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

D3.1: Requirements Analysis for Adaptation Techniques and Tools

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1. Introduction

This document aims to describe and synthetize the mapping between requirements provided by the application work package (WP6-9) and existing partner's tools available in the WP3.

The methodology to achieve that was the following:

1) We collect partner's tools and categorize them in five categories:

    1. Cognitive psychology / Human Factor / Ergonomics
    2. Modeling
    3. Computer Science
    4. IA / Adaptive Systems / Multi-agents Systems
    5. Simulation / experimentation / test

2) We selected from the overall list of requirements the ones that could be fulfill by methods, techniques and tools for adaptation (WP3).

3) We identified cross-domain requirements by merging similar requirements coming from different applications WP.

4) We assessed each requirements:

    - Adaptation (WP3) relevance
    - Which sub-field of adaptation the requirement belongs to
    - Ids of similar requirements
    - Number of similar requirements
    - Which application use case the requirement belongs to
    - Which available tools may be useful
    - Comment from WP3 partners.

2. Context

2.1 AdCoS: Adaptive and Collaborative System

A Cooperative Human-Machine System (Figure 1) can be defined as a set of agents, either human (2a) or machine (2b). The agents interact and communicate (3). Tasks (4) are assigned to the cooperative system and allocated (6) to the agents who achieve them thanks to some resources (5). Each agent has access (7) to specific resources. The cooperative system operates on one or more controlled objects (8), either a vehicle (on-board perspective) or traffic (traffic perspective). It is, with the objects it controls, immersed in an environment (9) (e.g., weather, communication infrastructure).

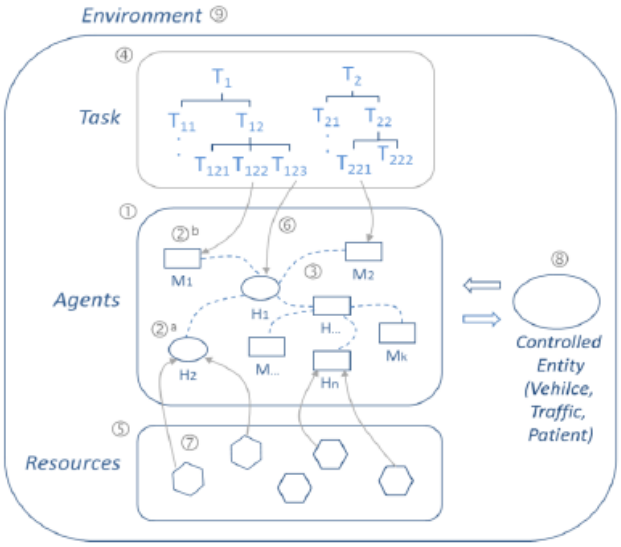

Figure 1 : Cooperative Human-Machine System

An "AdCoS : Adaptive Cooperative Human-Machine System", is such multi-agents oriented system with dynamics and real-time reconfiguration of its own overall structure, globally and locally as well. It means that tasks (1), task allocation (6), agent interactions (3), resource allocation (7) and resources (5) can be adapted.

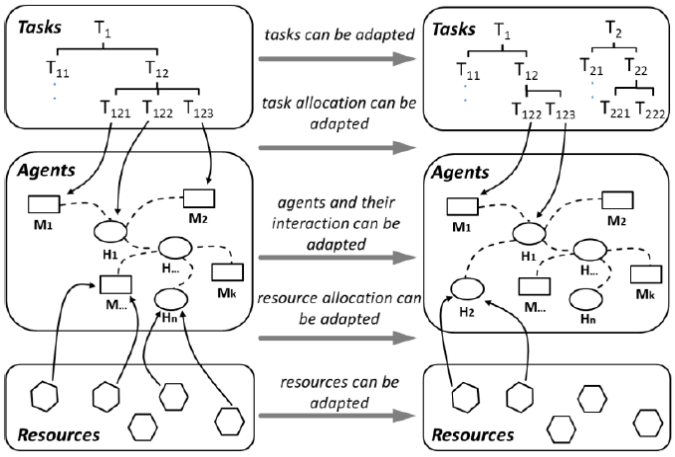

Figure 2 : AdCoS : Adaptive Cooperative Human-Machine System

2.2 WP3: Techniques & Tools for Adaptation

The objective of "WP3: Techniques and tools for adaptation" is to develop techniques and tools for manual as well as automatic adaptation of the configuration of Cooperative Human-Machine Systems on a global and local level based on measurements of the systems' external and internal context.

