RESEARCH SHOWCASE

AVIATION HUMAN FACTORS AT THE UNIVERSITY OF SOUTHAMPTON

The Human Factors Engineering team in the Transportation Research Group at the University of Southampton conducts research on human performance in systems, especially in the aviation industry. In this Research Showcase, **Katie Plant** and **Neville Stanton** outline some of the group's research activities.

The Human Factors Engineering team at the University of Southampton has a decade-long history of conducting research into aviation human factors. Our work primarily focuses on the design, development and evaluation of aviation technologies and processes. We strive to conduct research with a tangible impact, so we work closely in partnership with industrial organisations including GE Aviation Systems, Rolls-Royce Engines and BAE Systems. Our current flagship aviation research programme, Open Flight Deck (OFD), is an industry-academia collaboration, aimed at developing an open architecture platform so that manufacturers can build and customise their own flight deck. We also supervise PhD students, many of whom study part-time whilst working in aviation-related fields. Four of our current projects have been selected to showcase what we do and the impact they might have in the future.

What's it doing now? Developing decision-making support tools for engine conditions[1]

A key focus for human factors in aviation is the drive to bring more technological applications into the flight deck. This aims to provide the pilot with better information on the current state and future projection of the aircraft's capabilities. In relation to engine parameters, flight-deck displays have remained relatively unchanged since the early days of powered flight. Analogue dials might have been replaced by digital readouts but limited, descriptive information is still provided, despite technological advancements in sensing and processing. During abnormal operating conditions, this can result in flight crews having insufficient information to make an accurate assessment of engine conditions. As part of the open flight deck project, Rolls-Royce are developing a suite of technologies for enhanced cockpit decision-making, aimed at guiding flight crews through decision-making processes related to abnormal operating scenarios (e.g., engine oil leak or fan blade damage).

The intended outcome is to reduce the disruption associated with such scenarios, including minimising in-flight shutdowns or significant maintenance costs. To enable this, pilots will be presented with information about the context of the flight, such as range and distances to nearby airports, and facilities at those airports.

We are working with Rolls-Royce to develop these 'user-centred flight-deck applications'. This involves ensuring that principles of human factors are implemented at the very beginning of, and throughout, the design process to ensure that the technological system matches the cognitive processes and needs of the end user, i.e., commercial pilots. We have conducted interviews to understand how pilots currently make decisions in abnormal operating scenarios. This enables pilots' cognitive processes to be represented in decision support tools.

Enhanced cockpit decision-making applications comprise two main interconnected elements: the 'engine condition application' and the 'user application'. The engine condition application consists of advanced diagnostic algorithms that determine the condition of the powerplant and how it is being operated. As these algorithms are aware of aircraft state and operation, they can determine what to tell the flight crew and when. The user application provides the human-machine interface for the flight crew. This is carefully designed for each specific feature using human factors methods. These methods help to ensure that pilots are correctly guided through the decision-making process. Ultimately, these new technologies change the role of the pilot and the tasks they need to conduct. Factors such as end-user satisfaction, acceptance, trust and decision-making will be evaluated in simulated flight trails in the near future.


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Future technology on the flight deck: the use of touchscreens in turbulent conditions[2]

The functionality and complexity of the flight deck has increased significantly in recent years. Current displays are already crowded, with little room to incorporate increased functionality. Touchscreens have the potential to increase functionality as they are more customisable and provide a virtually unlimited array of user applications. They also have the added value of offering immediate feedback, potentially reducing the need for recalling items from memory. The ease in which touchscreens can be updated and modified is attractive to aircraft manufacturers. What is less well known is how their usability might be impacted in turbulent conditions, especially in a fixed location.

Working with GE Aviation Systems, as part of the Open Flight Deck project, we've been investigating the usability of touchscreens in turbulent representative motion, generated on a 6-axis motion simulator. We have tested touchscreens in centre, side, and overhead positions under conditions of light chop, light turbulence and moderate turbulence (for ethical reasons we were not allowed to put people into simulated heavy turbulence). Performance measures including error rate, movement times, accuracy and arm fatigue/discomfort were captured. We found that central screen positioning meant faster movement times and lower error rates across all vibration conditions. However, side screen positioning was more comfortable for the user. Longer interaction styles (e.g., slide bars) are likely to increase discomfort so should be avoided. Confirmation of input selection is important, especially at high levels of turbulence where errors are more prevalent. Our research has shown that it is possible to interact with a touchscreen using short, single, presses with reasonable accuracy and low error rate, even under moderately turbulent conditions. It is likely that touchscreens will be commonplace on the flight deck in the near future, so well-designed human factors studies are increasingly important, to ensure optimal implementation for the user.

