

Table 1: AdCoS overview - list of test-vehicles and simulators developed in WP9

In addition to the AdCoS listed in the table, the tailoring is also done for one selected subproject, the HMI of REL (see section 3.2). It has been selected since it provides additional information for a different development process considering prototype development. In addition it serves as an example, that the tailoring rules can also be applied to the module development of an AdCoS and not only to the development process of the complete AdCoS.

For each MTT currently available in the HF-RTP, the status of the usage is presented in Table 2 for each of the AdCoS. The status can be:

- **in use**: first results expected to be presented at the next review November 26th, 2015
- **planned:** MTT & AdCoS agreed on an evaluation of the MTT. If the evaluation result is positive, results can be demonstrated at the final review
- **interesting:** MTT & AdCoS agreed that this MTT is relevant and should be evaluated, but because of time or effort constraints an evaluation is currently not possible
- **no:** The AdCoS owner has understood the MTT developer. Both parties can state sound reasons concerning the MTTs irrelevance for the AdCoS.

MTT	Type	Used Models	Partner	CRF	IAS	TAK	IFS
WP 2							
CASCaS	Simulation	human behavior model	OFF	no	no	planned	no
COSMODRIVE	Simulation	human driver model	IFS	interest	interest	no	in use
djnn	Tool	UI / interaction model	ENA	interest	no	no	interest
Driver distraction model	Simulation	human distraction model	TWT	interest	planned	planned	no
Driver distraction classifier	Tool	visual distraction classifier	UTO	in use	interest	interest	interest
GreatSPN - MDP part	Tool	Petri Net	UTO	in use	no	interest	interest
Human Efficiency Evaluator	Tool	task model, human behaviour model (CASCaS)	OFF	interest	no	interest	no
MagicPED	Tool	task model	OFF	planned	no	no	no
Training Manager	Tool	task model, training model	OFF	no	no	no	no
Pilot Pattern Classificator	Technique	human behavior model	TEC	no	no	no	no
Bad MoB	Simulation	human behavior model	OFF	in use	no	interest	interest
WP 3							
CBR: Case Based reasoning	Technique	return of experience	EAD-F	interest	no	no	no
Hgraph: hierarchical graph modeling	Technique	task model	EAD-F	no	no	no	no
AEON	Tools	cloud message managment	ATOS	no	no	no	no
LEA: Learning classifier system	Tools	learning behaviors	EAD-F	interest	no	interest	interest
APA	Tools	sequential patterns assesment	EAD-F	no	no	no	interest
Uppaal	Tools	time automata	UTO	no	interest	no	no
MOVIDA	Tool	Cosmodrive / Monitoring	IFFSTAR	interest	no	interest	in use
AMAS: Advanced multi-agent system	Technique	multi-agents	EAD-F	no	no	no	interest
CONFORM	Tool	behaviour model	DLR	no	in use	no	no
Driver intention recognition	Tool	behaviour model	OFFIS	in use	interest	interest	interest
Operator Pattern Classifier	Tool	behaviour model	TEC	no	no	no	no
HF-Guidline	Technique		EAD-IW-DE	interest	interest	interest	interest
WP 4							
RT-MAPS	Tool	base for HF-RTP	INT	in use	in use	in use	in use
Anaconda	Tool	dynanmic analysis of C++ programs	BUT	no	no	no	no

Search Bestie	Tool	support for testing	BUT	no	no	no	no
Data Race Detector & Healer	Tool	data race detection for Java programs	BUT	no	no	no	no
Pilot Monitoring	Tool		BUT	no	no	no	no
I-DEEP	Tool	observation and playback	INT	interest	planned	interest	in use
COSMO-SIVIC	Tool	human operator model& simulation	IFS	interest	interest	no	in use
GreatSPN	Tool	Petri Net	UTO	interest	interest	no	interest
Experiment Database Management	Tool		TEC	no	no	no	no
CaSACaS	Simulation	human behavior model	OFF	no	no	in use	no
djnn	tool	UI / Interaction Model	ENA	interest	no	interest	interest
ProSivic	Tool	virtual car and 3D road environment simulator	CVT	interest	interest	no	in use
WP 5							
HF Filer	Tool	OSLC data / filings of human factors evaluations	AWI	interest	no	interest	no
Modelling of AdCoS data from a means-ends perspective	Technique	observations / task model	AWI	interest	no	interest	no
Detection of operators' head orientation	Tool	videos of human operators' heads / description of operators' heads orientation	BUT, HON	no	no	interest	no
Operator state detection from implicit hand gestures	Tool	whole-body videos / description of operator gestures	BUT, HON	no	no	no	no
CPM-GOMS task analysis of a Lane Change for manual and automated driving	Technique	video data, driving data, verbal data, eye tracking data / detailed description of a driver's cognitive, perceptual and motor activities	DLR	no	planned	interest	no
Methods and techniques for the driver adaptive parameterization of a highly automated driving system	Technique	manual driving data / preference for automation driving style	DLR	interest	in use	no	no

Theater Technique for acceptance tests during AdCoS design	Technique	interaction concept for the overtaking manoeuvre / qualitative data from exploration	DLR	no	planned	interest	no
Tests for cognitive task models	Technique	empirical data from task analysis / MTTs for testing predictions of task models	HFC	no	no	no	no
MEBEF (Mean number of Examinations Between Examination Failure)	Tool	systematic log-file analysis and reporting on routine system use in the installed base	PHI	no	no	no	no
Empirical analysis of cognitive and communication processes	Technique	empirical data	SNV	in use	no	interest	interest
Detection of driver distraction based on in-car measures	Tool	driving data, audio data, video data / measure of distraction	TWT	interest	planned	planned	no
Surrogate Reaction Task	Tool	empirical data	DLR	in use	no	in use	no
Detection of driver distraction based on data on vehicle dynamics	Tool	driving data / qualitative description of driver's degree of inattention	UTO	in use	interest	interest	interest

Table 2: AdCoS specific MTT usage

3.1 AdCoS Adapted Assistance (CRF)

This section describes some important aspects of the CRF AdCoS. A more detailed description of the AdCoS has been provided in D9.2.
The partners for the development of the Adapted Assistance AdCoS consists of two SMEs for the HMI and for the laser-scanner sensors, as well as one research institute and one university for the algorithms of the adaptiveness and core strategies (co-pilot). All of the partners use standard office tools for most development steps. Moreover, a prototype is developed. This is reflected in the development process.

3.1.1 Status of the AdCoS development

The Lane-Change Assistant (LCA) use case can be regarded as a single supporting system, adapting to the behaviour of the different agents, namely, it is able to adapt to the internal and external scenarios. This means that the "optimal" manoeuvre is suggested from machine-agent to human-agent, by means of specific warnings, advice and information, according to the visual or cognitive state and intentions of driver, as well as to the external environment. In the CRF Test-Vehicle (TV), the following functionalities are implemented:

- Lane-Change Assistant (LCA) and Overtaking Assistant (OA)
- Forward Collision Warning (FCW), including assisted braking (and, optionally, automatic emergency braking).

For the real AdCoS of CRF, the basic idea is to adopt a statistical approach. The principle is to model our system as an MDP (Markov Decision Process), in order to construct optimal warning and intervention strategies (WISs).

The LCA use case deals with the Adapted Assistance, where the classification of distraction is the "trigger" for the adaptation. In fact, depending on the cognitive state of the driver (if he/she is distracted or not), the strategies of the AdCoS are modified. This is true also for the driver's intention: the preferences, once detected, are taken into account by the decision processing system.

As mentioned in D9.3 "Requirements & Specification & first Modelling for the Automotive AdCoS and HF-RTP Requirements Update", the Adapted Assistance system is implemented on the CRF test-vehicle (TV), which is a Fiat 500L, with the following sensors installed on-board:

- One external camera to detect the edges of the lanes on the road and the relative position of the ego-vehicle in the lane.
- Four Laser-scanner sensors, installed on the front, on the rear and on the two lateral sides of the vehicle, in order to detect and to reconstruct the surrounding scenarios and to select the obstacle(s) of interest. In the previous cycle – as described in D9.3 – only the Middle Range Radar was installed and used.
- One internal camera to detect the head position of the driver (and where he/she is looking at).

All these sensors are used for the detection of both the external and the internal environment. Based on this configuration, the AdCoS architecture for the CRF test-vehicle is represented in the following figure:

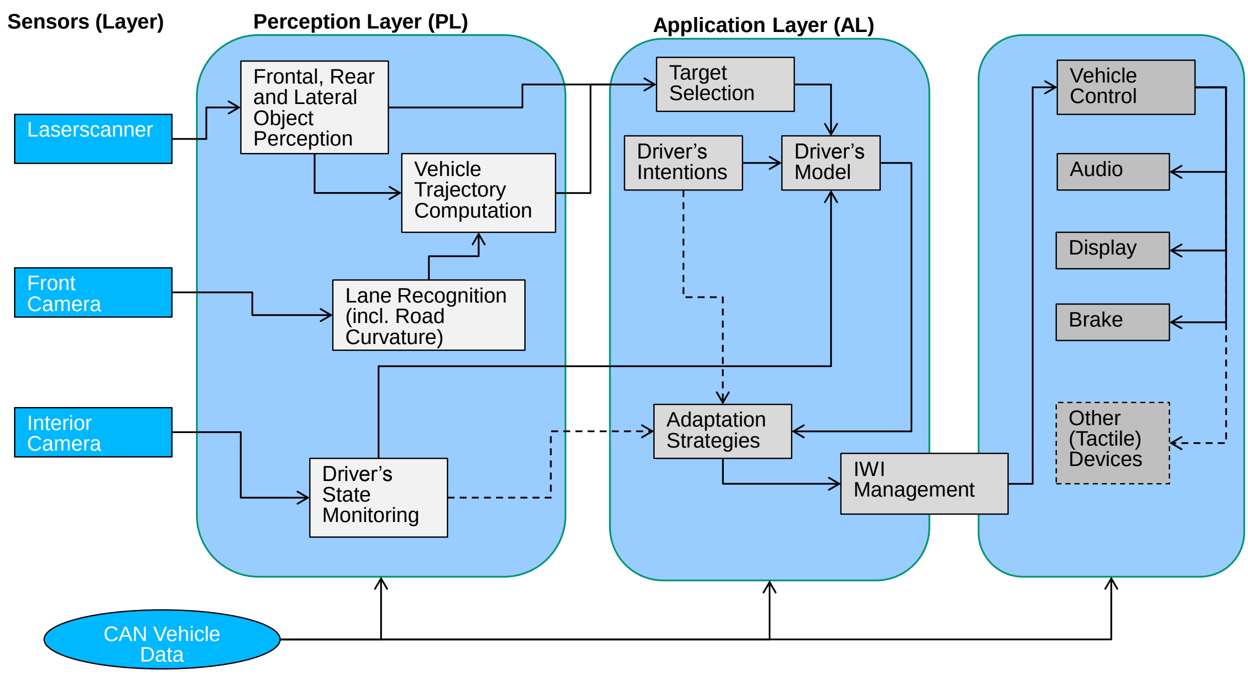

Figure 2: System architecture for the LCA system implemented in CRF demonstrator, where the main layers and related connections are highlighted.

The messages and the connections between the different modules are the same as described in D9.3; also in this case we have four main layers, that are: Sensor (SL), Perception (PL), Application (AL) and Information, Warning & Intervention (IWIL).
In particular, the artificial intelligence for the adaptive assistance driving is implemented within the machine-agent, where the driving process can be broken down into four stages:

- the perception of the traffic environment around the host vehicle in real-time,
- the interpretation and assessment of the current traffic situation,
- the planning of appropriate manoeuvres and actions and
- the action to control the vehicle and guide it safely along the planned trajectory.

This is similar to human-agent cognitive process and to the functions present in the IAS AdCoS.

3.1.2 Tailoring Step 1 – Development process and issues

Due to the similarity of identified issues over all of the WP9 AdCoS, step 1 is documented in the appendix section 7.1 for all AdCoS.

3.1.3 Tailoring Step 2 – Selection

Tailoring step 2 is the selection of methods and tools which can be integrated into the development process to solve some issues. The selected tools for this AdCoS are listed in the table below.

MTT	Description
COSMODRIVE (IFS) **planned**	**Module Testing and Evaluation** This simulation tool may be used to test the AdCoS in two specific conditions: • Risky situations, for which tests on real vehicle can be dangerous. • Preliminary evaluation before the final implementation, to tune parameters, define thresholds, etc.
Driver distraction model (DDM), (TWT) **interest**	**Module Implementation** Since a driver distraction classifier is also developed in CRF AdCoS from UTO partner, an exchange of information can be very useful, in particular if the model can be chosen as providing an additional input for the adaptation.
Driver distraction classifier (DDC), (TWT) **interest**	**Module Implementation** Since a driver distraction classifier is also developed for this AdCoS from UTO partner, an exchange of information can be very useful, in order to compare results.

