	HoliDes **Holi**stic Human Factors **Des**ign of Adaptive Cooperative Human- Machine Systems	

D5.1 - Empirical Human Factors Techniques – Analysis of requirements

Project Number:	332933
Classification:	Public with Confidential Annexes
Work Package(s):	WP 5.1
Milestone:	M1
Document Version:	V1.3
Issue Date:	07.04.2014
Document Timescale:	Project Start Date: October 1, 2013
Start of the Document:	20.03.2014
Final version due:	08.04.2014
Deliverable Overview:	Main document: HoliDes-Deliverable-5_1v10 Appendix A: WP 6 Requirements - D6.1_v03.xlsx Appendix B, WP 7 Requirements - D7.1_140319_TRS.xlsx Appendix C WP 8 Requirements - D8.1_A_3.xlsx Appendix D WP 9 Requirements-D9.1_2014-01-30_v1.6.xlsx
Keywords:	Empirical Human Factors methods, analysis of requirements
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| **Holi**stic Human Factors **Des**ign of Adaptive Cooperative Human-Machine Systems |

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RECORD OF REVISION		
Date	Status Description	Author
19.03.2014	Draft	Gründl
24.03.2014	1st correction	Käthner
25.03.2014	2nd correction	Gründl
25.03.2014	3rd correction (Review)	Collina
25.03.2014	4th correction	Gründl
08.04.2014	Review	Böcker

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Executive Summary

The objective of WP 5 is to develop techniques and tools for the empirical analysis of Adaptive Cooperative Human-Machine Systems (AdCoS) against Human Factors and safety regulations.

In WP 5.1 the collected requirements of WP 6-9 were analysed both by WP5-members who were also members of one of the WPs 6-9 with domain specific expertise and other WP5-members with more experience in Human Factors. The starting point of this analysis were the requirements of WP 6-9 which were fixed in Excel tables. The goal is to determine the requirements more precisely, to refine the requirements and to define new ones, if needed.

For all requirements with high relevance regarding Human Factors three variables (columns) containing reviewers' feedback were added to the tables: (1) applicable Human Factors methods, (2) applicable standards, and (3) feedback for WP 6-9 The variable "applicable Human Factors methods" is the actual results of WP5.1 work. The variable "applicable standards" provides the scientific context constituting the methodological state of the art which often has a legal impact (if e.g. an ISO norm exists). The variable "feedback for WP 6-9" feedback was important because it also contained very detailed advices regarding the procedure or evaluation. In addition, for the WPs 7 and 8 WP 5 partners made a SMART-analysis regarding the defined requirements which was integrated in the Excel tables as well.

1 Introduction

The objective of WP 5 is to develop techniques and tools for empirical analysis of Adaptive Cooperative Human-Machine Systems (AdCoS) against Human Factors and safety regulations. In order to achieve this, WP 5 gets as input the requirements and feedback from the demonstrator applications in WP6-9 as well as from the HF-RTP definition in WP1. Additionally, it will receive input from WP2 regarding the input requirements of the Human Factors models. The WP is structured into five tasks (see figure).
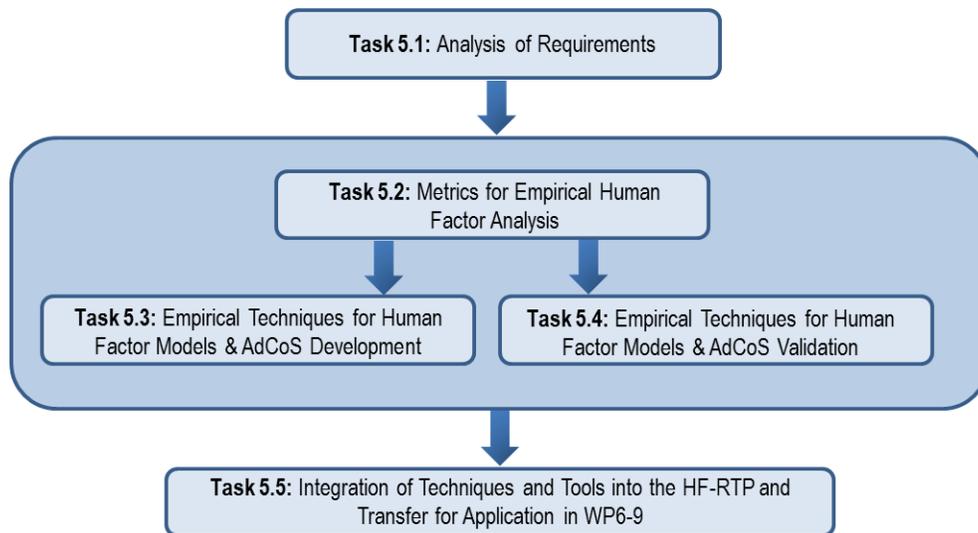
Figure1: Task structure of WP5

One of the most important functions of Task 5.1 is to provide feedback to WP 6-9 partners regarding the empirical evaluation of the AdCos. The analysis of the requirements is, so far, a necessary precondition for defining metrics and associated measures for the evaluation of AdCoS. This procedure ensures the detection of possible problems in the fulfilment of requirements and to take, as a consequence, the necessary steps. The feedback can be used by WP 6-9 partners to refine the requirements and to define new ones, if needed.