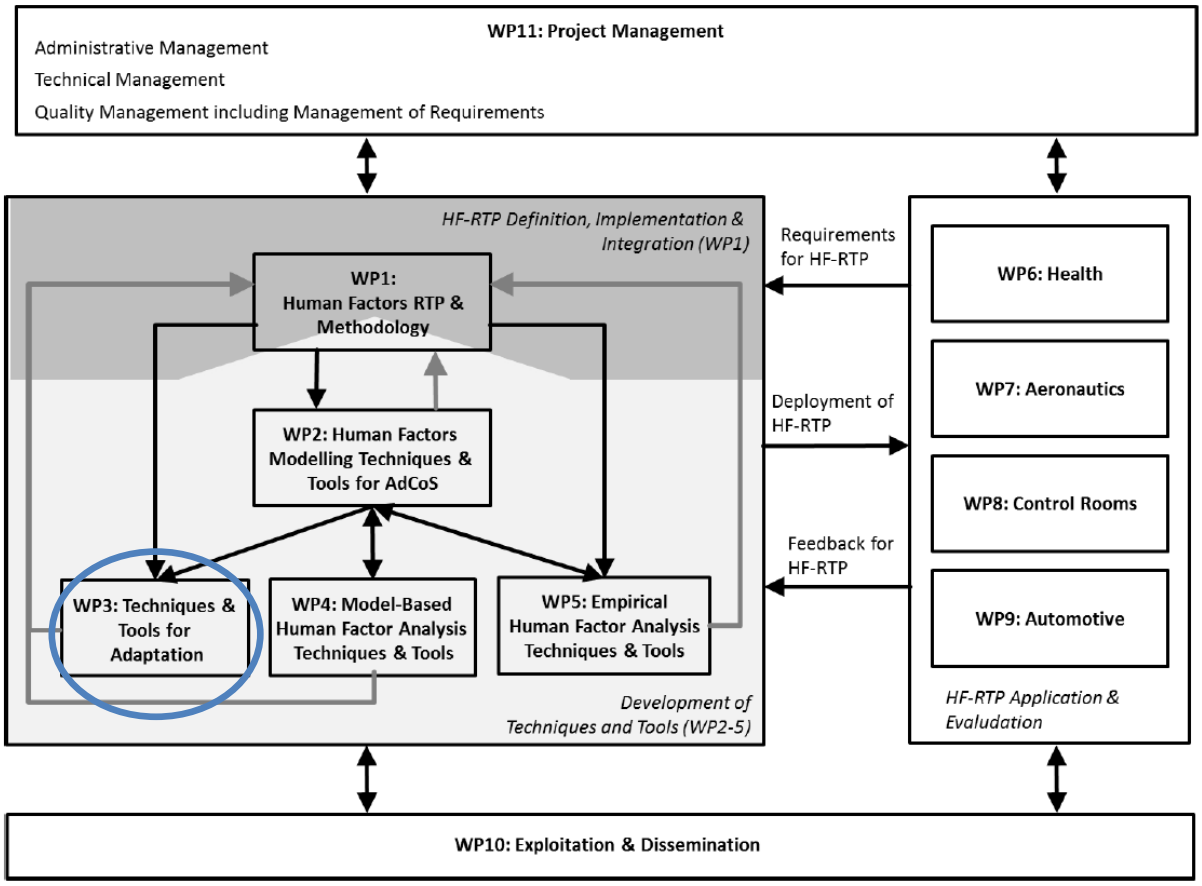

Figure 2: Interaction between work packages

The WP3 gets as input the requirements and feedback from the demonstrator applications in WP6-9 as well as from the HF-RTP definition in WP1. Furthermore, it gets models from WP2. WP3 is structured in six tasks (see Figure 3). After an analysis of the requirements and/or feedback (Task 3.1) we will research a theoretical framework and software architecture for adaptation (Task 3.2) which will in detail define and specify the What, Why, How and Who of AdCoS Based on these underpinnings we will develop adaptation mechanisms in Task 3.4 (or AdCoS re-configuration mechanisms, see Figure 1 above) that are driven by measurements (developed in Task 3.3) of the external and internal context of cooperative human-machine systems taking into account in particular humans operator states, intention and activities. The AdCoS has to assure that all adaptations are recognized and understood by the involved agents and thus we will work on multi-modal (visual, acoustic, haptic and tactile) strategies to support communication of system adaptations (Task 3.5) to human agents.