MagicPED	see section 3.2.3
Driver intention recognition (DIR), (OFF) **in use**	**Module Implementation** The driver intention recognition is used within the CRF AdCoS to adapt the decision making process to the preferences and intentions of the human driver. In fact, selecting manoeuvres that are most suitable to the estimated intention of the human driver could improve the acceptance of AdCoS by the human operator.
HF-Guideline, (EAD-IW-DE) **interest**	**Requirements Definition / System Design** The Human Factors Guideline could be used to define the system and all relevant aspects comprehensively and identifying potential issues in the system design at an early stage in the project. The number of iterations for designing the system could be reduced. Therefore both the CRF and IAS AdCoS applications are interested.
RTMaps, (INT): **in use**	**Interface and Module Implementation, System Integration:** The tool used for the interface and module implementation, as well as for the system integration, is RTMaps. It has been selected from the HF-RTP, since it solves the issue on synchronization, operating system dependencies and gateway installations. RTMaps is well suited, since it provides a lot of interfaces to standard protocols, like CAN, Ethernet, etc. In addition, it provides also the interfaces and the related blocks of many sensors used inside the CRF AdCoS and even when not originally present, their implementation was quite easy. Most of the selected modules used within this AdCoS will be developed in C++, and RTMaps allows easy integration of C++ modules. The usage of RTMaps is expected to highly reduce the interface implementation effort.
I-Deep, (INT) **interest**	**Module Testing:** The evaluation of the overall AdCoS needs to be done in simulations, since no reproducibility is given for the real vehicle. The tools used for testing

	single modules depend on the module itself. However for the functional testing of modules, I-Deep is expected to be usable, since it is a server based application which allows to run RTMaps projects with variable parameters and stores the results in a database. It is therefore expected that I-Deep will allow an extensive testing of the AdCoS module functions. This opportunity will be investigated by the CRF AdCoS team.
Cosmo-SiVIC, (IFS) **interest**	Cosmo-SiVIC is a common platform involving the virtual environment, the vehicle, the cognitive driver modelling with its functionalities (eye modelling, gaze direction, mental driving environment representation, etc.). It is possible to model and simulate the main AdCoS functionalities.
Great-SPN for MDP, (UTO) **in use**	**Module Implementation** Great-SPN is used in this AdCoS to model task allocation and transition between human-agent and machine-agent. Moreover, it is used to develop and implement the co-pilot concept, which the "core" of the AdCoS.
ProSivic, (CVT) **interest**	**Module Testing** ProSivic may be useful for generating simulation scenarios for offline testing. The interface to RTMaps allows using all of the AdCoS modules to be tested with simulated data. Most critical scenarios can be simulated in this way, without any risks.
Surrogate Reaction Task (SuRT),(DLR) **in use**	**System Design, Module Implementation** It is a tool to create a kind of visual distraction in the user. In our AdCoS, it has been adapted to be used inside the vehicle and integrated in RT-MAPS. The goal is to induce a form of visual distraction in the driver and collect the data to develop the related classifier.
Empirical analysis of cognitive and communication process (SNV)	**System Design, Module Implementation** This is the used process to design the experiments for the driver distraction. A dedicated test-site has been selected, with segments where the SuRT was ON and others

in use	where it was OFF.
Detection of driver distraction based on data on vehicle dynamics (DDDBDVD), (UTO) *in use*	**Module Implementation** This module MTT represents the classifier of the visual driver's distraction and it is based on ML techniques. The basic idea is to use only the vehicle dynamic data, the environment data and the ego-vehicle positioning data (with respect to the lane) an inputs to the classification algorithm.

Table 3: MTTs selected to be integrated into the development process of CRF

3.1.4 Tailoring Step 3 – Integration and interfaces

The integration of MTTs in the development process is based on two aspects: the definition of interfaces and the possibility to share data between tools. These two topics are also addressed in details in the sections 3.2.4 and 3.3.4.

For the first point, the interface definition is not part of the current AdCoS development and thus only a list of outputs generated by the development steps is available. This list may help the MTT work-packages to identify needs for interfaces:

- Requirements definition/refinement: WORD or EXCEL files are available with the list of requirements, including the ones related to modules.
- Test specification: WORD or EXCEL files are available with the test specification (derived by the requirements and specifications document, manually). This document can contain also a test report.
- High-Level/Low-Level design: a POWERPOINT file is available, with a schema of the overall system architecture, pointing out also the modules connections.
- Interface definition: WORD file with the definition of the interfaces
- System Integration: product/prototype, the AdCoS itself
- Module implementation: RT-MAPS files containing the algorithms for the module functionality together with the defined interfaces.
- Performance evaluation: WORD or EXCEL file containing the results of the evaluation.

Concerning the sharing of the data among tools, it is important to understand which data is produced by the existing tools and in which format. For the corresponding list of outcomes, the details are provided in Section 3.2.4, where the development process of REL is illustrated, for the implementation of the HMI for the LCA of the CRF AdCoS.

3.1.5 Tailoring Step 4 – Implementation

Step 4 will not be carried out in this version of the tailoring.

3.1.6 Conclusions

By following the methodology defined by WP1 in D1.4 and adapting it to the actual needs of the CRF AdCoS, the first 3 steps of the tailoring of the HF-RTP have been performed. In particular, the development process of CRF AdCoS has been formalized and the issues have been identified (step1), together with the related MTTs which may solve these problems. These MTTs have been selected and tested, in order to check if they can be included in the development process of CRF.

However, despite the fact that the mentioned tailoring process could solve some issues in the development and design phases, some others still remain unsolved (even if the HF-RTP provides already a good overview of available tools for developing an AdCoS, although it is in an early stage).
In this context, for some issues, no suitable MTTs are available, for other issues, MTTs are available, but are not selected, because they do not add benefit in comparison to standard tools, or even because their usage is not so immediate and easy to accelerate/facilitate the design / development process.

Moreover, since MTTs are not only tools, the CRF AdCoS development process would benefit from methods and techniques assisting the development using standard tools. The MTTs can be guidelines, methodologies or even templates, to support the integration of human factors into a technical system.

3.2 HMI of the Lane Change Assistant developed by CRF (REL)

In HoliDes, REL develops the HMI for the Lane Change Assistant (LCA) of CRF. Even though it is part of the AdCoS, the HMI is implemented by following a different process compared to the LCA.
Therefore, the different workflows will be presented separately in order to show the different needs and how the selected MTTs can address them.

The development process for the delivery of a prototype is different from the development of a product.

There are key differences between prototypes and actual products. Such differences usually appear in three fundamental ways:

- Materials: prototypes are engineered using less expensive materials.
- Processes: while a manufacturing company will eventually produce the product, is it more economical to outsource the prototyping and hire a company that specializes in prototypes. A good prototyping company will save a manufacturing company time, manpower, and money – and can deliver and be trusted with an original design.
- Lower volume: prototypes are considered "dry run" products, and, as such, the production numbers are much lower.

Creating prototypes is a highly practical manufacturing strategy to meet the expectations of the customer who commissions the prototype:

- very short development process in order to assess the feasibility of the prototype as soon as possible
- ability to understand (and implement) vague and sometimes generic requests (often even the customers do not know what they clearly want and commission a prototype in order to see if an idea is feasible and how it can be used)
- flexibility in the definition (and refinement) of requirements and constraints, and ability to adapt to the changes required during the development
- prototyping of a single part of the product (often without having a global vision of the overall product)

Prototypes provide the best testing models because they are a physical manifestation of the product and can be tested to find any characteristics that could make or break the design. Manufacturers can then take the information gathered from the prototype and make changes to the actual product.

In order to understand the development process of REL and the issues REL faces, it is important to highlight that REL develops prototype solutions, not products.
Moreover, since REL develops HMI in different domains (automotive, control rooms, medical equipment, industrial machinery, etc.), its tools and development processes must adapt to each domain (with different standards, constrains, etc.).

Therefore, the development process of REL includes tools and methodologies that are:

- cross-domain
- flexible (they should allow including text, notes, images, schemas, etc.)
- can be shared with customers (as well as project partners) in order to fasten the achievement of a common understanding

When tailoring an instance of the HF-RTP for our HMI, all mentioned aspects have been taken into consideration.

3.2.1 Status of the Module development

So far, for the development of the HMI for the LCA of CRF we have carried out the following activities:

- Modelling of the tasks the driver must perform to complete the lane change and the overtaking manoeuvre (tasks modelling)
- Analysis of the task in order to identify the cognitive and visual load of each of them
- By considering the cognitive and visual loads, the HMI concept has been defined
- A preliminary draft of the graphical interfaces has been completed, in order to associate different messages according to the state of the driver (cognitive and visual loads) and the intention of the driver (provided by the Driver Intention module).

The results of these activities have been detailed in D9.3.

Regarding the current activities, at this stage of the project, the actual implementation of the Android app has started, and the definition of the metrics and experiments for the evaluation is in progress.

3.2.2 Tailoring Step 1 – Development process and issues

Step 1 foresees the description of the development process of the HMI for the CRF AdCoS(an Android app) and the identification of issues where MTTs could help to improve the development process and the system quality.

The existing development workflow is shown in Figure 3.

The blocks in the diagram show the activities performed for the actual design, implementation and evaluation of the Android app. Arrows between the blocks indicate the flow of information.

Issues in the development process are indicated with yellow markers and described in Table 4.

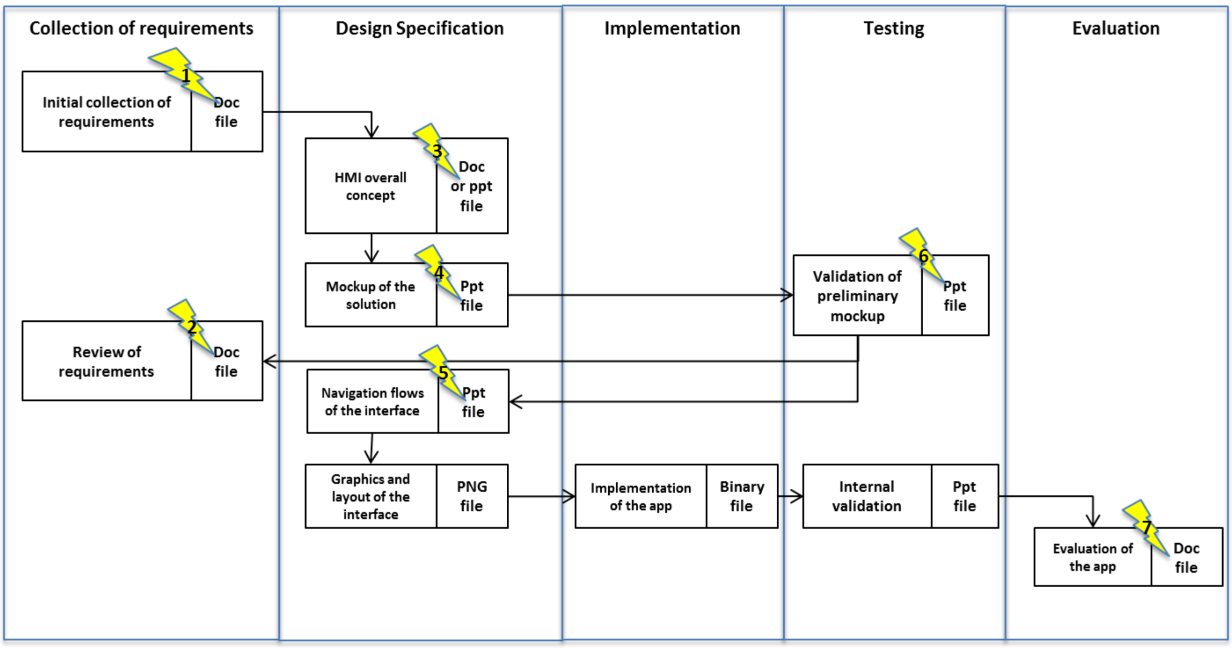

Figure 3: Development process and existing tool chain for the HMI of the Lane Change Assistant developed by CRF.

Issue	Challenges
Collection of requirements	1) Since REL develops prototype solutions (and not products), it tries to shorten up the development process. Usually the requirements

	and constraints are defined only at a high level and, by writing down the vague and sometimes generic requests of customers. 2) No refinement of requirements is performed if changes are requested (as always happens) so there is no chance of tracking them back.
Design specification	3) So far, Microsoft Power Point has been used for the task modelling. This tool presents several advantages (mainly regarding the flexibility it allows and its cross-domain nature). However, it has also relevant drawbacks, such as: - It does not support the designer in the definition of the task model - It does not provide any graphical support to create and modify the tasks and subtasks - The representation of a non-trivial task (such as the LC Manoeuvre) requires several subtasks and sublevels that can be hardly represented in a single Power Point slide (or even a set of slides). Moreover, the task analysis is currently conducted without any support, and the modeller must rely on his/her own experience to understand the cognitive and visual load of each task. 4) Microsoft Power Point is also used for the creation of the mock-up. However, it does not provide any means to model the interface and associate different interaction modalities (haptic, visual and audio) to the different states of the HMI due to the status of the driver (intention, cognitive/visual loads, distraction, etc.). 5) Microsoft Power Point is also used for the HMI navigation flows, but no simulation is available to assess whether the design of the navigation is correct.

Testing and evaluation	6) and7) REL has a consolidated experience in human factors and empirical experiments with users. However, due to the limits of time of the prototype development, unless explicitly requested by the customer, REL usually do not apply empirical methods for the final testing and evaluation.

Table 4: Issues of the existing development process (REL).

