Over the past few years, global air traffic growth has exhibited a fairly stable positive trend, even through various circumstances. According to a prevailing opinion, this trend is unlikely to change in the future. Within this picture, traffic flow patterns will become more complex, making conflicts and situations harder to identify for human operators.

As envisaged by SESAR JU and HALA! Research Network, higher levels of automation will help Air Traffic Controllers (ATCOs) to deal with increasingly complex airspace scenarios, enabling them to manage complexity in a safe and efficient way. Research has shown that supportive automation can be beneficial and lead to reduced workload, increased management capacity and performance.
reliability. However, the absence of automation errors can often not be guaranteed. Consequently, a human operator has to monitor the automation and to intervene in the unlikely event of system failure or the misinterpretation of the situation by the system.

It has been shown that the monitoring role of human operators results in negative effects, such as lack of attention, loss of Situation Awareness (SA) and skill degradation. It is expected that a monitoring task reduces ATCOs’ ability to detect problems, determine the current state of the system, understand events and to react to situations. Therefore, adaptive automation should be taken into account to avoid keeping the ATCO ‘out-of-the-loop’ (OOL).

MINIMA will pursue this goal by developing a vigilance and attention controller. Specially, MINIMA will:

• Identify the frequency and the severity of the OOL phenomenon in a highly automated terminal manoeuvring area (TMA). Based on a review of OOL performance problems identified in the literature, MINIMA will analyse which of these problems affect the performance of ATCOS.

• Analyse the task environment, define new task distributions and procedures and develop new attention guidance tools. New task distributions which decrease the level of automation and hand back tasks from the automation to the human operator may decrease system performance, but may be necessary to avoid OOL problems. Also new tasks will be defined in order to increase the operators’ vigilance. Attention guidance tools will be arranged as well to highlight specific air traffic situations when necessary.

• Develop a real time “Vigilance and Attention Observer” to monitor the state of the human operator. This will be based on cutting edge technologies, such as electroencephalography, kinematic sensors, and eye trackers. Ad hoc indexes, combining multi-source information, will compare the ATCO’s psychophysical state to a reference state. Applying a Brain-Computer-Interface to measure the operators’ state is a core aspect of MINIMA.

• Develop an adaptive automation based on the Vigilance and Attention Observer. Activation tasks and attention guidance tools will be dynamically assigned based on the ACTO’s state measured with the vigilance and attention observer. As reducing the level of automation can reduce system performance, adaptive automation will dynamically switch between modes of high and low automation to avoid OOL occurrence.

In summary, MINIMA will develop an automated system capable of providing substantial and verifiable capacity and efficiency benefits while fully addressing the risks associated with assigning a monitoring role to the human operator, such as dissatisfaction, lack of attention, loss of SA and de-skilling. This way, MINIMA will provide guidance for the future design of fail-safe complex human-machine environments in the presence of high levels of automation.
As of today, MINIMA achieved five major goals:

1. Completion of the State of the Art Report
2. Development of the MINIMA concept
3. A successful Intermediate Review Meeting with SJU in March 2017
4. Technical implementation of the MINIMA concept, including the Task Environment and the Integrated Vigilance and Attention Controller
5. The successful conduction of the evaluation study for the MINIMA concept in November 2017

After the completion of the MINIMA State of the Art Report and the MINIMA concept based on the former’s results, and a successful Intermediate Review Meeting with SJU in March 2017, the project achieved its third Milestone in Mid 2017. More precisely, the MINIMA concept was successfully implemented, resulting in a fully functional high-fidelity Task Environment and an Integrated Vigilance and Attention Controller.

MINIMA’s evaluation study, completed in November 2017, marked the achievement of the 4th and 5th Milestones, after 15 air traffic controllers of the Italian air navigation service provider ENAV participated in the evaluation study conceptualised in D3.1. During the two week experiment, the controllers completed several air traffic control scenarios with either a continuously high level of automation or MINIMA’s vigilance and attention-based adaptive automation concept. During the last reporting period of MINIMA, the data will show to which extend the MINIMA concept is able to mitigate the so-called Ironies of Automation.

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

MINIMA’s OOL analyses contributed to improving the knowledge about human performance monitoring functions and the understanding of this phenomenon, its characterization at both physiological and psychological level, and the condition of its emergence. Additionally, the State of the Art report provides an extensive overview of methods that can be applied to measure vigilance and attention of human operators.

These results enabled the MINIMA project to develop the Vigilance and Attention Controller and the task environment used for its evaluation. This adaptive automation system is designed to avoid OOL in air traffic control. Such progress could have important implications to increase safety and diminish fatigue of humans in highly automated systems.

The results described above can also be helpful for other researchers pursuing similar goals beyond MINIMA. While the characterization of the OOL phenomenon can help ergonomists to design automation interfaces mitigating the related negative effects, the adaptation mechanisms described in the concept can inspire researchers to develop similar ideas for adaptive task environments. Lately, the project teams of MINIMA and AUTOPACE started a collaboration to profit from each other’s expertise, exchange ideas and improve their means of dissemination. Moreover, both teams will explore their options for possible (collaborative) follow-up projects. Also, the attention guidance
components developed in MINIMA will influence the attention guidance concept and prototype
developed within PJ16.04.

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