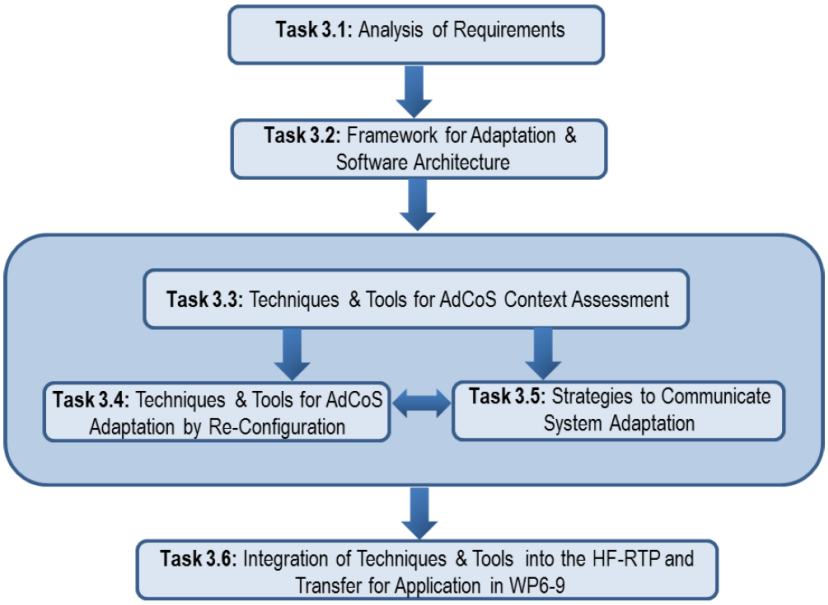

Figure 3: Task structure of WP3

The objective of the task 3.1 is to analyze the requirements received from WP6-9 as well as from WP1 and prepare them to be used as main drivers of the research work in all WP3 activities. After release of HF-RTP Vs0.5 (in month 8) and in the Project Cycles II and III feedback will be gathered from the application of the modeling techniques and tools in W6-9. The feedback will be analyzed and used to refine the requirements and to define new ones, if needed.

3. Input

The Requirements from WP6-WP9 were extracted from the following deliverables:

- D6.1: Health related scenario descriptions – Vs 1.1
- D7.1: Requirements Definition for the HF-RTP, Methodology and Techniques and Tools from a Aeronautics Perspective – Vs 1.0
- D8.1: Requirements Definition for the HF-RTP, Methodology and Techniques and Tools from a Control Room Perspective – Vs 0.8
- D9.1: Requirements Definition for the HF-RTP, Methodology and Techniques and Tools from an Automotive Perspective – Vs 1.0

4. Collected WP3 Methods and Tools

We have collected background, methods and Tools related to 5 fields of activity:

1. Cognitive psychology / Human Factor / Ergonomics
2. Modeling
3. Computer Science[1]
4. IA / Adaptive Systems / Multi-agents Systems
5. Simulation / experimentation / tests

In total we gathered 29 different tools. The excel file that describe these tools are on annex A: WP3 Partners Materials v2.xlsx.

An analysis of these 29 available tools reveals more specifics sub-fields of adaptation capabilities:

a) AI techniques and algorithms
b) Hierarchical and functional modeling
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework[1]
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

If we map the list of tools available and the WP3 task structure we see that:

- 0 tool belongs to task 3.1: Analysis of Requirements
- 4 tools belong to task 3.2: Framework for adaptation & software architecture
- 10 tools belong to task 3.3: Techniques and tools for AdCoS Context Assessment
- 9 tools belong to task 3.4: Techniques and tools for AdCoS Adaptation by reconfiguration
- 4 tools belong to task 3.5: Strategies to communicate system adaptation

[1] This field regroups software tools that are not link to any field: for example, a specific eclipse RCP, middleware to manage data exchange, software module to visualize data …

- 2 tools belongs to task 3.6: Integration of techniques & tools into the HF-RTP and Transfer for application in WP6-9

5. Mapping with AdCoS

In this chapter the use cases are summarized per AdCoS for each application Work Package. The main functional need for the AdCoS is specified, and a summary is given of the required methods, tool & techniques (MTT) support. Lead partner is included between brackets.

5.1 Methodology

To run the mapping of the needs defined by the various applications WPs, WP6-9, to the tools and techniques that can be provided by the partners on WP3, we decided to have two levels of processing: a global and local one, through the mean of two different matrixes.

The first matrix gives a global view and maps Use Cases of WP6-9 with the tools.

On the horizontal axis, are listed:

- The use case Identifier and names,
- The main needs that are addressed by the use case, summarized,
- The AdCoS expected to answer the needs,
- The current 'As is" status through the current available tools that summarizes the Application Partner context,
- The potential links with WP3 tasks,

On the vertical axis, are listed:

- The WP3 tool provider's names,
- Some key words, that give the main technics that will be deployed by the WP3 partners,
- A global contribution summary, that explains in more details the added value of the partners through the provided technics/tools,
- The main domains concerned in term of potential application of technics.

On this basis, the potential contributions of partners have been summarized and in the cross cases. Names of applied tools have been also included if they yet exist.