3.2.3 Tailoring Step 2 – Selection

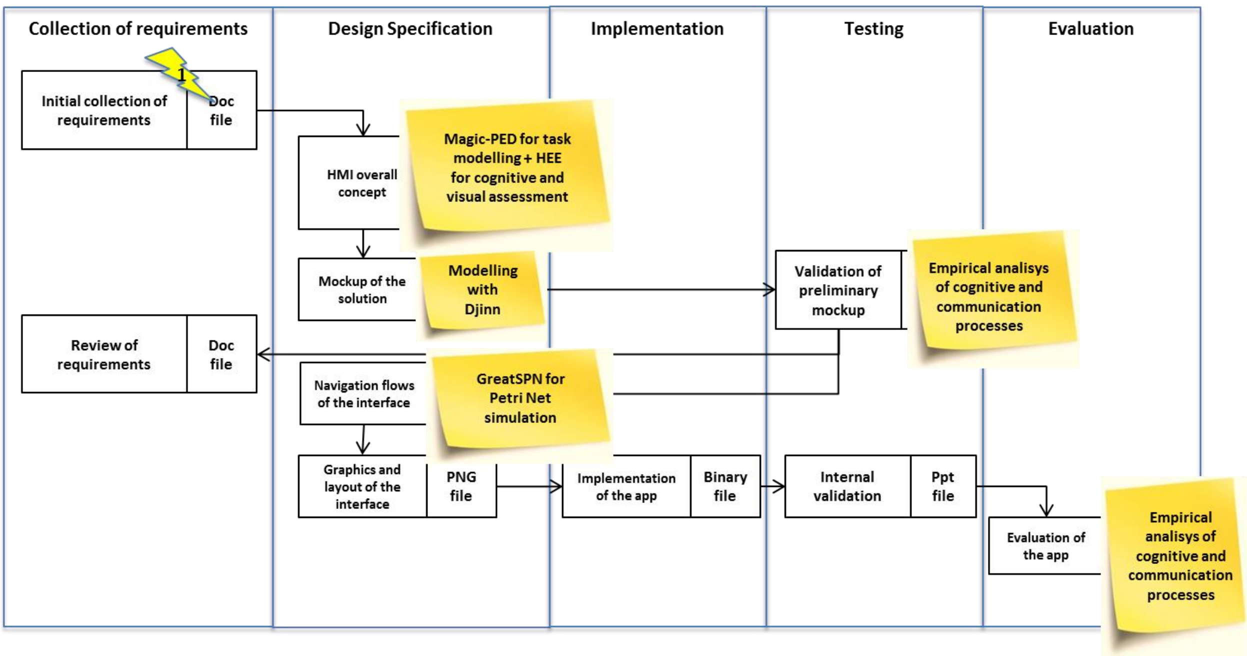

Figure 4: Selection of MTTs to improve the development process of the HMI of the Lane Change Assistant developed by CRF.

Tailoring step 2 is the selection of MTTs which can be integrated into the development process to solve some issues. The selected tools for this AdCoS are shown in Figure 3 (in place of the yellow markers corresponding to the needs of REL) and detailed in Table 4.

MTT	Description
Magic-PED (OFF) *planned*	Magic-PED will be used to formalize the task modelling of the Lane Change manoeuvre in place of Microsoft Power Point.
Human Efficiency Evaluator (OFF) *interest*	The HEE will be tested to check if it can provide an automatic evaluation of the cognitive and visual load of the driver during the lane change and overtaking manoeuvre.
DJNN (ENA) *interest*	Djnn will be tested to check if it can easily model the HMI interaction of the Android app in order to evaluate how it adapts to the different inputs.
GreatSPN *interest*	GreatSPN will be employed to check if it can effectively simulate the navigation flows and assess the correctness of the interface with different simultaneous inputs.
Empirical analysis of cognitive and communication processes *interest*	It could be interesting to identify new MTTs to empirically test and evaluate the prototypes while meeting the time constraints of the prototype development.

Table 5: MTTs selected to be integrated into the development process of REL.

No MTT has been identified to address the issue 1) on requirements, so it still remains unresolved and is listed below together with the currently used tools.

3.2.4 Tailoring Step 3 – Integration and interfaces

The integration of the MTTs into the development process will rely on sharing data between tools. Therefore, as a starting point for the definition of the logical interfaces to share this data, it is important to understand which data is produced by the existing tools, and in which format.

The following list shows the outcomes, and the corresponding formats, of each step of the development process of REL for the implementation of the HMI for the LCA of CRF:

- Collection and refinement of requirements: .doc (or excel) file with the list of requirements.
- HMI overall concept: doc or pptfile with the graphic elements of the HMI concept.
- Mock-up of the solution: .pptfile with a low-fidelity representation of the HMI.
- Validation of preliminary mock-up: ppt file with comments and feedback on the validation conducted with users on the mock-up.
- Navigation flows of the interface: .ppt file with the overall navigation of the HMI.
- Graphics and layout of the interface: png file with the actual graphics of the HMI.
- Implementation of the Android app: binary file of the application.
- Internal validation: ppt file with comments and feedback on the internal validation conducted on the mock-up.
- Evaluation of the app: .doc file with the final evaluation.

At this stage of the project, no MTTs planned by REL to be used in its development process share resources in compliance with the HoliDes IOS. However, the definition of the information (input and output) used in the existing tool chain of REL will support the definition of the data to be shared and, as a consequence, the definition of the RDF XML structure compliant to the HoliDes meta model that will be made available through a Restful interface in order to complete the tailoring.

3.2.5 Tailoring Step 4 – Implementation

Step 4 will not be carried out in this version of the tailoring.

3.2.6 Conclusions

By following the methodology defined by WP1 in D1.4 (and partially adapting it to the actual needs of the AdCoS owners), the first 3 steps of the tailoring of the HF-RTP for the HMI developed by REL have been performed.

In particular, the development process of REL has been formalized and the issues have been identified (step1).
The MTTs which have the potential to address these issues have been identified and selected to be tested in order to check if they can be included in the development process of REL.

The outcome (and the corresponding format) for each existing tool has been identified in order to understand how to interface them with the MTTs and the HF-RTP.

Finally, in order to actually tailor the MTTs developed in HoliDes for the needs of REL, and include these tools in its development process, a further requirement should be met by the partners developing MTTs in WP2-5: the tools should have the ability to shorten the development process (a tool that delays the delivery of the prototype will be never adopted by the developers).

3.3 AdCoS Adapted Automation (IAS)

This section presents the development of the Adapted Automation AdCoS, which is led by Ibeo.

At first a brief description of the AdCoS is given, along with the roles of all partners contributing to the AdCoS.

3.3.1 Status of the AdCoS development

Today the development of highly automated driving is the research focus of many OEMs and research institutes. A major need regarding automated vehicles is an increased usability and operability for the human driver. This encompasses cooperation and adaption of the machine agent to the human driver and other road users, with a human-centred design process as the foundation of the system development. The main challenges are the development of a fluent, yet transparent task allocation and transition between human driver and the machine agent and at the same time integrating the host vehicle into the flow of other road users, where a number of agents are acting in a shared space with shared resources. This aims at increasing the confidence of the human driver in a highly automated system, as described by vehicle automation level 3, which is defined by the NHTSA.

The novelty of the automated driving approach presented here is the advanced cooperation with a human driver and adaptation to his or her capabilities, needs and preferences, to other road users and the environmental conditions, as illustrated in Figure 1. It is characterized by a decentralized decision making between the artificial and the human intelligence.

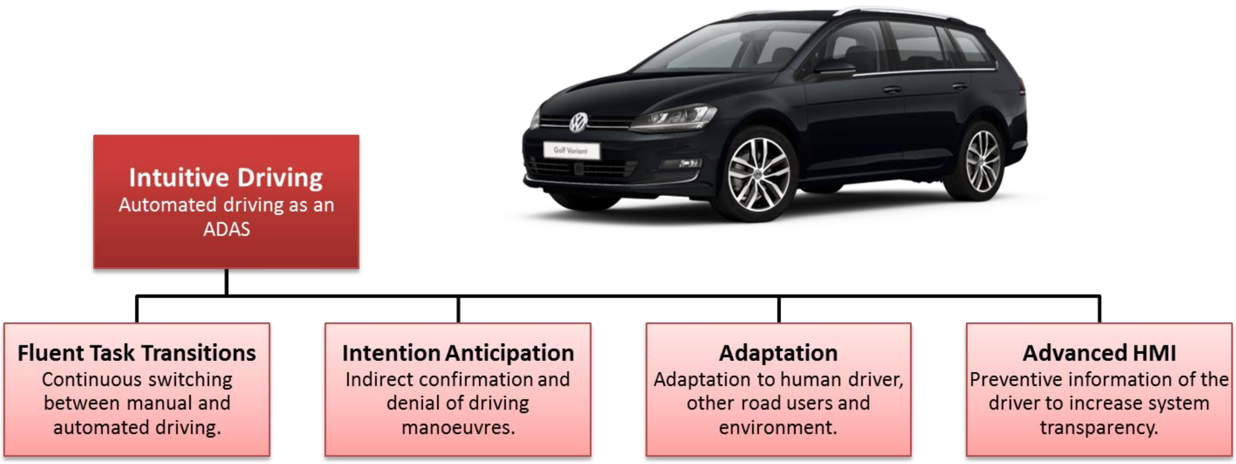

Figure 5: Key features of the Ibeo AdCoS

The highly automated driving (HAD) system is characterised by four main features, as shown in Figure 5:

1. **Fluent Task Transition.**
   The switching between manual and automated driving shall be fluent. This means that the driver can give control to the automated system at any time, while the automated driving function is available. Also the driver can interact with the automated system by operating the standard control inputs (gas, brake, steering wheel, indicators). In case the system detects that it is unable to handle an upcoming traffic situation it will warn the driver early to take over control.
2. **Intention Anticipation.**
   In case the human driver operates the pedals, the steering wheel or the indicators during automated driving, the system will automatically anticipate the driver's intention, e.g. if the vehicle is following a truck in the outer lane of a highway and the driver sets the indicator to the left, the automated system could anticipate that the driver wants to overtake and go faster.
3. **Adaptation**
   The automated vehicle will be able to determine a range of safe driving manoeuvres at any time. Within this range the system offers room to adapt the driving style according to the driver's characteristics, intentions and level of distraction.
4. **Advanced HMI**
   To keep the driver informed about the detected traffic situation and

planned manoeuvres the system will include and HMI to communicate these information to the driver. The HMI is an important part of the overall system to create transparency for the human driver.

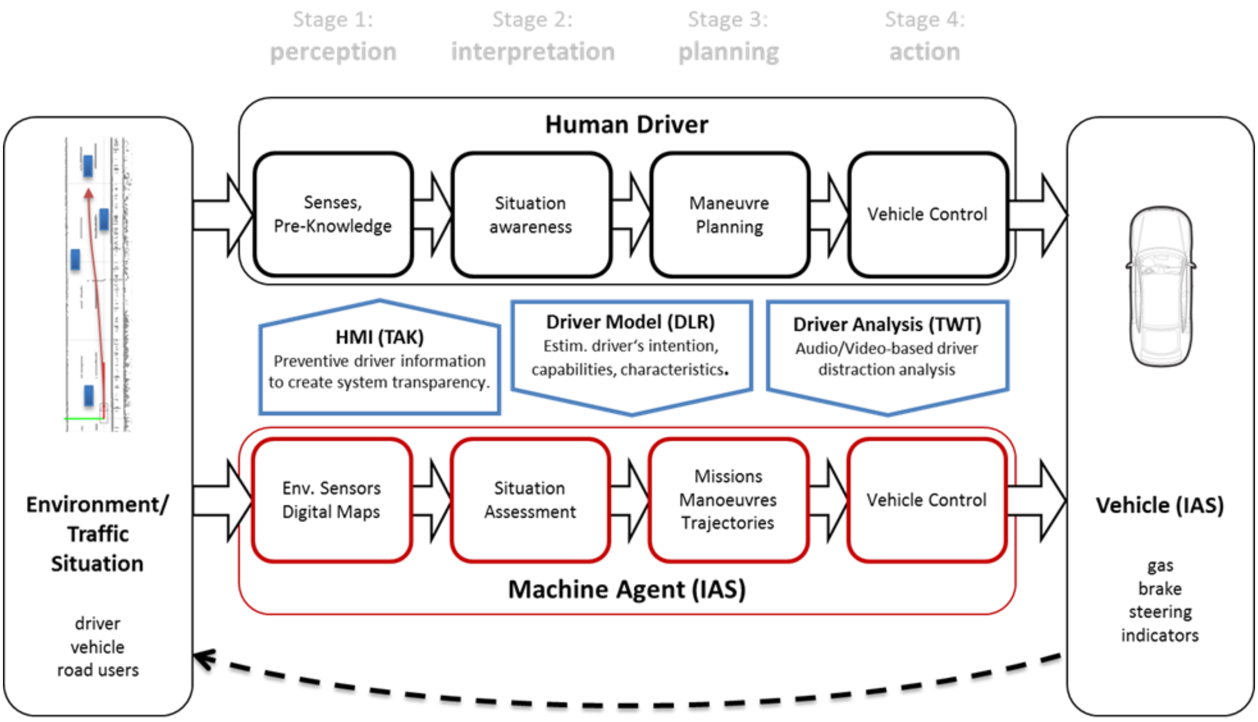

Figure 6: High Level Architecture of the Ibeo AdCoS

The process of driving can be broken down into four layers that are similar for the human driver as well as the automated system, as illustrated in Figure 6. The four layers are

1. perception,
2. interpretation,
3. planning and
4. action.

Also, Figure 6 visualises the interaction between the human driver and the machine agent. There are two modules connecting the communication flow between the human driver and the machine agent, and which close the loop of interaction:

1. **HMI**
   The HMI in this AdCoS is a display to provide information from the machine agent to the human driver. Standard control inputs,

such as the pedals, the steering wheel and the indicators allow the driver to interact with the automated system.

2. **Driver Model**
   The Driver Model analyses the behaviour of the human driver and provides information about the driver to the machine agent. The machine agent can then use this information to adapt the driving style to the individual human driver.

