THE RIGHT AUTOMATION IN THE RIGHT CONTEXT

A conceptual and methodological framework for human performance automation support

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WHAT

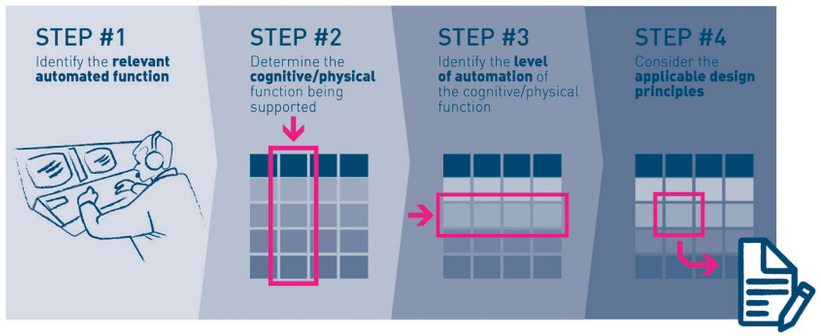
A **conceptual and methodological framework** based on the **LOAT (Level of Automation Taxonomy)** to guide the identification of the best level of automation in a given context and to tailor the automation design to specific operational needs.

WHY

When **failing to identify the proper level of automation**, even tools with high technical capabilities may not provide the desired benefit or may induce the human operator to reject them. In the worst cases, **the user may decide to ignore or switch off the automation** with potential negative effects on the safety of operations.

HOW

A **four steps methodology** based on the LOAT table and on the application of a dedicated set of automation design principles.



BACKGROUND

The conceptual framework derives from a work done in the context of the SESAR Project 16.5.1 *(Identification and integration of Automation Related Good Practices)* where the LOAT table was originally proposed. The LOAT table describes a taxonomy grounded on the seminal work by Sheridan and Verplanck – the first to introduce the idea of automation levels – and on the following work by Parasuraman, Sheridan and Wickens (2000) which defines four functions to be supported in a human-machine system: *information acquisition*, *information analysis*, *decision and action selection* and *action implementation*. These models have been essential to understand the variable nature of automation support, but encounter limitations when identifying distinctive levels useful to analyse and compare concrete automation examples. In the LOAT proposal the original automation levels are modified based on a combination of theoretical work investigating the different ways of sustaining human performance and on the analysis of 26 examples of automated functionalities. These functionalities own to both ground and aircraft related systems and were analysed in detail in the context of the SESAR Project 16.5.1. Based on the experience of analysing these functionalities, a set of design principles was also defined, guiding both the identifiation of the proper automation level and the tailoring of automation features to specific operational needs. These design principles refer to factors such as: the number of information items to be considered by the user, the level of workload associated to the task, the variability and the complexity of the operational environment, the criticality of the task being supported, etc. The combination of the LOAT table with the design principles allows the comparison of successful experiences of automation in defined operational contexts with less successful examples, providing insight on how to prevent human performance issues and take full benefit of the available technical solutions.

References

Parasuraman, R., Sheridan, T. B., & Wickens, C. D. (2000). A model for types and levels of human interaction with automation. *IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans*, 30, 286–297.

Save, L. Feuerberg, B. (2012), *Designing Human-Automation Interaction: a new level of Automation Taxonomy.* In De Waard, D. et al (Eds.) (2012), Human Factors: a view from an integrative perspective.

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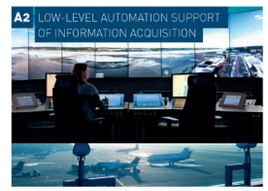
From INFORMATION to ACTION