This matrix is the basis for starting the discussion between WP3 and WP6-9 partners. Contributions to more than one uses case/ application are by this mean also highlighted.

The second matrix maps the requirements with the tools with a more detailed view.

For each requirement listed and identified, by the name, their definition, the rationale, the proof (that the requirement is satisfied), and the responsibility of the requirement, some columns concerning specifically WP3 have been added. They concern:

- The WP3 relevance: Adaptation (WP3) relevance: is the requirement concerned by WP3 tools?
- To which sub-field of adaptation the requirement belongs to,
- Identifier of similar (same as, close to) requirements: the goal of this column is to detect similarities between requirements to define their cross domain applicability,
- Number of similar requirements for this requirements: the goal of this column is to highlight the generality of requirements,
- Which application use case the requirement belongs to?
- Which available tools may be useful?
- Comment from WP3 partners.

After a first level of analysis, due to the large number of requirements, the large definition of some of them, and some heterogeneity, the detection of similarities was not evident, and there is a risk that some similarities between requirements have not been detected.

Also, the analysis of the sub-field of adaptation the requirements belongs to, gives a list of sub-field of adaptation. Each of these sub-fields of adaptation belong to different problem categories and will be addressed in a specifics WP3 task:

- Task 3.2: Framework for Adaptation
  - integrated architecture
  - network architecture
  - simulation
  - test

- Task 3.3: Context Assessment
  - behavior learning
  - classification
  - data fusion
  - image recognition

  - manage uncertainty
  - real time classification
  - situational awareness

- Task 3.4: Adaptation by reconfiguration
  - adaptation to unexpected event
  - learning loop
  - classification
  - complexity
  - confidence level
  - dynamic reconfiguration
  - manage uncertainty
  - modular adaptation
  - multi-objectives optimisation
  - real time classification
  - return of experience

- Task 3.5: Communication of the adaptation
  - Complexity
  - confidence level
  - design
  - ergonomics
  - HMI communication
  - return of experience

This list, quite large, is mainly covered by all the WP3 tasks of the WP3, but needs to be refined, to reach to a good understanding between both software developers and Human factors partners. The final objective is to fit with the list of sub-fields of adaptation with the tool point of view (chapter 4: ”Collected WP3 Methods and Tools”).

The framework defined in task 3.2 will have to take into account the maximum of these sub-fields.

For all these reasons, this first matrix is considered as a first version of the mapping between tools and requirements. It will be also refined along the project (Cycle 2 and 3), after getting more in depth in the tools maturity, capacities of integration, inputs, outputs, …

5.2 WP6: Health

5.2.1 Overview of use cases and requirements

1. Use Case: Activities Management Guidance (Integrasys)
   AdCoS**:** Handheld device for guidance of medical staff in various situations in the hospital, including connection with the OpenEHR
   Main Functional Need: The nurse needs to find the right staff to serve the patient
   Required MTT Support: Currently workflow tools are being deployed at hospitals but usability is not optimal. Tools are lacking to support the models of workflow based on model and human factor. Tools needed to improve this situation.
   Potential WP 3 contributions:
   a) AI techniques and algorithms
   b) Hierarchical and functional modeling
   c) Physiological and physical human monitoring and analysis
   d) Context and system modeling
   e) Software framework
   f) Validation framework
   g) Human behavior monitoring
   h) Simulation and tests

2. Use Cases: Querying OpenEHR; internal analyzing & reporting; patient access of data (ATOS)
   AdCoS**:** Open Electronic Health Record system (OpenEHR)
   Main Functional Need: Access of all patient related data by any (authorized) physician or patient at any location for fast and full documented medical support and statistical analysis
   Required MTT Support: Integral solution within hospitals and in between hospitals to share patient data and facilitate prompt access; Integral solution to analyze patient databases for statistical analysis
   Potential WP 3 contributions:
   a) AI techniques and algorithms
      a. EAD-FR: Provide decision helping based on "case based reasoning" technics to assess patient pathologies according to past record stored in databases
   b) Hierarchical and functional modeling
   c) Physiological and physical human monitoring and analysis
   d) Context and system modeling
   e) Software framework (ATOS)

f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

3. Use Case: Safe patient transfer (Philips-MRI)
AdCoS**:** Trolley to transport patient to and from MRI scanners.
Main Functional Need: Safe transfer and transport of patients on and off a patient support
Required MTT Support: Human Factors Design tooling: Tooling to model the trolley, users and environment, in order to analyze Human Factor properties of patient trolley concepts and to systematically validate the final design on safety and easy handling.
Potential WP 3 contributions:
a) AI techniques and algorithms
b) Hierarchical and functional modeling
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