These two modules close the interaction loop between the human driver and the machine agent.

The roles of the partners which are involved in this AdCoS are given in the table below.

Partner	Role
IAS	• Development of the Machine Agent for Highly Automated Driving. • Coordination of the AdCoS development. • Providing interfaces for adaptation to the human driver.
DLR	• Implementing the driver model to characterize the human driver during phases of manual driving. The estimated characteristics are then used to adapt the driving style of the Machine Agent accordingly.
TWT	• Implementing an audio-based distraction estimation for the human driver to adapt the driving of the Machine Agent such that the risks during a required driver take-over is minimized during phases of high distraction.

Table 6: Role of partners for the IAS AdCoS

The partners for the development of the Adapted Automation AdCoS consist of two SMEs and one research institute. All of the partners use standard office tools for most development steps. Massive tool chains (e.g. for requirements management) are not available.

Another aspect is, that a prototype is developed, which reflects in the development process.

When tailoring an instance of the HF-RTP for this AdCoS, the mentioned aspects need to be considered, since using MTTs which require a lot of training, take a lot of time when using or increasing the cost, may not be selected although they could assist the development.

3.3.2 Tailoring Step 1 – Development process and issues

Due to the similarity of identified issues over all of the WP9 AdCoS, step 1 is documented in the appendix section 7.1 for all AdCoS.

3.3.3 Tailoring Step 2 – Selection

Tailoring step 2 is the selection of methods and tools which can be integrated into the development process to solve some issues. The selected tools for this AdCoS are listed in the table below.

MTT	Description
COSMODRIVE (IFS) **interest**	**Module Testing** COSMODRIVE is indented to be used for testing purposes for the driving style classification as well as the driver distraction classification.
Driver distraction model (DDM), (TWT) **planned**	**Module Implementation** The driver distraction model will be used within the AdCoS for adaptation of the autonomous driving style. When the driver is distracted, a more "defensive" style will be selected. The model was chosen as providing an additional input for the adaptation. The implementation of the model will provide an RTMaps interface, so it can be integrated without much effort.
Driver distraction classifier (DDC), (UTO) **interest**	**Module Implementation** The driver distraction classifier could be used as a reference for the driver distraction estimation which is implemented in this AdCoS by TWT.
Uppaal (UTO) **interest**	**Module Implementation** The time automata could be of interest in this AdCoS to model the task allocation and transitioning between manual and automatic driving.
CONFORM, (DLR) **in use**	**Module Implementation** This driver model is implemented in the AdCoS to characterize the individual driving style of the

	human driver in real time. This information is used in the real time system to adapt the driving style of the automation according to the individual driver. The relation between manual driving style and preferred automation characteristics is determined through user studies.
Driver intention recognition (DIR), (OFF) **interest**	**Module Implementation** The driver intention recognition could be used within the AdCoS to adapt the decision making process of the automated driving according to the preferences of the human driver. Selecting manoeuvres that are most suitable to the estimated intention of the human driver could improve the acceptance of the human operator.
HF-Guideline, (EAD-IW-DE) **interest**	**Requirements Definition / System Design** The Human Factors Guideline could be used to define the system and all relevant aspects comprehensively and identifying potential issues in the system design at an early stage in the project. The number of iterations for designing the system could be reduced.
RTMaps, (INT): **in use**	**Interface Implementation:** The tool used for the interface implementation is RTMaps. It has been selected from the HF-RTP, since it solves the issue on synchronization, operating system dependencies and gateway installations. RTMaps is well suited, since it provides a lot of interfaces to standard protocols, like CAN, Ethernet, etc. Most of the selected modules used within this AdCoS will be developed in C++, and RTMaps allows easy integration of C++ modules. The usage of RTMaps is expected to highly decrease the interface implementation effort.
I-Deep, (INT) **planned**	**Module Testing:** The testing of the overall AdCoS needs to be done in simulations, since no reproducibility is given for the real vehicle. Since a simulator is available at DLR which is involved in the AdCoS development, it will be used instead of the simulators available in the HF-RTP.

	The tools used for testing single modules depend on the module itself. However for the functional testing of modules, I-Deep is expected to be usable, since it is a server based application which allows to run RTMaps projects with variable parameters and stores the results in a database. It is therefore expected, that I-Deep will allow an extensive testing of the AdCoS module functions.
COSMO-SIVIC, (IFS) **interest**	**Module Testing:** COSMO-SIVIC can be used together with COSMODRIVE to test core functionalities of the AdCoS. The integration is intended to be done with COSMODRIVE, ProSivic and RTMaps.
Great-SPN, (UTO) **interest**	**Module Implementation** Great SPN could be of interest in this AdCoS to model the task allocation and transitioning between manual and automatic driving.
ProSivic, (CVT) **interest**	**Module Testing** ProSivic may be useful for generating simulation scenarios for offline testing. The interface to RTMaps allows using all of the AdCoS modules to be tested with simulated data.
CPM-GOMS task analysis of a Lane Change for manual and automated driving, (DLR) **planned**	**Requirements Definition / System Design** This task analysis method will be used further to understand the cognitive, perceptual and motor actions of the human driver during lane changes. It consists of a critical path analysis of the operators applied by the human driver during this task. This information will provide critical input to the human-machine-interaction strategy used to design the handover-of-controls between human and machine.
Methods and techniques for the driver adaptive parameterization of a highly automated driving system, (DLR) **in use**	**Requirements Definition / System Design / Module Testing** This activity encompasses the empirical studies necessary to determine driver styles and design appropriate automation driving styles. Data from the experiments are used to implement the CONFORM-module.

Theatre Technique for acceptance tests during AdCoS design, (DLR) **planned**	**Requirements Definition / System Design** The Theatre Technique is used to explore design alternatives for the fluent task handover between human driver and automation. Due to its Wizard-of-Oz approach, this technique will allow the designers and human factors expert to explore possible functions without the necessity of implementation.
Detection of driver distraction based on in-car measures, (TWT) **planned**	**Module Implementation** The tool can detect driver distraction using a microphone, a camera, and driving data from the CAN bus. Together with the distraction model mentioned above, a value is calculated which is an estimation of the current degree of distraction of the driver. If the value indicates a distracted driver, more defensive manoeuvers are selected.
Detection of driver distraction based on data on vehicle dynamics (DDDBDVD), (UTO) **interest**	**Module Implementation** This module could be used either as a reference for the driver distraction estimation which is implemented in this AdCoS by TWT or as an additional source of information for driver distraction.

Table 7: MTTs selected to be integrated into the development process of IAS

Some of the issues identified in step 1 still remain unresolved and are listed below, together with the currently used tools.

Issue	Current process
(1) Requirements definition	The tool currently used tool for managing requirements is Microsoft Excel. It is well suited for listing requirements. A drawback might be that there is no interface from requirements defined in Excel to other tools, but for the partners in this AdCoS, this is not relevant. The issue marked in step 1 is, that the definition of requirements needs to be assisted by an MTT. No MTT satisfying this request could be found within the HF-RTP.
(2) High Level Design	The tools used for the high level design are Microsoft PowerPoint and Microsoft Visio. There are

	tools listed within the HF-RTP which allow a link from the system design to previously defined requirements, but as mentioned before, for this AdCoS, the management of requirements is not identified as an issue and there would be no benefit switching to other tools. The issue results from the fact that none of the MTTs supports the selection of modules required for the AdCoS to satisfy the previously described requirements.

Table 8: Currently used tools for unresolved issues (IAS)

3.3.4 Tailoring Step 3 – Integration and interfaces

The integration of MTTs in the development process requires definition of interfaces. The interface definition is not part of the current AdCoS development and cannot be applied within this deliverable. Instead a list of outputs generated by the development steps is collected. This list may help the MTT work packages to identify needs for interfaces.

- Requirements definition/refinement: .doc (or excel) file with the list of requirements.
- Module requirements definition/refinement: .doc (or excel) file with the list of requirements.
- Test specification: .doc file with list of test specification (derived from the requirements manually)
- High-Level design: .ppt file with a schema of the overall system architecture.
- Interface definition: .doc file with the definition of the interfaces
- Low-Level design: .ppt file with schemes of the modules architecture.
- System Integration: product/prototype, the AdCoS itself
- Module implementation: binary files containing the module functionality together with the defined interfaces.
- Functional/System testing: .doc file containing a test report.
- Module testing: .doc file containing a test report.
- Performance evaluation: .doc (or excel) file containing the results of the evaluation

3.3.5 Tailoring Step 4 – Implementation

This step is not covered within this deliverable.

3.3.6 Conclusions

The tailoring process for the IAS AdCoS could solve some issues in the development process. Although the HF-RTP is in an early stage, it provides already a good overview of available tools for developing an AdCoS.

However, some issues still remain unsolved. For some issues, no suitable MTTs are available, for other issues, MTTs are available, but are not selected, because they do not add benefit in comparison to standard tools. For instance, it was evaluated that MagicPED cannot be used for the IAS AdCoS development in a manner that it adds more value than using PowerPoint. This will probably not be true for other development processes.

The introduction of a new tool into the development process needs to add enough value to overcome the effort for training staff, financing the tool and the necessary time to adequately use the tool. For the development of the IAS AdCoS, it is desired to keep the number of tools low.

Since MTTs are more than just tools, the AdCoS development process would benefit from methods and techniques assisting the development using standard tools. The MTTs can be guidelines or templates assisting the integration of human factors into a technical system.

3.4 AdCoS Virtual HCD Platform (IFS)

In this section, we describe the different aspects of the AdCoS to be designed by IFS in WP9, in order to monitor drivers' visual distraction risk when driving. This AdCoS will be progressively designed, developed and then tested by using a Virtual Human Centred Design platform (so-called Virtual HCD). That is a tool chain (developed in WP4; D4.4, Bellet et al., 2015) aiming at supporting the virtual prototyping of adaptive and cooperative systems for the automotive domain. At this V-HCD level, the challenging issue in HoliDes is to develop this integrative platform interfacing (1) a human driver model (named COSMODRIVE, and using a "virtual eye" for road scene scanning) able to drive (2) a virtual car (3) equipped with a virtual ADAS (Advanced Driving Aid Systems) and the AdCoS, for progressing in (4) a virtual road environment. From this approach, it is expected to better integrate end-users' needs in the AdCoS design process.

The core partners involved in the development and the implementation of this Virtual HCD platform are three SMEs (CVT, INT), a major group (EAD-FR), and two research institutes (ENA, IFS). All of the partners use standard office tools for most development steps. From the integration of the different Methods, Models, Technics and Tools (MTTs) provided by these six partners, this virtual HCD platform will constitute a tailored HF-RTP for the virtual prototyping, test and validation of an AdCoS, liable to:

- Support the AdCoS specification by integrating HF requirements
- Assist the design and development process
- Support the virtual evaluation process
- Test hazardous and critical situations

3.4.1 Status of the AdCoS development

Regarding the AdCoS itself (Figure 9), virtually designed and developed by IFS from this V-HCD platform, it will be an integrative device combining several simulated Advanced Driving Aid Systems (ADAS) to be managed in and Adaptive and Cooperative way by a set of MOVIDA functions (Monitoring of Visual Distraction and risks Assessment), according to the drivers' visual distraction status and to the situational risks assessment:

- The core ADAS systems to be combined in this AdCoS are a Collision Mitigation and Avoidance (CM&A) system (we could share both the Front Collision case and the Rear Collision case), a Lane Keeping Assistant (LKA), a Lane Change Assistant (LCA), an Adaptive Cruise

Control (ACC). In addition, Full Automation (FA) could be also simulated, by combing the preceding ADAS.

- Adaptive and Cooperative abilities in the AdCoS will be supported by a set of monitoring functions (i.e. MOVIDA module), in charge to monitor the drivers, to assess their visual distraction state, and to evaluate the risk of accident in the current traffic situation. Then, from MOVIDA monitoring, Risk-based analysis algorithms and a Centralized Management of ADAS systems will be implemented, in order to provide an adaptive and cooperative driving aid (based on warning or on vehicle control taking), specifically adapted to the current driver's needs, their visual distraction state and the situational risks.