2 Procedure of collecting Human Factors methods for requirements

2.1 Human Factors methods template

The starting point of this analysis were the requirements of WP 6-9 which were fixed in Excel tables. During several teleconference meetings it was discussed which aspects were important to provide Human Factors methods for WP6-9 partners.

In a first step reviewers judged if a requirement was relevant with respect to Human Factors. In the Excel table, a new column was added where Human Factors relevance was coded with "yes"/"no". This process restricted the number of the requirements to those that were relevant for the subsequent analyses.

It was decided to focus on those requirements where a proof was determined by WP 6-9 partners. Proof is defined in the legend of the tables as the "Description of how it is shown that the requirement is fulfilled." The workpackage members decided not to provide methods where no proofs were given by the requirements' owners because it was intended to keep the recommendations as concrete as possible. Without a definition of a proof, however, it is difficult to focus on methods which will be useful for evaluation later on the project.

The requirement tables of WP 6-9 were then expanded and three additional variables (columns) were inserted to assign the Human Factors methods to the requirements. This procedure was chosen to make it as easy as possible for the WP 6-9 partners to use the analyses.

In addition to "Human Factors relevance", the following columns were added to the table:
1. applicable Human Factors methods
2. applicable standards
3. feedback for WP 6-9

The variable "applicable Human Factors methods" represents the core of WP5.1 work. The variable "applicable standards" provides the methodological state of the art which bases on scientific research or at least on a consensus within a community, for example, points out the legal impact of the method

(if e. g. an ISO norm exists). The variable "feedback for WP 6-9" contained very important advices regarding the procedure or evaluation.

2.2 Applicable Human Factors methods

As the analysis considered requirements coming from different domains (WP6-9), a mix of methodological recommendations were given. In fact, some requirements were more concrete whereas others were more general. For example, in WP 9 a requirement (WP9_[TAK]_AUT_REQ21_v1.0) was defined as follows:

"Minimize ACC indicator interference with car environment."
Definition:
"The visual ACC indicator should be designed to minimize interference with the driver's perception of car's environment and the traffic situation."
That means:
"By minimizing interference with information about the traffic situation and the car environment the correct detection of the visual ACC indicator is ensured. Also, the level of distraction caused by the indicator is minimized, which will improve Situation Awareness."

In this case, methodological recommendations can be precise and concrete. For the evaluation of this requirement (e.g. in the demonstrator vehicle that will be built) there are several Human Factors methods that may be suitable:
- Expert evaluation
- Inspections methods
- Check lists (e.g. "Safety Checklist For The Assessment Of In-Vehicle Information Systems")
- Usability testing including Eye-Tracking to measure driver's eye gaze behaviour
- Situation Awareness Global Assessment Technique"" (SAGAT) (Endsley, 1995)

However, other requirements were formulated in a rather global way. In those cases the methodological recommendations could not be more precise

than the requirement's specificity. An example is represented by WP 9 requirement (WP9_[TAK]_AUT_REQ16_v1.0):

"Provide easy mental model of systems functions"
Definition:
"System surface-features shall be designed to be as simple as possible and to provide information about what the system does in a simple way, possibly using metaphors and analogies."
Rationale:
"Design for appropriate and easy-to-learn mental model to provide better understanding of the systems capabilities and limitations."

This requirement taken as an example here clarifies the challenge in building the recommendations. Of course it represents an important requirement. However, it is a very general psychological construct regarding mental models, which is difficult to examine. In this case the WP 5 partners recommended to use a card sorting structuring technique. This is a commonly used method for that purpose. Card sorting is a simple technique in user experience design where a group of subject experts or "users", however inexperienced with design, are guided to generate a category tree or folksonomy. It is a useful approach for designing information architecture, workflows, menu structure, or web site navigation paths, and it can also be used for examining users' mental models.