4. Use Case: Guided patient positioning (Philips-MRI)
AdCoS**:** Dedicated guidance facilities for the operator based on patient characteristics and type of examination via a local display + UI and with camera guidance
Main Functional Need: Safe positioning of patients for MRI exams by any operator
Required MTT Support: Means to optimize the guidance, e.g. by observation of the behavior of users.
Potential WP 3 contributions:
a) AI techniques and algorithms
b) Hierarchical and functional modeling
    a. EAD-FR:
        i. Analysis of operator, patient and nominal interaction (based on patient characteristics and type of examination).

ii. Assess current operation and provide dynamic guidance according to the context
b. AWI : Functional modeling and data integration

c) Physiological and physical human monitoring and analysis
a. ARG: Eye tracking study to optimize interaction
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

5. Use Case: Safe parallel transmit scanning (UMCU)
AdCoS**:** Semi-automatic system calibration facilities of the parallel transmit system of an MRI scanner
Main Functional Need: Safe behavior of the system and effective feedback
Required MTT Support: Support to design optimal user interfaces and safe product behavior for the variance in user roles/skills and ways of working, and support to validate the design and implementation.
Potential WP 3 contributions:
a) AI techniques and algorithms
a. SNV : Analysis of system and operator actions from log files
b) Hierarchical and functional modeling
a. Provide guidance to the operator in term of what has been automatized and what should be done by the operator.
b. AWI : Functional modeling and data integration
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

6. Use Case: 3D acquisition (Philips-iXR)
AdCoS**:** A variable system of acting agents that consists of user agents and the product agent. Variability is in the roles of different users, order in which they perform tasks, skills they have, the way they are organized to work with 3D

acquisitions and feedback provided by the product agent based on detected events.

Main Functional Need: Optimized design to reach high confidence level of users and assure high efficient in acquiring and using 3D data.

Required MTT Support: Support to design optimal user interfaces and product behavior for the variance in user roles/skills and ways of working, and support to validate the design and implementation.

Potential WP 3 contributions:

a) AI techniques and algorithms
b) Hierarchical and functional modeling
    a. EAD-FR : Reconfiguration between user agent and product agent could be assessed according to efficiency measurements (like time, number of interactions...)
    b. AWI : Functional modeling and data integration
c) Physiological and physical human monitoring and analysis
    a. ERG: Eye tracking study to optimize interaction
    b. DLR: Eye tracking study to detect abnormal behavior
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
    a. SNV : Study of safety related operator interactions
h) Simulation and tests

5.3 WP7: Aeronautics

5.3.1 Overview of use cases and requirements

1. Use Case: Core (Honeywell)

AdCoS**:** Diversion airport assistant software implemented on EFB of a commercial aircraft

Main Functional Need: The system detects the current aircraft state (e.g. aircraft position, performance, flight plan, etc.) and by comparing it with relevant pieces of relevant static information (e.g. navigation database, charts, etc.) and dynamic information (e.g. strategic weather, DNOTAM, etc.), it presents the flight crew a prioritized list of potential deviation airport encompassing appropriate

information in selected categories (e.g. distance of the airport from the current position, weather at the airport, runway length, approach type, etc.
WP7 use-cases for 'Diversion airport assistant (DivA)' consider adaptation being invoked by detecting the deterioration of operator, system or external conditions.

The external conditions will be studied for thresholds that signal invoking the adaptation. The thresholds are related to

1) Machine failure – specifying the severity of failure, its impact on pilot's tasks and possible counter-actions
2) External conditions
    a) Weather
    b) Aerial traffic and ground conditions
3) Internal environment and operator state
    a) Information perception/recognition due to noise, illumination and direct light, turbulence
    b) Human state due to workload, temperature, humidity, pressure and oxygenation

The adaptive behaviour should be modelled with respect the state of the pilot as the pilot is the major cause of accidents/incidents in aviation. The workload arises from external and internal environment and it will be evaluated by a number of approaches to identify those that are applicable in the cockpit during routine flights.

<u>Required MTT Support:</u>
- Theoretical bases for conditions when system should invoke adaptation
- Techniques to communicate reasons for adaptation when it may be difficult for a human (such as high workload)

<u>Potential WP 3 contributions:</u>

a) AI techniques and algorithms
b) Hierarchical and functional modeling
    a. EAD-FR: Analysis of pilot, aircraft system and nominal interaction (based on navigation data base). Assess current operation and provide dynamic deviation airport according to the context, sorted by confidence.
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework

f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

Remark on related requirements :

To accomplish the objectives of collaboration within WP3, it is necessary to

Investigate and define the transition thresholds in the external and internal environment.

Define methods to measure and analyse the sources of information. This may require ability to synchronize/integrate several heterogeneous data sources.