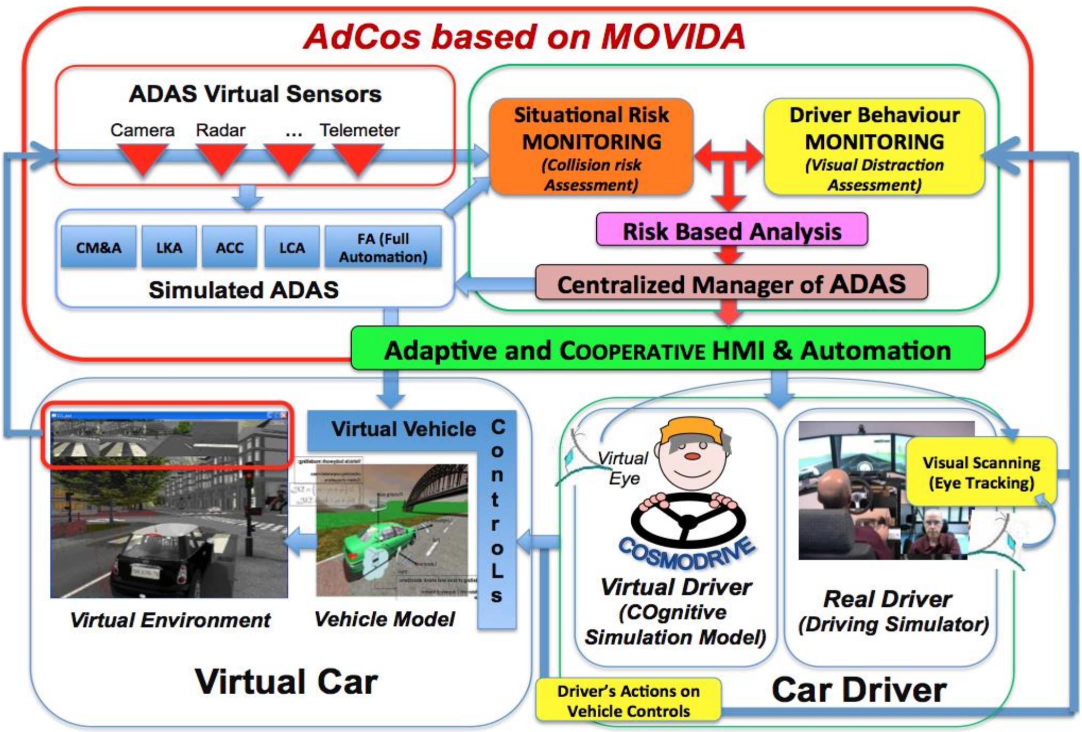

Figure 7: Functional architecture of the AdCoS based on MOVIDA

All these ADAS and the global AdCoS based on MOVIDA will be interfaced and/or supported by RTMaps platform (one of the MTTs involved). In order to run the different ADAS and AdCoS, the designer needs either to replay sensors databases (from real or virtual sensors), or to use real time sensors data flow coming from embedded sensors or virtual embedded sensors available in the pro-SiVIC platform.

The different modules and functionalities needed in the Virtual HCD platform are shown in the following figure.

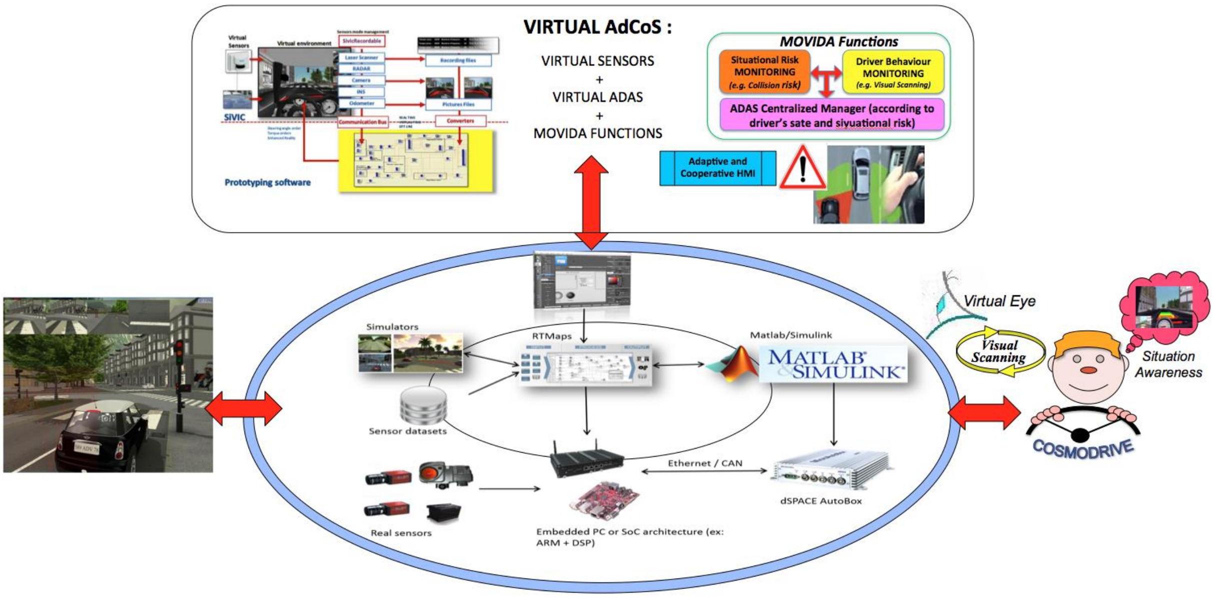

Figure 8: Overview of the virtual HCD platform

3.4.2 Tailoring Step 1 – Development process and issues

From the Human Factor point of view, the core advantage of this Virtual HCD platform based on HF model (i.e. COSMODRIVE) it is to better integrate end-users' needs in the AdCoS design process at 2 main levels.

At the earliest stages of the V-Cycle of the design process presented in Figure 11, COSMODRIVE-based simulations will be used to estimate human drivers' performances and risks in case of unassisted driving, in order to identify critical driving scenarios due to visual distraction for which a given AdCoS based on MOVIDA could support them, in an adaptive and cooperative way. These critical scenarios will correspond to traffic situations for which the visual distraction could critically impact the human drivers' reliability, and then increasing the risk of accident. Through these simulations, it will be possible to provide ergonomics specifications of human driver needs, as a set of "Critical Scenarios" and "Use Cases" of reference, liable to be stored in a "reference database".

During the virtual design process of the MOVIDA-AdCoS, this reference database associated with visual distraction simulations based on COSMODRIVE, will be used to progressively increase its *efficiency* (i.e.

ADCOS developments & virtual tests Cycle on the figure) in accordance with the different variations of the critical scenarios previously identified. Such COSMODRIVE + AdCoS based simulations will also allow the designer to assess the potential *effectiveness* of MOVIDA, before developing a real prototype and then testing its effectiveness among real human drivers, through full scale tests with end-users implemented on driving simulators and/or with real cars (final stage of the design process).

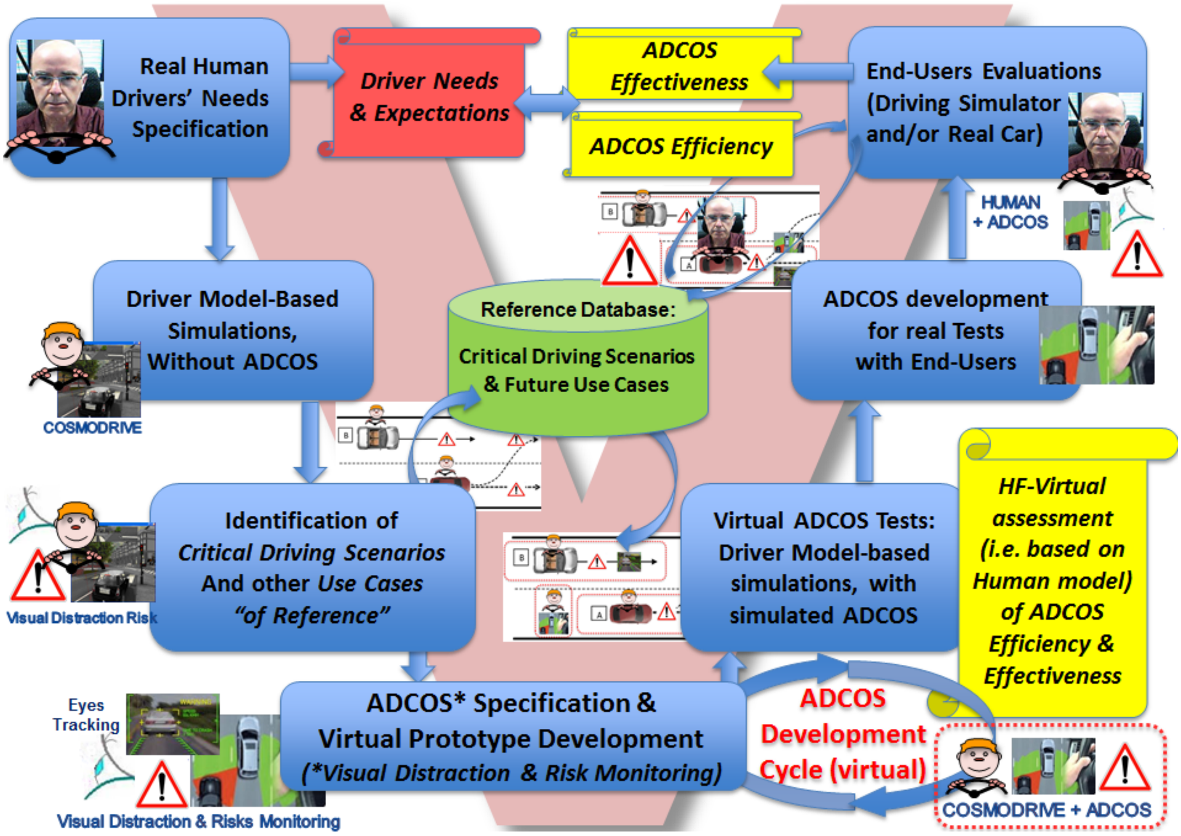

Figure 9: V-Cycle Design process of AdCoS with the V-HCD platform

Advantages of using a Human operator model in this design process are to consider end-users' needs since the earliest stages (even if not any AdCoS prototype is available), and also to investigate driving scenarios and AdCoS functioning in a systematic way (that was not possible or highly expensive to do among real drivers).

From the technological point of view, the core advantage of the Virtual HCD platform is to support the virtual prototyping and simulation of ADAS and AdCoS, in a very realistic way (from the car sensors to full advanced and complex embedded assistances; following Figure).

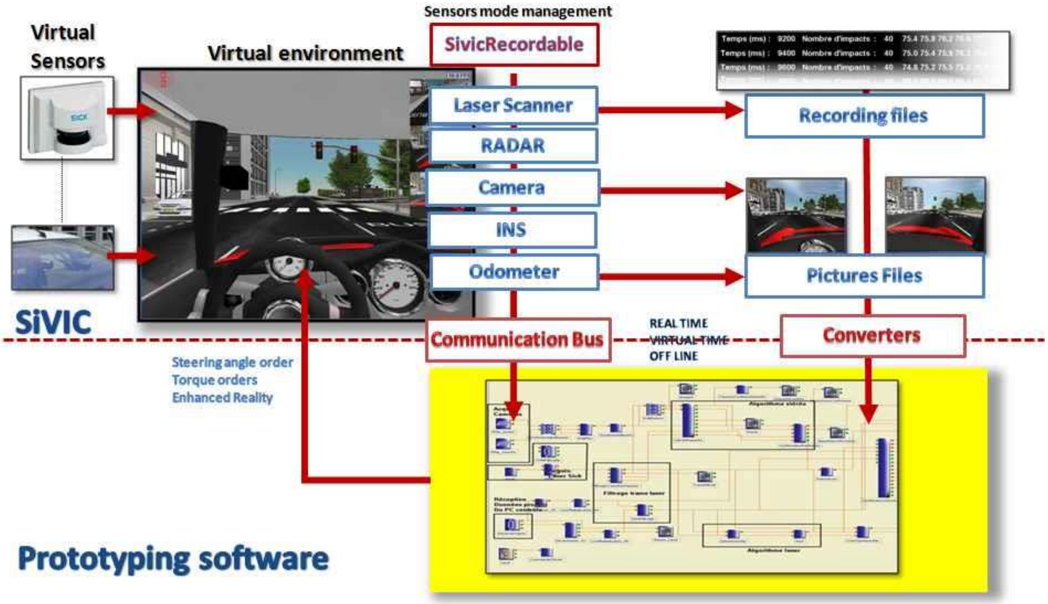

Figure 10: Example of ADAS and AdCoS simulation with the V-HCD platform

This virtual prototyping process to be supported by the V-HCD platform is presented in following figure showing the development workflow of the IFS AdCoS. This workflow comes from standard methodologies in software development. For each step, a set of issues is identified and for each one, one or several MTTs are listed. These MTTs are chosen to help the development process and to guarantee a level of system quality.

At the implementation stage of the development process, we need, for the modules development of the ADAS part of the AdCoS, to implement a set of modules involved in several levels of implementation and several MTTs. The levels are representing the environment, the vehicles and sensors used in the ADAS, the interface mechanism, and the ADAS modules. The following figure shows an example of these levels and modules needed for active ADAS.

