Automation of Trajectory based Operation for Future Flight Decks

Research plan
Institute of Flight Systems and Automatic Control

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Glossary of terms used

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<tr>
<td>ATM</td>
<td>Air Traffic Management</td>
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<tr>
<td>HALA</td>
<td>Higher Automation Level in Air Traffic Management</td>
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<td>HMI</td>
<td>Human-Machine Interface</td>
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<td>IFR</td>
<td>Instrument Flight Rules</td>
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<td>PhD</td>
<td>Doctor of Philosophy</td>
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<td>SESAR</td>
<td>Single European Sky ATM Research</td>
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<td>SWIM</td>
<td>System Wide Information Management</td>
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<td>TBO</td>
<td>Trajectory Based Operation</td>
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<td>TUD</td>
<td>Technische Universität Darmstadt</td>
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1. PHD Proposal

1.1. Abstract/ Executive summary

To enable safe and efficient commercial air traffic it is important to have state-of-the-art air traffic management (ATM) systems. Current ATM systems have reached their capacity limits and have to be adapted to cover future demand (1). Based on the constraints of current ATM systems, improvements with higher levels of automation are needed to enable future air traffic growth (2). The Single European Sky ATM Research (SESAR) concept introduced a new operational concept in order to meet the expected capacity (3). This trajectory based operation (TBO) concept uses business trajectories in a tactical and strategic level to manage the air traffic flow. This new concept creates completely new information requirements for all stakeholders (3). To meet these required information's, an increase of automation that will support the human's task is needed. This thesis will analyze the required information and develop a conceptual demonstrator of new cockpit system functions to support TBOs (2). This demonstrator shall improve the cognition of information for TBO by the pilot, using information automation. A concept demonstrator, its framework, and the implementation of new operating system functions, to support TBO on existing and future flight deck systems, will be developed during this thesis. The system will be designed as a HMI system including automation tasks. These developed functions shall support the pilot’s situational awareness about the TBO and the ATM system but shall not increase the human workload.
1.2. Introduction

Based on current forecasts, the air traffic all over the world will grow continuously over the next twenty years (1). For Europe, the Eurocontrol long-term forecast presents the future air traffic development with different scenarios (1). According to these different scenarios, presented in Figure 1, the forecast of the growth factor in commercial air traffic will be in between 1.4 and 2.2 till 2030 (1).

![Figure 1: IFR movements (1)](image)

The objectives of the SESAR concepts of operations states, that new capacity and safety principles can only be achieved with an increase in automation (3). Future ATM systems will offer higher levels of automation and completely new human-machine interfaces (HMI) (2). To interact with these new highly automated HMIs, the human perquisite a good understanding of the system architecture and structure.

Today especially on the flight deck there are a high number of automated systems to display and handle the required information’s. This major quantity of information’s cannot be further increased without an increase in human workload or more complex automated systems with decision support tools. This thesis aims to develop a highly automated operating system functions for the flight deck to implement the required information. It is aligned on the SESAR objectives of automation or ATM and will produce results which can interlink with other projects performed with the HALA! Network. All generated results describe an overall operational concept for SESAR TBO concept.
1.3. Goal of this thesis

With the new objectives of the SESAR concept and the system wide information management (SWIM) the required information for each flight increases (3). Focusing on the flight deck, this research will analyze what information is required for efficient TBO and how the required information can be integrated into the cockpit functions. This thesis will improve the cognition of information for TBO by the pilot using information automation. Integrating additional information and new TBO functions into existing cockpit systems would reduce the number of additional flight deck systems. In contrast to additional systems, an integration of these functions into current avionic systems will flatten the man-machine interface. The goal of this thesis is to propose a concept demonstrator, its framework, and the implementation of new operating system functions to support TBO on existing and future flight deck systems. This demonstrator shall be integrated into a flight deck to enable TBO functions without additional avionic systems. The system will be designed as a HMI system including automation. These HMI functions shall support the pilot’s situational awareness about the TBO and the ATM system but shall not increase the human workload. The pilot shall understand the past situation, shall interact at present and shall foresee the future situation with the help of the integrated functions.
2. Concept

2.1. Trajectory definition/ Trajectory calculation

This thesis will be a human centered flight deck system analysis. The used trajectory will be a detailed uninterrupted description of the flight track including time. The definition and calculation of the complete Trajectory will be done by an algorithm. Unexpected events, constrains or changes will be continuously implemented into the trajectory. The communication of the trajectory will be done with state-of-the-art data link technologies.

2.2. Required information

On the ground and on the flight deck TBOs are not fully supported with state-of-the-art systems. The SESAR concept advantages using TBO can only be achieved if TBOs can be preceded at the flight deck and on the ground with a large group of users. To enable TBOs, the required information’s at each phase of the flight has to be defined. Therefore a detailed information analysis will be the first step of this research thesis. The required information will be analyzed, using a task oriented breakdown of the information required at the flight deck to support the pilot in TBO.

2.3. System design

To present the required information on the flight deck, additional system functions will be implemented into the flight deck. The flight simulator at the Technische Universität Darmstadt will be equipped with the new system functions to demonstrate the developed HMI. The design of the flight trials will be based on the outcome of the task and information analysis.

2.4. Operational concept

To analyze the required information, an operational concept will be defined. This concept will be based on the results of the information and task analysis.

2.5. System validation

This thesis will investigate how the pilot has to be supported in order to be able to manage and use the defined concept of TBO with the additional automation and information functions. The flight simulator at the Institute of Flight Systems and Automatic Control at Technische Universität Darmstadt will be used to evaluate the concept. The new system will be implemented into the flight deck layout and performed using a defined demonstration plan.
3. Methodology

This research will be a human centered flight deck system analysis. It will be grouped into an information analysis, state-of-the-art system analysis, a conceptual phase to define the required information, a demonstrator development phase and a presentation phase. The demonstration on the flight deck includes an experiment, consisting of simulator flight trials. A new interface concept will be developed as a part of this thesis to implement all required information’s and operating elements. The flight trials will take place at a research flight simulator. The new functions developed during this research work shall be modular to enable an easy integration into a flight simulator. To limit the parameters, the research will be focused on the TBO relevant tasks on the flight deck only, according to the SESAR concept.

4. Thesis Tasks

1. Definition of a concept for TBO design operational in 2050
2. Analysis of the required information and tasks on the flight deck
3. Definition of an demonstrator including information and task flow on the flight deck
4. Definition of the experimental setup for the flight trials
5. Demonstrator flight trials
6. Validation of the concept
5. Schedule

The research work is planned according to the following timetable. The defined tasks may be performed in a different order or parallel.

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<tr>
<th>Task</th>
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<tr>
<td>Research Plan</td>
<td>3 months</td>
<td>01/09/2012</td>
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<tr>
<td>Analysis of current information's and system interfaces</td>
<td>3 months</td>
<td>01/12/2012</td>
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<tr>
<td>Analysis of future required information and system interfaces</td>
<td>3 months</td>
<td>01/03/2013</td>
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<td>Experimental design definition including demonstrator platform</td>
<td>3 months</td>
<td>01/06/2013</td>
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<td>Definition and Implementation of system architecture of demonstrator</td>
<td>5 months</td>
<td>01/11/2013</td>
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<tr>
<td>Implementation of the concept demonstrator into the flight simulator</td>
<td>7 months</td>
<td>01/06/2014</td>
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<td>Thesis</td>
<td>6 months</td>
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6. Reference

   http://www.sesarju.eu/.