Classify the acquired data based on theoretical knowledge.

Implement adaptation in the system and focus on communicating the change especially when it is difficult to be perceived by the pilot – such as self-estimation of workload. The critical aspects must be addressed

- salience of change – pilot notices the adaptation when he should notice it
- level of understanding - pilot understands the reasons for adaptation
- level of determinism – pilot does not feel confused by random-like behaviour of the application

2. Use Case: State Interference (Honeywell)

AdCoS**:** State interference module of diversion airport assistant software implemented on EFB of a commercial aircraft

Main Functional Need: The state inference module combines data from various sensors (physiological, video, physical). It provides time synchronization and normalization of the data.

Required MTT Support:

- Recording of complex data, data synchronization and interpretation.
- Human operator state inference with respect to environmental conditions, readability aspects of the presented information in varying environment.

Potential WP 3 contributions:

a) AI techniques and algorithms
b) Hierarchical and functional modeling
    a. AED-FR: use the distributed situation awareness developed previous use case.
c) Physiological and physical human monitoring and analysis

d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

3. Use Case: Adaptation (Honeywell)
AdCoS**:** Information monitor module of diversion airport assistant software implemented on EFB of a commercial aircraft
Main Functional Need: The information monitor module integrates various sources of information and combines them into a scalar measure that the system uses to react to the current situation.
Required MTT Support:
- Evaluation of complex data, data synchronization and interpretation.
- Techniques to communicate reasons for adaptation when it may be difficult for humans (such as high workload)
Potential WP 3 contributions:
a) AI techniques and algorithms
b) Hierarchical and functional modeling
    a. AED-FR: use the HMI communication strategies developed in previous use cases.
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

5.4 WP8: Control Rooms

5.4.1 Overview of use cases and requirements

1. Use Case: Operator overload and underload (Airbus DS)
AdCoS**:** Border Security system, Command & Control part
Main Functional Need: AdCoS detects that the operator is over- or underloaded and enables a return to normal working mode (de-loading the operator or keeping him busy)

Required MTT Support: Tools and techniques for optimal analysis, design and validation of the required solution
Potential WP 3 contributions:

a) AI techniques and algorithms
b) Hierarchical and functional modeling
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
    a. AED-FR: Develop specific counter-measures to keep operator in a normal working mode.
h) Simulation and tests

2. Use Case: System Failover at Sector Headquarter (SHQ) level (Airbus DS)
AdCoS**:** Border Security system, Command & Control part
Main Functional Need: The SHQ system degrades from a normal operational state to a non-operational state; events that are managed at this SHQ level have to be assigned to adjacent SHQs
Required MTT Support: Tools and techniques for optimal analysis, design and validation of the required solution
Potential WP 3 contributions:

a) AI techniques and algorithms
b) Hierarchical and functional modeling
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
    a. AED-FR : use of all AdCoS capabilities. Situation awareness, dynamic reconfiguration and HMI communication
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

3. Use Case: Managing of inappropriate calls; Peak of inappropriate calls; Foreign language speaking caller (IREN)
AdCoS**:** Power plant control system
Main Functional Need: Effective call handling

Required MTT Support: Methods, tools & techniques to find the best strategy to handle inappropriate calls and peak of incoming calls
Potential WP 3 contributions:

a) AI techniques and algorithms
b) Hierarchical and functional modeling
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

4. Use Case: Collection of relevant information for the correct interpretation of malfunction; Collection of historical information about intervention of each installation for future events (IREN)
AdCoS**:** Power plant control system
Main Functional Need: Gathering all relevant information from a call in case of malfunction report
Required MTT Support: Methods, tools & techniques to find the best strategy to obtain and interpret all relevant data
Potential WP 3 contributions:

a) AI techniques and algorithms
b) Hierarchical and functional modeling
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

5. Use Case: Communication between headquarter and the operational team in the field (IREN)
AdCoS**:** Power plant control system
Main Functional Need: Provide the operational team that need to fix a problem with all relevant information in time
Required MTT Support: Methods, tools & techniques to find the best strategy to have effective communication between the HQ and operational team
Potential WP 3 contributions:

a) AI techniques and algorithms

b) Hierarchical and functional modeling
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

5.5 WP9: Automotive

5.5.1 Overview of use cases

1. Use Case: Classification of driver's state; driver model (CRF)
   AdCoS**:** Highly automated vehicle which is driver and situation adaptive with regard to the preference of applied maneuver and trajectory by the machine agent.
   Main Functional Need: Classification of driver's state and driver model for reproducing driver's behavior
   Required MTT Support: Adaptation strategies
   Potential WP 3 contributions:
   a) AI techniques and algorithms
   b) Hierarchical and functional modeling
   c) Physiological and physical human monitoring and analysis
      a. ERG: Eye tracking study to optimize interaction
   d) Context and system modeling
   e) Software framework
   f) Validation framework
   g) Human behavior monitoring
   h) Simulation and tests

2. Use Case: Learn natural driving behavior (DLR)
   AdCoS**:** Highly automated vehicle which is driver and situation adaptive with regard to the preference of applied maneuver and trajectory by the machine agent.