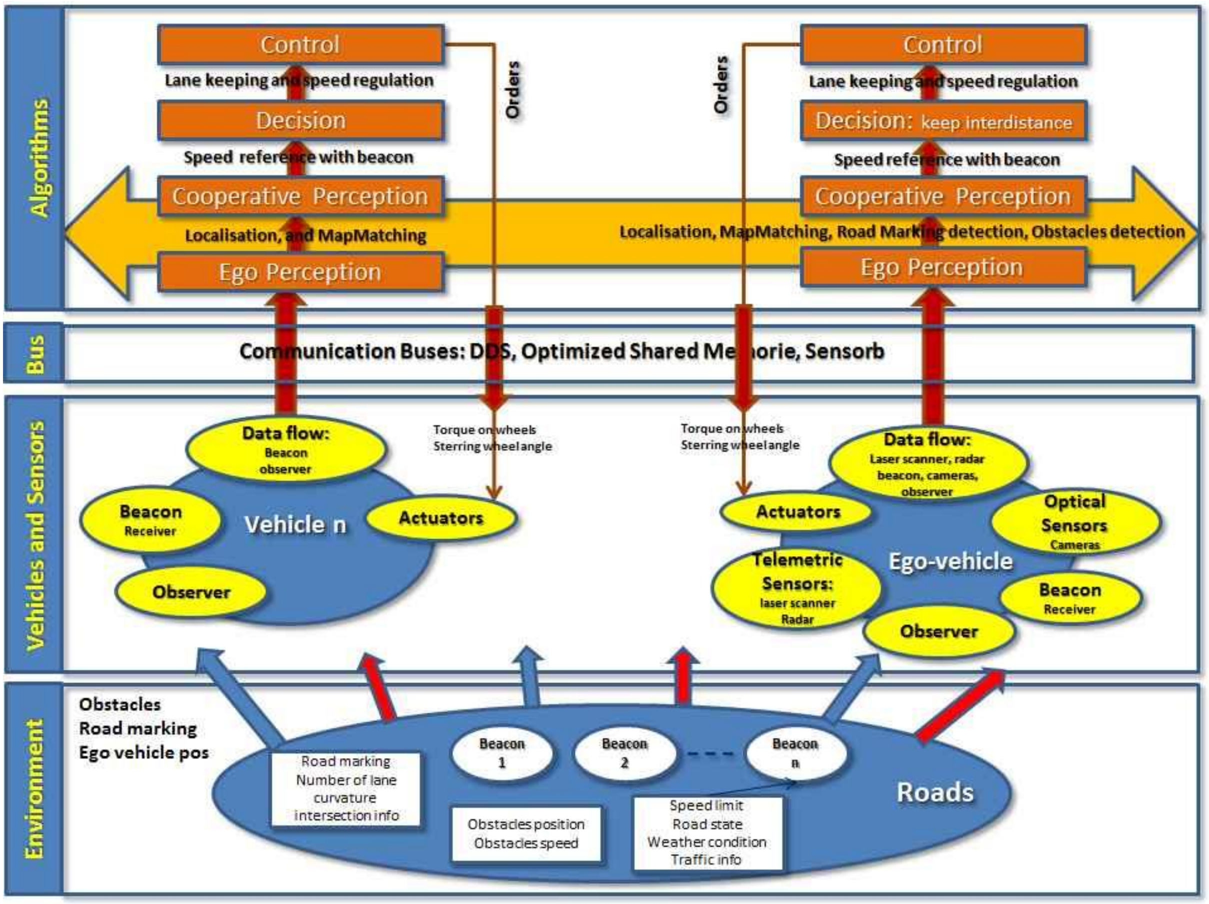

Figure 11: Modules implementation in the ADAS part of the AdCoS (IFS AdCoS) for Virtual HCD platform

From the figure dedicated to the development process (figure 12), it is also interesting to highlight the use of the two MTTs, called COSMODRIVE and COSMO-SiVIC, in order to generate, at the requirements and design specification stages, a set of requirements, definitions, and specifications in critical situation From HF model based simulation (as presented in the preceding V-Cycle Figure).

Due to the similarity of identified issues over all of the WP9 AdCoS, step 1 is documented in the appendix section 7.1 for all AdCoS.

3.4.3 Tailoring Step 2 – Selection

Tailoring step 2 is the selection of methods and tools which can be integrated into the development process to solve some identified and highlighted issues. The selected tools for this AdCoS are listed in the table below.

MTT	Description
COSMODRIVE (IFS)	COSMODRIVE (COgnitive Simulation MOdel of the DRIVEr) provides a solution to the issues identified in the implementation and testing stages: • In the issue 1, COSMODRIVE (with COSMO-SiVIC) used without ADAS or AdCoS can be seen as a generator of critical scenario. The outputs of this virtual platform centred HF become the inputs of the HF-Guideline MTT. • In the issue 2, COSMODRIVE (with COSMO-SiVIC) used without ADAS or AdCoS can be seen as a generator of critical scenario for the specifications determination. • In the issue 5, COSMODRIVE provides the cognitive driver modelling needed in the Cosmo-SiVIC MTT. • In the issue 7, COSMODRIVE is a part of the MTT called MOVIDA. In the two cases, COSMODRIVE is able to simulate human drivers visual strategies, cognitive processes, and driving behaviors.
Pro-SiVIC (CVT)	Pro-SIVIC is a software platform able to simulate embedded Sensors, infrastructure, roadside equipment, Vehicles, and mobile objects (pedestrians), in a virtual 3D Road Environment. • In the issue 5, pro-SiVIC is an adapted MTT allowing to implement virtual sensors (physically realistic) needed for the ADAS developed in the AdCoS. • In the issue 6, Pro-SiVIC is one of the MTTs used to generate references and ground truth to test and to evaluate some of the modules implemented in the implementation stage of the development process. • In the issue 7, pro-SiVIC is a part of the integrated system and provides measurements and references in order to test the functional system.

COSMO-SiVIC (IFS)	COSMO-SiVIC is a common platform involving the virtual environment, the vehicle, the cognitive driver modelling with its functionalities (eye modelling, gaze direction, mental representation of the driving environment and Situation Awareness). • In the issue 1, COSMO-SiVIC (with COSMODRIVE) used without ADAS or AdCoS can be seen as a generator of critical scenario. The outputs of this virtual platform centred HF become the inputs of the HF-Guideline MTT. • In the issue 2, COSMO-SiVIC (with COSMODRIVE) used without ADAS or AdCoS can be seen as a generator of critical scenario for the specifications determination.
MOVIDA (IFS)	MOVIDA (*MOnitoring of VIsual Distraction & risks Assessment*) is the MTT included algorithms in charge to centrally manage ADAS and to interact with the car Driver in an Adaptive and Cooperative way.
RTMaps (INT)	RTMaps is a software platform allowing to easily and efficiently interconnect the data streams of the different tools and models, such as simulators, sensors and actuators, or HMI, and can integrate data processing algorithms, also with capacities for synchronized recording and playback of any kind of streams. These functionalities provide MTT : • In the issue 3, RTMaps allows to implement and to develop the API modules for the modules interconnection allowing to implement the full system. • In the issue 5, RTMaps allows to provide a solution in order to integrate ADAS modules for the ADAS and AdCoS application and platform. • In the issue 6, RTMaps will be one of the MTT integrated the module testing.
iDeep (INT)	In order to test and to evaluate either the overall AdCoS or a specific module of the AdCoS, it is relevant to use a software which allows to monitor a great set of scenario and which provide the

	variation of critical parameters in the scene. This MTT is iDeep. This MTT needs to be used with a simulation platform, since no reproducibility is given for the real vehicle. iDeep is perfectly adapted to work with the Virtual HCD platform which is involved in the AdCoS development. The MTT usable for the testing of a single module depends of the module itself. However for the functional testing of modules, I-Deep is expected to be efficient, since it is a server based application which allows to run RTMaps, Pro-SiVIC, and Cosmo-SiVIC MTTs with variable parameters and stores the results in a database. It is therefore expected, that I-Deep will allow an extensive testing of the AdCoS module functions.
HF-Guideline, (EAD-IW-DE)	The Human Factors Guideline could be used to define the system and all relevant aspects comprehensively and identifying potential issues in the system design at an early stage in the project. The number of iterations for designing the system could be reduced.
ERG **planned**	Eye tacking technics and tool, provided by ERG, should be used by MOVIDA module to monitor drivers' visual scanning and to assess visual distraction risks.
HF-Guideline (EAD-IW-DE) **interest (planned)**	The Human Factors Guideline could be used to define the system and all relevant aspects comprehensively and identifying potential issues in the system design at an early stage in the project. The number of iterations for designing the system could be reduced.
- GreatSPN-MPD, - Driver distr. classif. - Detection of driver distraction based on data on veh. dynam. (UTO) **interest (planned)**	Liable to be used to support exchanges / interactions / partnership with teams involved in CRF demonstrator, regarding drivers' distraction and risk issues.
Djnn (ENA)	Liable to be used to support HMI verification of IFS AdCoS based on MOVIDA

**interest (planned) **	
- Bad MoB & Driver - Intention Rec. (OFF) **interest (planned)**	Liable to be used in association with COSMODRIVE model to support interactions with teams involved in CRF demonstrator, regarding drivers' distraction and risk issues.
LEA, APA & AMAS (EAD-F) **interest (planned) **	Liable to be used to support the design and development of drivers Monitoring Functions to be integrated in IFS AdCoS from MOVIDA module
Empirical analysis of cognitive and communication processes (SNV) **interest (planned)**	Liable to be used to support interaction with teams working on CRF demonstrator, more particularly regarding methodological issues, driving scenarios selection or empirical/simulated data sharing.

Table 9: MTTs selected to be integrated into the development process of IFS

3.4.4 Tailoring Step 3 – Integration and interfaces

All the MTTS to be integrated in the Virtual HCD plarform are connected from the RTMaps software provided by INT. The following figure provides an overview of this V-HCD based onRTMaps, for supporting the MOVIDA-AdCoSvirtual design and evaluation, and then, its potential transfert towards real cars, from some RTMaps functionnalities.

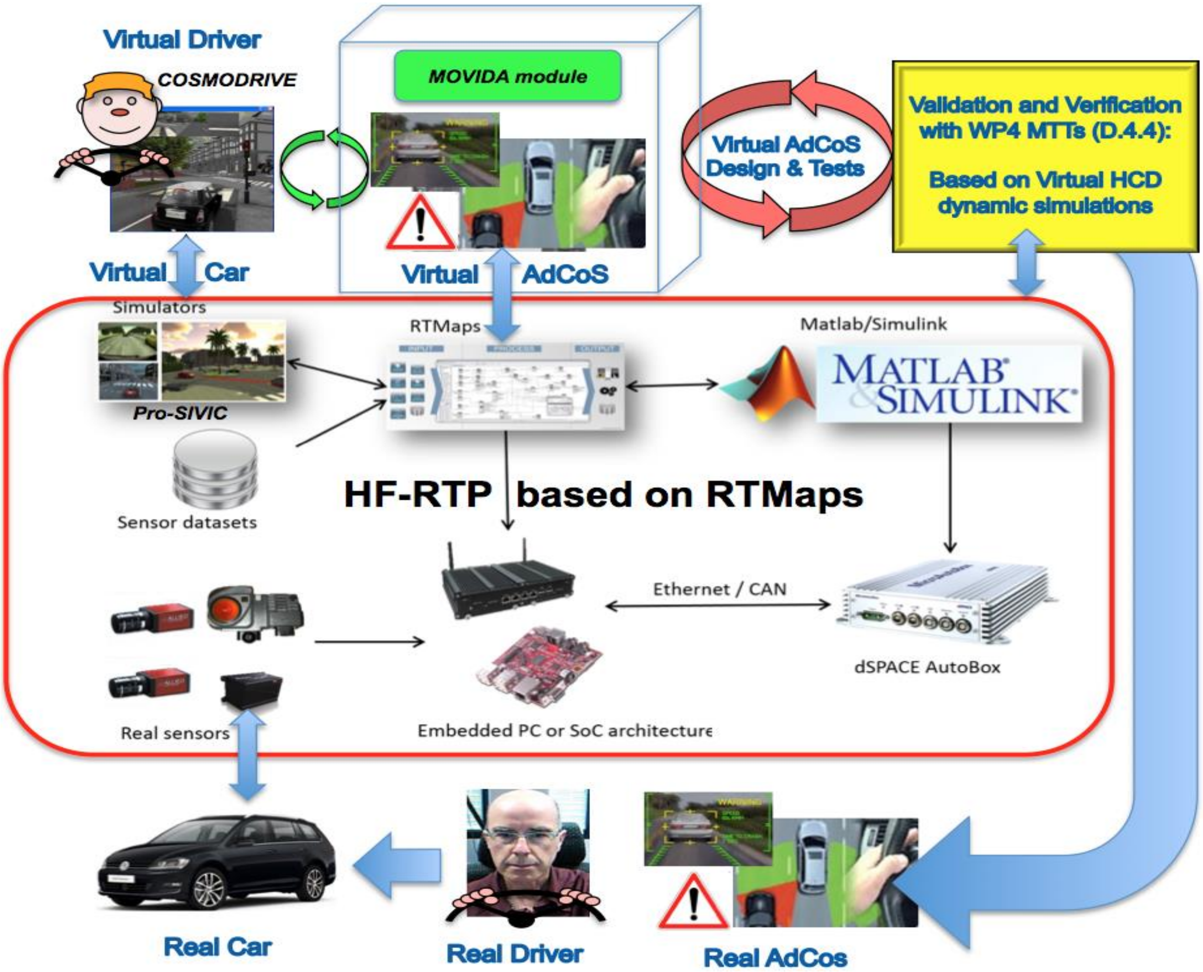

Figure 12: Overview of the Virtual HCD tailored HF-RTP based on RTMaps

In this approach, RTMaps, Pro-SiVIC and COSMO-SIVIC will support virtual simulations ofcar sensors, ADAS and AdCoS, to be used by HF driver models (COSMODRIVE). Simulated data, or data collected on real car (e.g. CRF Demontrator) could be also used to design MOVIDA-AdCoS algorithms. Connection with other MTTsin WP4 (see D4.4), like Djnn or GreatSPN tool chain could be also used to support AdCoS Verification and Validation at a virtual level, in association with RTMaps dynamic simulation functionnalities and/or through the shared Database of collected/simulated driving data. At last, RTMaps could also provide a support for the transfer of virtual AdCoS toward real cars and/or for empirical data sharing with IAS, CRF and TAK demonstrators.

3.4.5 Tailoring Step 4 – Implementation

All the core MTTS to be integrated in the Virtual HCD plarform were interfaced during the first phase of the project with RTMaps software. Of course, some of this tools are currently under development, like COSMODRIVE in WP2, MOVIDA in WP3, or COSMO-SIVIC in WP4 for ADAS and AdCoS simulation. However, all the development are currently done under the constraint to be interfaced with RTMaps.