A second recommendation was to make a user test. In combination with the technique of card sorting previously described the user test can be an helpful device.
Unfortunately, in the case in which requirements were too abstract, it was difficult to find specific empirical methods.
An example for that is a requirement (WP6_ATO_HEA_REQ09_v0.1.) of WP 6 which simply is "Usability".
The definition is:
"The system MUST allow easier usage of the information."
The rationale is:
"The system MUST be easy to use, intuitive and fast"

We agree that usability is a very important property of a human machine interface, but it's very hard to derive specific system functions or properties from which it could be tested empirically.

Therefore, for the current review cycle our recommendations had to stay on a comparable level of abstraction: Conduct a "usability test with a focus of efficiency testing against a pre-defined level of efficiency". However, as it will be explained in the next section, abstract requirements can benefit of standards, which will be deeply evaluated on a subsequent phase of the project.

2.3 Applicable standards

With HoliDes' focus on norms and standards, we found it important to include a column on applicable standards. We reasoned that standards often contain methods, which then would have to be applied, given the standard's binding effect. We expect to get this column filled in later review rounds, partly fed by WP 1's currently ongoing collection of standards and norms.

For the WP 6 requirement (WP6_ATO_HEA_REQ09_v0.1.), as mentioned above, some standards or heuristics listed could be useful for testing:

- Heuristic Evaluation (Nielsen, 1994)
- Eight Golden Rules of Interface Design (Shneiderman, 1998)
- ISO 9241

2.4 Feedback for WP 6-9

In a last step WP 5 partner also gave a concrete feedback for WP 6-9 regarding the requirements from a methodological viewpoint. Common suggestions were e. g.

- to structure the task in a better way,
- to describe the requirement more precisely or
- to specify the proof in a more detailed way

In some cases the feedback also contained very detailed advices regarding the procedure or evaluation. For this see the column "feedback" in the Excel tables of the appendix.

In some of those cases it was difficult to give a specific feedback because of the partly quite general nature of many (non-functional) requirements. However, this difficulty will be overcome when the scenarios and use cases will be defined in all applied work packages, giving WP5 the opportunity to provide a detailed methodological feedback.

2.5 Judgment of 5 SMART-criteria of requirements

In addition, for WPs 7 and 8, WP 5 partners made a SMART-analysis regarding the defined requirements which was integrated in the Excel tables as well. SMART is an acronym, giving criteria to guide the setting of goals, for example in project management. The meaning of these five criteria is explained in the following table:

Table 1: The five SMART-criteria

Variable	Definition
Specific	A requirement must say exactly what is required.
Measurable	It is possible, once the system has been constructed, to verify that this requirement has been met.
Attainable	It is possible physically for the system to exhibit that requirement under the given conditions.
Realisable	It is possible to achieve a requirement given what is known about the constraints under which the system and the project must be developed.
Traceable	Requirements Traceability is the ability to trace (forwards and backwards) a requirement from its conception through its specification to its subsequent design, implementation and test.

This analysis was made as an additional feedback for WP 7 and WP 8 partners. We decided to give that systematic feedback because by this the feedback in the column "feedback for WP 6-9" could be complemented. For example, if in the column "**s**pecific" the feedback was "no" this is an advice for our partners to define a requirement more precisely.

Since by definition a goal is only "S.M.A.R.T." if all five criteria are fulfilled these additional five variables in the table allow a good optimization of requirements for the next phase of the project.

3 Perspective for the next feedback cycle

The Human Factors methods listed are a useful input for the future evaluation if the requirements are fulfilled or not. So far, the work of WP 5 can be used by WP 6-9 partners

- to determine the requirements more precisely,
- to refine the requirements,
- to define the proof (where it is still missing), and
- to define new requirements, if needed.

The on-going definition of the scenarios and use-cases for the AdCos will allow WP5 to get through the problems caused by the different levels of categorization of requirements previously described (concrete, general, abstract) and to harmonize them by using different methodologies and standards. However, this will be an issue regarding the next feedback cycle.

One final point before concluding concerns the key role of WP1.
There are at least two important aspects that need to be considered:
1. Categorizing the kind of the Human Factors problem (e. g. workload, situational awareness, attention, perception, communication, error etc.)
2. Categorizing Human Factors activities (e. g. categorized into three groups of activities concerned with analysis, design, or evaluation)

This would also be helpful to identify general Human Factors aspects being relevant in several domains (WP 6-9) and to develop methodological solutions for similar Human Factors problems.

Appendix A, WP 6

Requirements - D6.1_v03.xlsx

Appendix B, WP 7

Requirements - D7.1_140319_TRS.xlsx

Appendix C, WP 8

Requirements - D8.1_A_3.xlsx

Appendix D, WP 9

Requirements - D9.1_2014-01-30_v1.6.xlsx