Main Functional Need: Learn natural driving behavior of the human agent context/situation adaptive. Optimize acceptance of the prototype vehicle by adapting machine agent behavior closer to the human agent.
Required MTT Support: Driving simulator and eye tracking to study driving behavior; tools with learning capabilities
Potential WP 3 contributions:

a) AI techniques and algorithms
b) Hierarchical and functional modeling
c) Physiological and physical human monitoring and analysis
    a. ERG: Eye tracking study to optimize interaction
    b. TWT: Driver distraction estimation based on audio situation which can be used to, e.g., raise or lower reaction thresholds of other assistance systems
d) Context and system modeling
    a. OFF: Development of a modular and hierarchical Bayesian driver model to be integrated in the ADCoS as a means for context-dependent situation recognition, behavior prediction, and detection of non-normative behavior. Starting from an initial (offline) learned model, its parameters shall be adapted during runtime.
e) Software framework
    a. IFS : SW framework: Car drivers visual scanning analysis and simulation
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

3. Use Case: Analysis of eye-tracking data (IFS)
AdCoS**:** Support IFS monitoring functions (to be implemented in WP3 & WP4) in a virtual AdCoS (e.g. Analysis of eye-tracking data coming from real drivers & simulated by IFS driver model)
Main Functional Need: Analysis of eye-tracking data (Coming from Human and Simulated via IFS COSMODRIVE Driver Model) as a mean of assessment of visual distraction of the Human driver & IFS cognitive model
Required MTT Support: Recording/Using/Simulating eye-tracking data, in order to assess driver' visual distraction
Potential WP 3 contributions:

a) AI techniques and algorithms
b) Hierarchical and functional modeling

c) Physiological and physical human monitoring and analysis
   a. ERG: Need a Feed-back / agreement of collaboration from ERGONEERS, regarding their Eye-Tracking system/methods
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

4. Use Case: Right information at the right time (TAK)
AdCoS**:** A HMI Information & warning strategy which adapts to the changing environment and to changing automation levels
Main Functional Need: Providing the right information at the right time
Required MTT Support: Tools and techniques for optimal analysis, design and validation of the required solution
Potential WP 3 contributions:
a) AI techniques and algorithms
b) Hierarchical and functional modeling
c) Physiological and physical human monitoring and analysis
d) Context and system modeling
e) Software framework
f) Validation framework
g) Human behavior monitoring
h) Simulation and tests

5.5.2 Complementary comments on selected requirements

5.5.2.1 Additional DLR comments

Adaptation of behavioral parameters

The requirements listed below deal with the issue of learning the natural behavior of the human agent/operator. The AdCoS uses the knowledge to adapt parameters to act more human like. Therefore the requirements demand for tools/techniques from the machine learning area. WP3 partners will offer appropriate tools/techniques (Bayesian models, behavior models, neural networks, multivariate time series analysis). See the excel table for more details.

Similar Requirements	
Offline Learning	Online Learning
• WP9_DLR_AUT_REQ01 • WP9_OFF_AUT_REQ01 • WP9_OFF_AUT_REQ07 • WP9_OFF_AUT_REQ08 • WP9_OFF_AUT_REQ09 • WP9_TAK_AUT_REQ45	• WP9_DLR_AUT_REQ02 • WP9_OFF_AUT_REQ02

Adaptation of HMI

The requirements listed below are slightly connected to the requirements above. But they go one step further. The requirements also deal with learning the natural behavior but in this case the AdCoS uses the knowledge to compare the learned natural human behavior with the current human behavior. This allows measuring the current human performance and/or the current human state, like visual or cognitive distraction. This information is used to adapt the interaction between human and machine agent. For instance the AdCoS could present warnings earlier. Therefore the requirements also demand for techniques/tools from the machine learning area but also for other tools (sensors) to measure the human state like an eye tracker. WP3 partners will offer appropriate tools/techniques (Bayesian models, behavior models, neural networks, multivariate time series analysis, eye tracker). See the excel table for more details.