In addition, connections with other MTTs, developped in WP4 (like Djnn or GreatSPN for instance, see D4.4) for AdCoS Verification and Validation, in WP2 and WP5 (like BadMod of OFF or SNV technic) for driver behaviour analysis, or in WP3 (e.g. EAD-FR tools like LEA, APA & AMAS, or UTO MPD-Copilot) for MOVIDA adaptative algorithms design an test, are also liable to be adequately supported by RTMaps. Lastly, empirical data sharing with IAS, CRF and TAK demonstrators in WP9 could also benefit of RTMaps and IDEEP functionalities to collect, synchronize and/or replay shared data sets.

3.4.6 Conclusions

The rapid development of information and sensor technologies in the past years has raised a growing need in the automotive industry to make driving safer. However road safety is directly related to the performance of embedded intelligent systems and also the reliability and robustness of sensors. Sensors used in the vehicular embedded intelligent systems are becoming more ubiquitous, numerous and complex. Moreover, these embedded systems need more and more to be interconnected with the driver. In this configuration of interaction between the vehicle automation and the driver intention, it is necessary to develop more adaptive ADAS. These new ADAS are called AdCoS.

In order to help ADAS developers in the design and the development of such “intelligent and adaptive systems”, and by extension in the test, the evaluation and the validation of the performance these AdCoS, we propose to develop a high level platform included simulation, prototyping and testing tools that can jointly operate in real time and in the closest possible way with the driver (either with real driver, or with a complex and cognitive driver modelling).

This virtual platform called Virtual HCD platform could solve a lot of issues encountered in the development process. In this Virtual HCD platform, the MTTs identified are:

- COSMODRIVE for the cognitive driver modelling,
- Pro-SiVIC for the road environment, the vehicles, and the sensors modelling
- COSMO-SiVIC which allows to merge the functionalities of the SiVIC platform with some perception attributes of the driver.
- RTMaps for the data flow management (coming from sensors or other sources) and the ADAS prototyping.
- i-DEEP for the scenario monitoring with the management of the variation of critical parameters in the scene.
- MOVIDA for the monitoring of driver distraction and risk assessment.

In fact, this virtual AdCoS focuses on the development of a generic simulation architecture dedicated to the adaptive ADAS prototyping involving the human factor. Moreover, a second outcome will be to provide test protocols and the set of adapted criteria of validation which is based on the concept of "extended" testing for intelligent vehicles involving a "physical" part on the track and a second virtual part by simulation.

The way this platform is designed allows to address the implementation of scenario and AdCoS not only in a simulation framework but also with real module and/or driver. In fact, for a same AdCoS, it is possible to prototype it with the Virtual HCD platform and in a second stage to implement in the same way the ADAS part in a real car demonstrator.

Another important advantage of this virtual platform is to allow to test AdCoS in very critical scenario and very hazardous situation which could not be applied with a real demonstrator. For instance, it is possible to test an AdCoS until the collision.

3.5 AdCoS Adaptive HMI (TAK)

The adaptivity of the adaptive HMI developed as AdCoS by TAKATA is based mainly on the detection of distraction. Here, a distinction is made between cognitive and visual distraction. Both kinds of distraction require different hard- and software in order to be reliably detected. The AdCoS in turn is depending on this reliable detection of distraction.

3.5.1 Status of the AdCoS development

Referring to Deliverable D9.2 TAKATA is currently in step three of the linear workflow that is development of tools and the HMI.

3.5.2 Tailoring Step 1 – Development process and issues

Due to the similarity of identified issues over all of the WP9 AdCoS, step 1 is documented in the appendix section 7.1 for all AdCoS.

3.5.3 Tailoring Step 2 – Selection

MTT	Description
HF-Guideline, (EAD-IW-DE) **interest**	**Requirements Definition / System Design** The Human Factors Guideline could be used to define the system and all relevant aspects comprehensively and identifying potential issues in the system design at an early stage in the project. The number of iterations for designing the system could be reduced.
SuRT (DLR) **interest**	**Evaluation** The SuRT can help to reliable induce visual distraction. It is therefore an important part in the evaluation of the AdCoS.
Visual Distraction Detection (n.n.) *planned*	**Module** Visual Distraction Detection is needed to reliably detect visual distraction.
Driver distraction model (DDM), (TWT) **planned**	**Module** The driver distraction model will be used within the AdCoS for adaptation of the HMI. The implementation of the model will provide an RTMaps interface, so it can be integrated without much effort.
Detection of Driver	**Module**

Distraction (DDD) (TWT) *planned*	The detection of (cognitive) driver distraction is a prerequisite for the AdCoS. Without DDD the AdCoS would not be possible.
CasCas (OFFIS) *planned*	**Evaluation** CasCas is used to reduce the simulator studies with real probands and speed up the development process of the HMI

Table 10: MTTs selected to be integrated into the development process of TAK

3.5.4 Tailoring Step 3 – Integration and interfaces

The integration of MTTs in the development process requires definition of interfaces. The interface definition is not part of the current AdCoS development and cannot be applied within this deliverable. Instead a list of outputs generated by the development steps is collected. This list may help the MTT work packages to identify needs for interfaces.

- Requirements definition/refinement: .doc (or excel) file with the list of requirements.
- High-Level design: .ppt file with a schema of the overall system architecture.
- Interface definition: .doc file with the definition of the interfaces
- System Integration: product/prototype, the AdCoS itself
- Module implementation: binary files containing the module functionality together with the defined interfaces. Will be wrapped into an RTMaps package.
- Simulator Study: raw data from simulator which needs to be analysed and compiled into a .doc file containing a test report
- Cognitive Modelling: raw data from simulator which needs to be analysed and compiled into a .doc file containing a test report

3.5.5 Conclusions

For the development of the Adaptive HMI AdCoS an effort was made to follow the proposed tailoring steps. The first step was the identification of issues. These issues are partly of technical/functional nature and partly cover specific human factors issues that are related to an adaptive HMI. Regarding the latter, these were to a certain degree already identified and defined in the requirements following the definition of the use-cases. The selected tools allow that these issues will be solved. However, the degree to which this will be the case depends on the implementation of the MTTs which at present is not yet clear. This also applies to the technical/functional issues and the proposed tools that were selected to tackle these issues. Nevertheless, the MTTs being at present in the HF-RTP are promising regarding the development of this specific AdCoS.

4 Conclusion and Summary

The tailoring of HF-RTP instances has been performed for all the WP9 AdCoS of the HoliDes project within this deliverable as far as possible at the current development status. Issues in the development process have been detected and MTTs have been mapped to development steps to solve some of the issues. Although it was the first application of the tailoring within the HoliDes project, it could be achieved, that all partners make use of MTTs from the HF-RTP to improve their development process.

A special situation for WP9 is that the majority of partners involved in the AdCoS development are SMEs or research institutes, who develop prototypes rather than products. For this reason, the requirements on the HF-RTP may differ from other work packages. This is caused by the fact, that standard office tools are used for most of the development steps when developing prototypes. In contrast, product development includes validation and certification which adds the need for powerful requirement tracking tools.
However, prototype development processes could benefit from methods and techniques assisting the development of human factor related products.

Other parts of the development process, where extensive use of MTTs from the HF-RTP has been made are mainly implementation and testing steps.

In summary the experiences made in WP9 are that the HF-RTP can already add benefit to the process development, although the tailoring has not yet been finished. However, some issues (e.g. a guideline for the derivation of a HF-system architecture from requirements) still remain unsolved, but will probably solved in future cycles.

5 Way forward and upcoming activities

The current deployment of the tailoring rules concentrated on step 1 and 2. Further activities within the AdCoS development will include tailoring step 3 in more detail, including the description of interface of MTTs and the development process. Also the implementation of interfaces will be started in the next project cycle, which will allow a description for tailoring step 4.

The outcome of this deliverable will be used as a feedback for the MTT work packages to identify requirements in the AdCoS development processes.

The next application of tailoring rules will be based on the HF-RTP version 1.5 and will be reported in D9.6 for the automotive work package.

6 References

[1] "*D9.2 – Tailored HF-RTP and Methodology Vs0.5 for the Automotive Domain*", HoliDes deliverable

[2] "*D1.4 - HF-RTP Vs1.0 incl. Methodology and Requirements Analysis Update*", HoliDes deliverable

[3] *"D4.4 - Techniques and Tools for Model-based Analysis Vs1.0 incl. Handbooks and Requirements Analysis Update",* HoliDes deliverable

[4] Gasser, T., Arzt, C., Ayoubi, M., et al. (2012). "*Rechtsfolgen zunehmender Fahrzeugautomatisierung*". Berichte der Bundesanstalt für Straßenwesen. Fahrzeugtechnik. Heft F 83. Bremerhaven: Wirtschaftsverlag NW.

Glossary

ACC = Adaptive Cruise Control

ADAS = Advanced Driving Assistance Systems

AdCoS = Adaptive Cooperative Human-Machine Systems

AUT = Automotive

CAS = Collision Avoidance Systems

COSMODRIVE = COgnitive Simulation MOdel of the DRIVEr

COSMO-SiVIC = Join platform COSMODRIVE/pro-SiVIC Research

DAS = Driving Assistance Systems

EV = Ego Vehicle

FCW(S) = Forward Collision Warning (System)

HF = Human Factors

HF-RTP = Human Factors Reference Technology Platform

HMI = Human Machine Interaction

HMS = Human Machine Systems

HoliDes = Holistic Human Factors Design of Adaptive Cooperative Human-Machine Systems

I-DEEP = Intempora Distributed Execution & Evaluation Platform

LCA = Lane Change Assistant

LKAS = Lane Keeping Assistance

MOVIDA = Monitoring of Visual Distraction and risks Assessment

MTTs = Methods, Techniques and Tools

PADAS = Partially Autonomous Driving Assistance Systems

Pro-SiVIC = Professional Simulator of Vehicles, Infrastructures, and Sensors

RTP = Reference Technology Platform

RTMaps = Real Time Multimodal applications

UC = Use Cases

V-HCD (platform) = Virtual Human Centred Design (platform)

WP = Work Package

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7 Appendix

7.1 Tailoring Step 1 – Development process and issues

Step 1 is performed by analysing the development process of the AdCoS and identifying issues where MTTs could help to improve this process and the system quality.
Issues in the development process are indicated with yellow markers and described below:

Issue	Challenges
(1) Requirements definition:	▪ the complexity of the system makes it hard for the developers to gain an overview of existing challenges in the development ▪ especially in the field of HF related aspects it can be very challenging to find suitable metrics to make requirements measurable. It is not always possible to define it precisely, especially at the beginning of a project. ▪ requirements need to describe both the virtual and real systems comprehensively so all aspects of the system are covered by the requirements. Virtual system is dedicated to the simulation platform. Real system is focused on the means used, for instance, to monitor the real driver (HF) ▪ requirements must be defined such that system engineers can design the system based on the requirements ▪ it was found that requirements defined were not useful for the design process of the system, as they did not cover all relevant aspects of the system ▪ it is hard to define requirements for interdisciplinary systems (e.g. engineering and psychology), or cross-domain, since they must be understandable to the other party. ▪ how to automatically generate the requirement in realistic driving situations?
(2) System Design	▪ deriving a high level system design from the defined requirements as a starting point and then link it to the low-level design.

	▪ integration of HF related modules into system architecture and related implementation. ▪ finding a suitable modularization of the overall system ▪ deriving a task allocation and transition model based on the defined requirements ▪ How to automatically provide specification in order to develop an AdCoS?
(3) Interface Implementation	▪ components need to be synchronized ▪ communication between modules may depend on the operating system ▪ common protocols need to be defined, between internal modules of the framework and external components. ▪ gateways need to be installed
(4) System Integration	▪ system integration requires detailed knowledge of the AdCoS functionalities ▪ task transition and allocation between AdCoS modules need to be modelled to identify issues in the AdCoS operating workflow ▪ how to integrate the full system taking into account efficiently the set of modules coming from MTTs in order to get the AdCoS platform.
(5) Module Implementation	▪ the implementation of the overall AdCoS functionalities requires tools which are dedicated for the purpose of the AdCoS. The selection and elaboration of tools can be challenging and time consuming. ▪ identify, for each function and functionality, the most adapted MTT.
(6) Module Testing and Evaluation	▪ integration with performance evaluation. ▪ use of simulation (including driving simulator). ▪ use of real vehicle for testing, which is very good from one side, but on the other side it causes the lack of repeatability and the impossibility to investigate risky situations. ▪ test-plan and protocol for experiments on real-roads. ▪ need to obtain specific and dedicated ground truth in order to evaluate and validate a specific module. ▪ have the capability to generate and handle

	virtual environment, test scenario corresponding to the use cases. (IFS only) ▪ get the real sensors configuration and parameters to validate the embedded virtual sensors. It is important to define the level of sensor modelling. (IFS only) ▪ find the MTT allowing to automatically generate the scenario variability. (IFS only)
(7) Functional system testing (IFS only)	▪ in a virtual simulation framework, we need to be able to simulate the full platform: the AdCoS, the vehicles, the environment, the sensors, the driver, the monitoring, and the evaluation tools. ▪ validation of the adaptivity and operability aspects of the system. The question is: does the system fulfil the requirements.
(8) Performance Evaluation	▪ not all requirements are well defined with measurable values and corresponding metrics. ▪ sometimes, requirements for evaluation are confused in different aspects (technical, user-related, in-traffic, etc.). ▪ how to evaluate the system performance. ▪ validate the criteria applicability. ▪ a tool to simulate/evaluate the AdCoS is needed to minimize the need for real simulator studies ▪ induction of distraction missing (TAK only for simulator study)

The development workflow charts are illustrated in the following figures. The schemes are derived from standard methodologies in software development.
The blocks in the diagram show various tasks along the work flow. Arrows between the blocks indicate the flow of information.