Increasing Automation

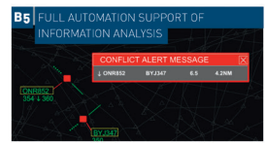
A INFORMATION ACQUISITION	B INFORMATION ANALYSIS	C DECISION AND ACTION SELECTION	D ACTION IMPLEMENTATION
A1 ARTEFACT-SUPPORTED INFORMATION ACQUISITION	**B1** ARTEFACT-SUPPORTED INFORMATION ANALYSIS	**C1** ARTEFACT-SUPPORTED DECISION MAKING	**D1** ARTEFACT-SUPPORTED ACTION IMPLEMENTATION
The human acquires relevant information on the process s/he is following with the support of low-tech non-digital artefacts.	The human compares, combines, and analyses different information items regarding the status of the process s/he is following utilising paper or other non-digital artefacts (e.g. use of flight strips)	The human generates decision options, selects the appropriate ones and decides all actions to be performed utilising paper or other non-digital artefacts.	The human executes and controls actions with the help of mechanical non-software based tools.
A2 LOW-LEVEL AUTOMATION SUPPORT OF INFORMATION ACQUISITION	**B2** LOW-LEVEL AUTOMATION SUPPORT OF INFORMATION ANALYSIS	**C2** AUTOMATED DECISION SUPPORT	**D2** STEP-BY-STEP ACTION SUPPORT
The system supports the human in acquiring information on the process s/he is following. Filtering and/or highlighting of the most relevant information is up to the human. (e.g. use of video cameras for Remote Tower)	**Based on user's request**, the system helps the human in comparing, combining and analysing different information items regarding the status of the process being followed. (e.g. use of Speed Vectors)	The system proposes one or more decision alternatives to the human, leaving freedom to the human to generate alternative options. The human can select one of the alternatives proposed by the system or her/his own one.	The system **assists** the operator in performing actions by executing part of the action and/or by providing guidance for its execution. However, each action is executed based on **human initiative** and the human keeps full control of its execution. (e.g. Aural and visual component of TCAS RA - also LOA C4)
A3 MEDIUM-LEVEL AUTOMATION SUPPORT OF INFORMATION ACQUISITION	**B3** MEDIUM-LEVEL AUTOMATION SUPPORT OF INFORMATION ANALYSIS	**C3** RIGID AUTOMATED DECISION SUPPORT	**D3** LOW-LEVEL SUPPORT OF ACTION SEQUENCE EXECUTION
The system supports the human in acquiring information on the process s/he is following. It helps the human in **integrating** data coming from different sources and in **filtering** and/or **highlighting** the most relevant information items, **based on user's settings.** (e.g. Flight level filtering in CWP)	**Based on user's request**, the system helps the human in comparing, combining and analysing different information items regarding the status of the process being followed. **The system triggers visual and/or aural alerts** if the analysis produces results requiring attention by the user. (e.g. What-if functions in controller tools)	The system proposes one or more decision alternatives to the human. The human can only select one of the alternatives or ask the system to generate new options.	The system performs automatically a sequence of actions **after activation by the human**. The human maintains full control of the sequence and can modify or interrupt the sequence during its execution.
A4 HIGH-LEVEL AUTOMATION SUPPORT OF INFORMATION ACQUISITION	**B4** HIGH-LEVEL AUTOMATION SUPPORT OF INFORMATION ANALYSIS	**C4** LOW-LEVEL AUTOMATIC DECISION MAKING	**D4** HIGH-LEVEL SUPPORT OF ACTION SEQUENCE EXECUTION
The system supports the human in acquiring information on the process s/he is following. The system **integrates** data coming from different sources and **filters** and/or **highlights** the information items which are considered relevant for the user. The **criteria** for integrating, filtering and highlighting the relevant information **are predefined at design level but visible to the user.**	The system helps the human in comparing, combining and analysing different information items regarding the status of the process being followed, based on parameters pre-defined by the user. **The system triggers visual and/or aural alerts if the analysis produces** results requiring attention by the user (e.g. MTCD alerts).	The system generates options and decides autonomously on the actions to be performed. The human is informed of its decision (e.g. aural and visual component of TCAS RA & Advanced AMAN).	The system performs automatically a sequence of actions **after activation by the human.** The human can **monitor** all the sequence and can **interrupt** it during its execution. (e.g. Autopilot following FMS trajectory).
A5 FULL AUTOMATION SUPPORT OF INFORMATION ACQUISITION	**B5** FULL AUTOMATION SUPPORT OF INFORMATION ANALYSIS	**C5** HIGH-LEVEL AUTOMATIC DECISION MAKING	**D5** LOW-LEVEL AUTOMATION OF ACTION SEQUENCE EXECUTION
The system supports the human in acquiring information on the process s/he is following. The system **integrates** data coming from different sources and **filters** and/or **highlights** the information relevant for the user. The **criteria** for integrating, filtering and highlighting the relevant info **are predefined at design level and not visible to the user**.	The system performs comparisons and analyses of data available on the status of the process being followed based on **parameters defined at design level. The system triggers visual and/or aural alerts** if the analysis produces results requiring attention by the user. (e.g. STCA)	The system generates options and decides autonomously on the action to be performed. The human is informed of its decision only on request. [Note that this level is always connected to ACTION IMPLEMENTATION, at a level not lower than D5]	The system **initiates and executes** automatically a sequence of actions. The human can **monitor** all the sequence and can **modify or interrupt it during the execution.**
		C6 FULL AUTOMATIC DECISION MAKING	**D6** MEDIUM-LEVEL AUTOMATION OF ACTION SEQUENCE EXECUTION
		The system generates options and decides autonomously on the action to be performed without informing the human. [Note that this level is always connected to ACTION IMPLEMENTATION, at a level not lower than D5].	The system **initiates** and **executes** automatically a sequence of actions. The human can monitor all the sequence and can **interrupt** it during the execution. (e.g.TCAS AP/FD mode concept during execution of a corrective TCAS RA).
			D7 HIGH-LEVEL AUTOMATION OF ACTION SEQUENCE EXECUTION
			The system **initiates and executes** a sequence of actions. The human can only **monitor** part of it and **has limited opportunities to interrupt it.**
			D8 FULL AUTOMATION OF ACTION SEQUENCE EXECUTION
			The system **initiates and executes** a sequence of actions. The human cannot monitor nor interrupt it until the sequence is not terminated.

Level Of Automation Taxonomy

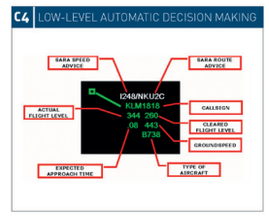
EXAMPLE HIGHLIGHTS



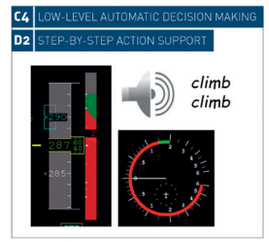
Use of video cameras in Remote Tower



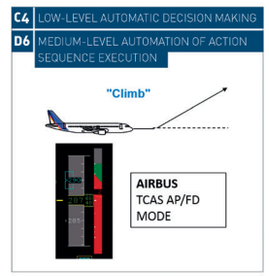
Short Term Conflict Alert



Advanced AMAN with speed & route advice on track labels
(example from SARA project)



TCAS RA



TCAS AP/FD Mode concept during the Execution of corrective RA