Similar Requirements
• WP9_TAK_AUT_REQ18 • WP9_OFF_AUT_REQ10 • WP9_CRF_AUT_REQ03 • WP9_CRF_AUT_REQ08 • WP9_CRF_AUT_REQ09 • WP9_CRF_AUT_REQ11 • WP9_TWT_AUT_REQ14

5.5.2.2 Additional OFFIS comments

In accordance to task 3.3 “Techniques and tools for AdCoS Context Assessment”, many of use-cases and requirements defined in the application work packages WP6-9 implicitly and explicitly

state the need for methods, techniques and tools that can be used for assessing, inferring, and classifying unobservable states of human operators, such as their intention, experience, cognitive states, workload, etc. (e.g., requirements WP6_AWI_HEA_REQ0, WP7_HON_AER_REQ87, WP8_ADS_CTR_REQ15, WP9_CRF_AUT_REQ03) or evaluate their behaviors (e.g., requirement WP7_HON_AER_REQ_78). The ability to infer this contextual information is crucial for any pro-active and context-sensitive adaptation. E.g., requirement WP7_HON_AER_REQ_07 asks for methods and tools for classification of measured physiological signals and related levels of stress/workload in real-time as a prerequisite to perform adaptation based on such physiological measures. Obviously, the similar prerequisites exist for each possible adaption based on unobservable measures.

WP3 partners and in particular OFFIS will provide techniques for the machine-learning and online adaptation of hierarchical and modular probabilistic models that can be used for intention prediction, behavior prediction, and behavior assessment. Currently these models called Bayesian Autonomous Driver Mixture-of-Behaviors (BAD MoB) models are used exclusively in the automotive domain for modelling and simulating context-dependent human driver behavior on highways. Within HoliDes, these models shall be advanced and used as a component of an AdCoS to provide means for maneuver classification, intention prediction, behavior prediction, and behavior assessment.

Concerning WP3, these models are related with the adaptation techniques and tools developed in WP3 in two ways.

1. The BAD MoB models can be used as a means to classify the context needed for the adaptation of the AdCoS. They can be therefore seen as tools for AdCoS Context Assessment.

2. The BAD MoB models themselves shall be adapted during their use within the AdCoS themselves.

Selected use-cases:

BAD MoB models will primarily be integrated in the AdCoS developed for the use-case WP9_CRF_AUT_UC1. The methods and techniques used for BAD MoB models should be applicable for all use-cases that can benefit from or require a means of intention prediction and behavior evaluation.

Selected requirements:

Requirements that shall be met using primarily BAD MoB models are the following:

- WP9_CRF_AUT_REQ03
- WP9_CRF_AUT_REQ12
- WP9_OFF_AUT_REQ01
- WP9_OFF_AUT_REQ02
- WP9_OFF_AUT_REQ03
- WP9_OFF_AUT_REQ04
- WP9_OFF_AUT_REQ05
- WP9_OFF_AUT_REQ06
- WP9_OFF_AUT_REQ07
- WP9_OFF_AUT_REQ08
- WP9_OFF_AUT_REQ09
- WP9_OFF_AUT_REQ10
- WP9_OFF_AUT_REQ11
- WP9_OFF_AUT_REQ12
- WP9_OFF_AUT_REQ13

Furthermore, the methods, techniques and tools related to BAD MoB models could be helpful in fulfilling the following requirements:

- WP6_AWI_HEA_REQ01
- WP7_HON_AER_REQ78
- WP7_HON_AER_REQ87
- WP8_ADS_CTR_REQ15
- WP8_IRN_CTR_REQ15
- WP9_TWT_AUT_REQ04
- WP9_DLR_AUT_REQ01
- WP9_DLR_AUT_REQ02
- WP9_DLR_AUT_REQ03

6. Conclusion

There are clear matches between the collected methods, techniques and tools presented in chapter 4 and the support required by that various applications presented in chapter 5.
All areas of expertise in WP3 are needed by various applications:

a) AI techniques and algorithms (7x)
b) Hierarchical and functional modeling (12x)
c) Physiological and physical human monitoring and analysis (10x)
d) Context and system modeling (8x)
e) Software framework (3x)
f) Validation framework (4x)
g) Human behavior monitoring (11x)
h) Simulation and tests (7x)

So there seem to be an interesting overlap between the required MTT supports of the various applications/domains, which implies that there are opportunities to define multi-domain support. More detailed discussion is needed to find the optimal links and to specify the provided methods, tools & techniques in detail.

A. Annex

This Annex contains two excel sheets:

- WP3 partners materials present an overview of the potential contributions of the WP3 partners, including references to contact persons, tools, etc.
- WP3 use case map presents the map between the use cases and and AdCoSs as defined by the application WPs and the potential WP3 contributions
- WP3 Requirements overview, with a more detailed map of requirements from the application WPs on the possible contributions of WP3


WP3 Partners Materials v2.xlsx


WP3 use case map - 07-04-14.xlsx


Requirements_Overview_WP3 (4).xlsx