Issues in the development process are indicated with yellow markers and described below:

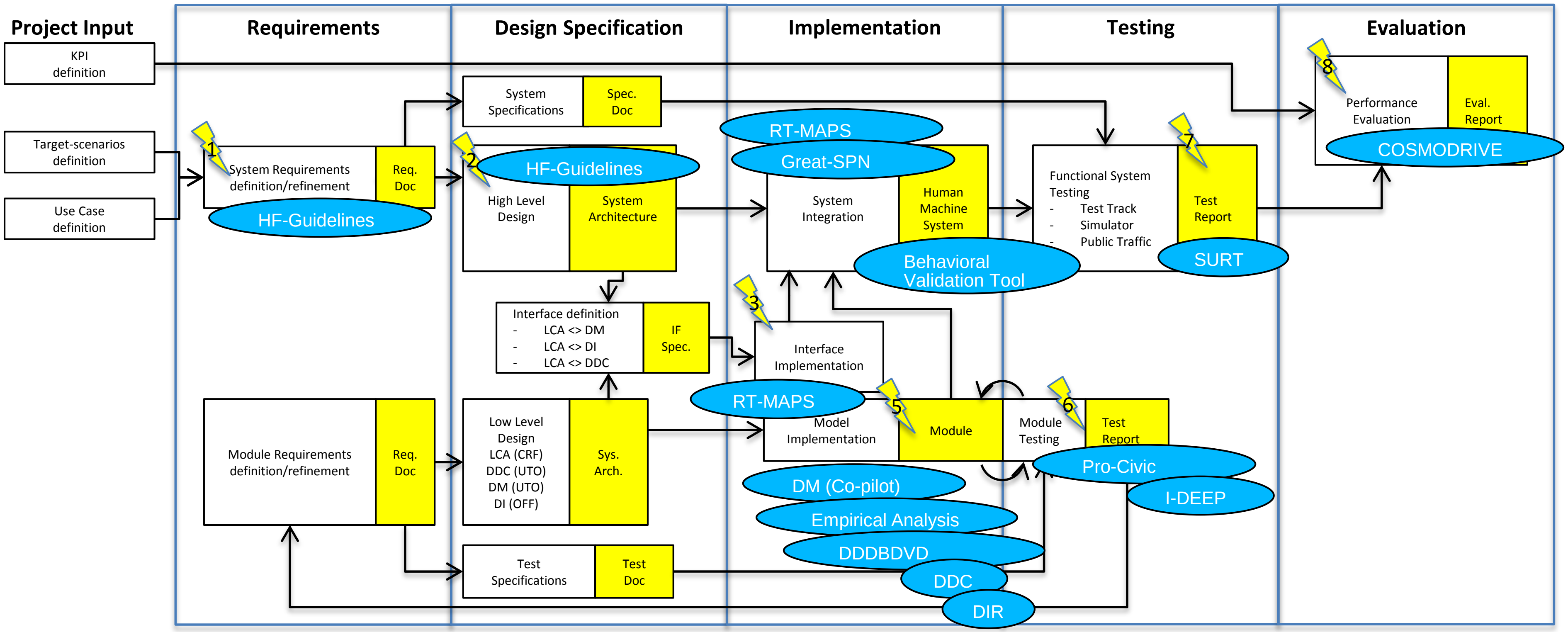

Figure 13: development process for CRF AdCoS.

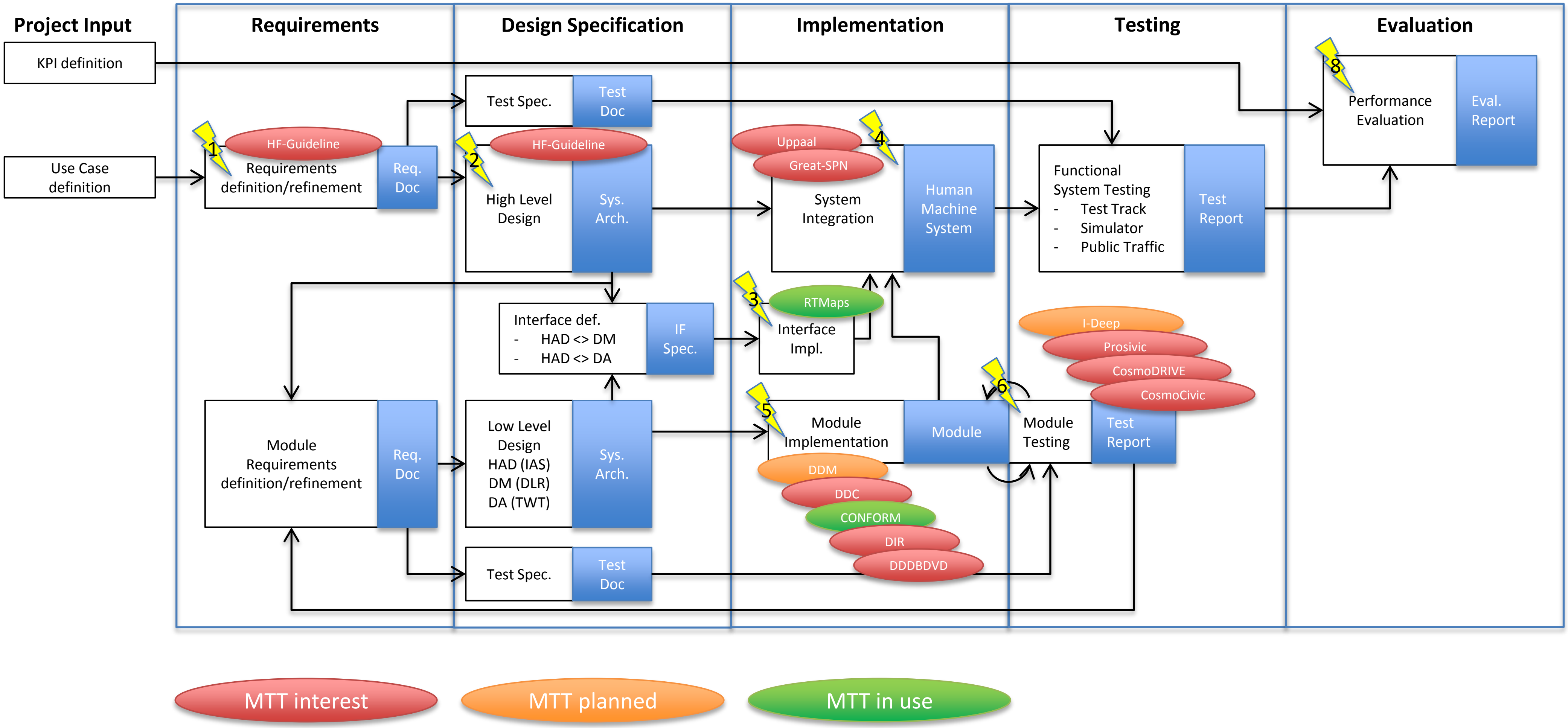

Figure 14: Development Process (IAS AdCoS)

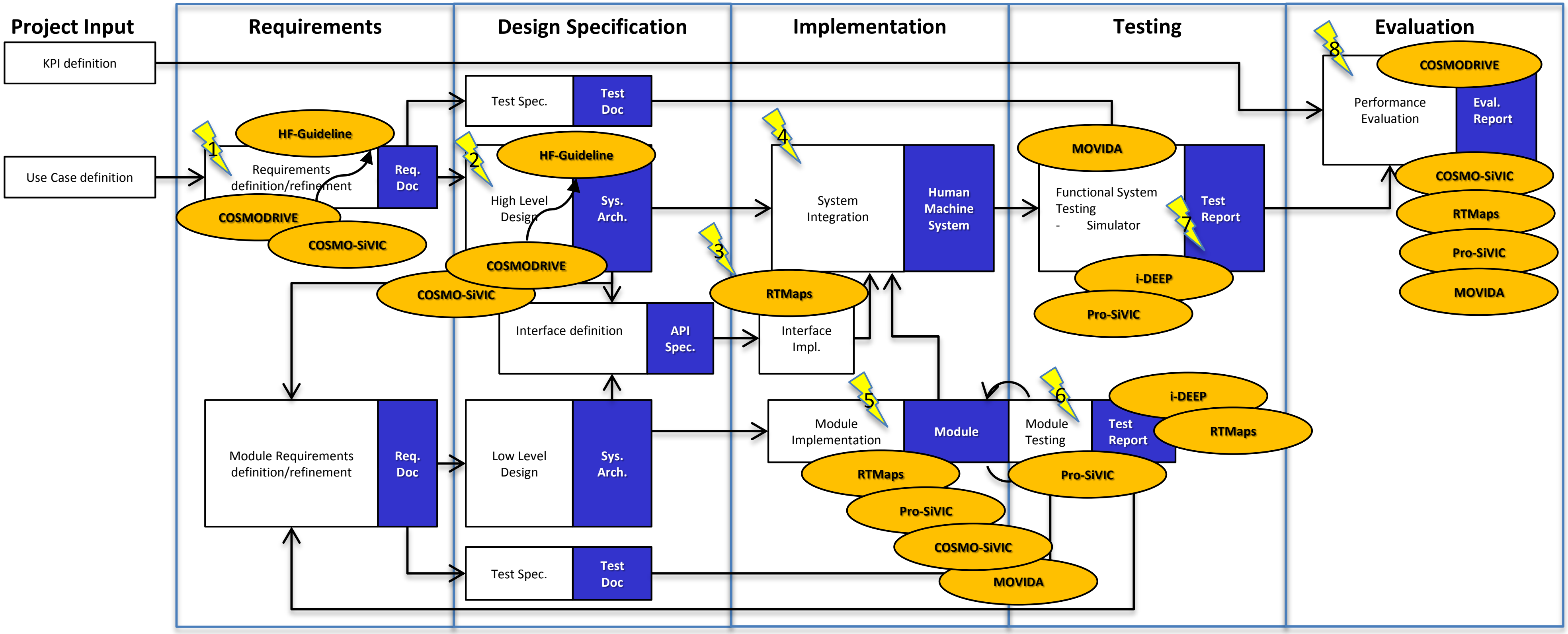

Figure 15: Development process of IFS AdCoS with Virtual HCD platform

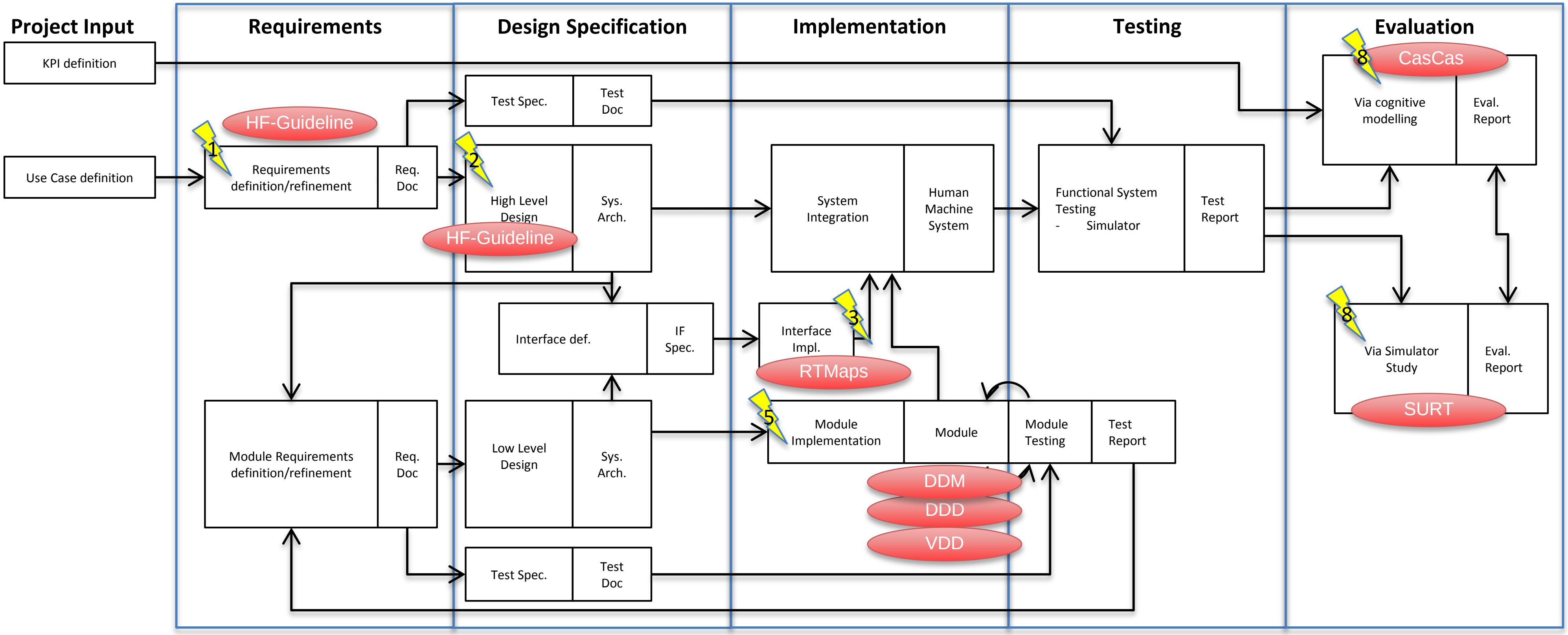

Figure 16: TAK development process and issues