What went right? Understanding adaptation in air traffic management[3]

Europe's air traffic control providers manage some of the most complex airspace in the world and have achieved excellent levels of safety performance. However, ATM is undergoing unprecedented change and a number of new challenges face the industry. New regulations, new technologies and automation, the desire to reduce the environmental impact of air travel, and a demand for further cost efficiencies could affect safety. The ATM industry needs to ensure that safety is managed appropriately in light of changing risks. The traditional approach to safety monitoring has been one that identifies and counts the number of times that a safe service was not provided. In the case of ATM, losses of separation had been a key measure. Safety occurrences are investigated so that the lessons can be learned to prevent a reoccurrence.

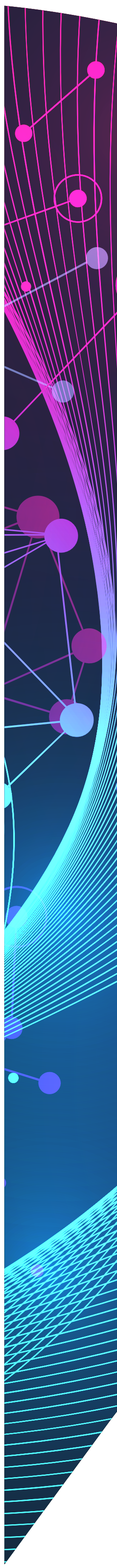
As safety occurrences reduce in frequency, and as there is less data, it can become even harder to understand the safety of operations. Recent advances in safety research suggest a new approach. At the heart of this is the idea is that safety is created through how people and the system as a whole adapts. Understanding how safety is created requires an understanding of why things go right, rather than just wrong, which means understanding everyday work. The ultimate goal of this research is therefore to provide guidance on how organisations can successfully harness 'adaptation' to improve their understanding of what keeps them safe. It is hoped that ATM organisations will use the findings to update how safety is managed. Whether this is formalised in safety management systems, or through guidance, training, and informal processes, remains to be seen. Our existing means of monitoring safety and understanding and assuring changes do not yet take into account ideas of adaptation. The complexity of the system is starting to catch traditional approaches out. So, this research will provide more guidance to ATM organisations trying to manage safety.

Two become one: The case for single pilot operations

One of the most controversial areas of research that we are involved with concerns single pilot operations (SPO) or distributed crewing. This is an emotive topic, causing passionate debate on either side of the argument. SPO involves removing the First Officer from the flight deck and distributing their duties to advanced automation systems in combination with a ground-based station, supported by human operators. As such, a remote co-pilot would support flight operations or even take over control in emergency situations. This is motivated by long-term savings in crew costs, improved aircraft availability and serviceability, as well the anticipated pilot shortage associated with increasing demand.

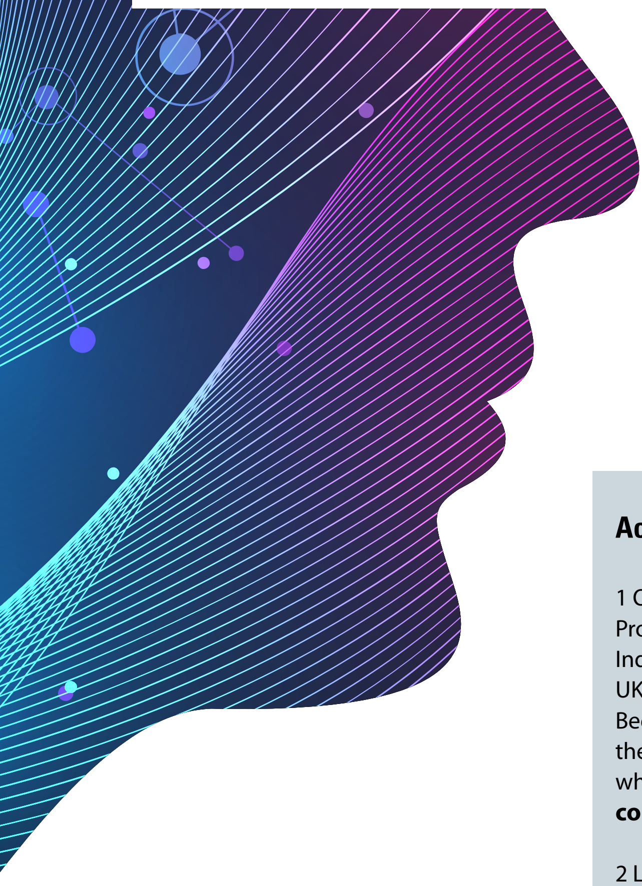
Arguably, the main barrier to SPO is not the technology; aircraft have been progressively 'de-crewed' for many years. The main barrier is public acceptance of the risk of pilot incapacitation, along with and the need for complete redesign of the concept of operations for a distributed air-ground system. Many issues remain to be solved, including crew coordination, workload allocation, single-pilot incapacitation, communication and social issues, the design of advanced automation systems and certification.

Human factors requirements are therefore a key driver in the case of SPO. Our research has applied a range of human factors methods to model how an SPO environment might work, exploring how different agents (both human and technological) might perform different functions. This has demonstrated the potential for increased safety, and systems as resilient as current operations, especially when SPO are facilitated by a ground station co-pilot instead of only on-board automation. Autonomous systems monitoring pilot health and the behaviour of aircraft systems are still at a premature stage of development. Also, many research questions remain, and there is much work to be done in gaining public, pilot, aviation industry and regulator acceptance for the proposed changes.



The aerospace industry is at a pivotal moment in history in terms of future technologies and capabilities. Hybrid and all-electric aircraft concepts are being investigated, as well as increasing automation and autonomy in traditional aircraft. With the introduction of new technology, as old problems are addressed new issues arise. The human factors discipline and profession has an important role to play in design and evaluation of new technologies to ensure that human performance is optimised to enable successful task performance, so that the system as a whole works optimally. The integration of human factors approaches into the early phases of the design of such systems is essential to ensure the success and continued safety of these future systems. S

For additional information about any of the projects mentioned or general interest about what we do please contact Dr Katie Plant at **K.Plant@soton.ac.uk.**



Dr Katie Plant is a lecturer in Human Factors Engineering in the Faculty of Engineering and Physical Sciences. She is the author of 'Distribution Cognition and Reality: How Pilots and Crews Make Decisions' (CRC Press, 2016) and was awarded the Honourable Company of Air Pilots award for Aviation Safety Research in 2014. Katie runs an undergraduate module called 'Human Factors in Engineering' and project manages the University of Southampton's contribution to the Open Flight Deck project.

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Professor Neville Stanton is Professor of Human Factors in Transport within Engineering and Physical Sciences at the University of Southampton and conducts research into human performance in technological systems. In 2007 The Royal Aeronautical Society awarded him the Hodgson Medal and Bronze Award with colleagues for their work on flight-deck safety. Neville is the Principal Investigator for the Open Flight Deck Project.

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Acknowledgements

1 Open Flight Deck is co-funded by the UK Aerospace Research and Technology Programme; a partnership between Department for Business, Energy and Industrial Strategy (BEIS), UK Aerospace Technology Institute (ATI), and Innovate UK. More information can be found at https://openflightdeck.co.uk/. Pete Beecroft is a Systems Design and Integration specialist for Rolls-Royce, one of the world's leading technology companies. He works primarily in research for whole engine and aircraft-level technologies. **peter.beecroft@rolls-royce.com**

2 Luke Bolton is a Senior Engineering Manager in Emerging Technologies at GE Aviation Systems. **luke.bolton@ge.com**

3 Craig Foster, a Safety Specialist at NATS, is undertaking a part-time PhD exploring the concept of adaptation in air traffic management. **craig.foster@nats.co.uk**