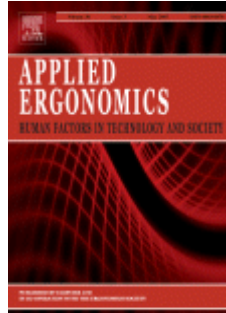# Applied Ergonomics - rok 2007, ročník 38

Číslo 4 (July 2007)

Sarah Sharples, Alex Stedmon, Gemma Cox, Alistair Nicholls, Tracey Shuttleworth and John Wilson. *Flightdeck and Air Traffic Control Collaboration Evaluation (FACE) : Evaluating aviation communication in the laboratory and field*. **Pages 399-407.**

The challenge to anticipate the human factors impact of introducing new technologies into a safety critical environment can be addressed in a number of ways. This paper presents a research programme that utilised both laboratory- and field-based assessments to examine the way in which datalink and freeflight may affect the communication and collaboration between pilots, air traffic controllers, and other actors and artefacts in the flightdeck–air traffic control (ATC) joint cognitive system. An overview of the results from these studies is presented, and guidance is provided as to the likely situations in which this new technology is most likely to be successfully applied. In addition, the methodological approach of combining results from field and laboratory data is discussed.

Erik Hollnagel. *Flight decks and free flight: Where are the system boundaries?* **Pages 409-416.**

The change from managed to free flight is expected to have large effects, over and above the intended efficiency gains. Human factor concerns have understandably focused on how free flight may affect the pilots in the cockpit. Yet it is necessary to see the change from managed to free flight as more than just an increment to the pilots' work. Despite the best intentions the transition will not be a case of a smooth, carefully planned and therefore uneventful introduction of a new technology. It is more likely to be a substantial change to an already challenging working environment, in the air as well as on the ground. The significant effects will therefore not just happen within the existing structure or distribution of work and responsibilities, but affect the structure of work itself. This paper takes a look at free flight from a cognitive systems engineering perspective and identifies two major concerns: first what effects free flight has on the boundaries of the joint cognitive systems, and second how this affects demands to control. The conclusion is that both will change considerably and that we need to understand the nature of these changes before focusing on the possible effects of free flight on pilots' performance.

- **Keywords:** Control; Delegation; Joint cognitive system; Substitution myth; System boundaries

Gordon Baxter, Denis Besnard and Dominic Riley. *Cognitive mismatches in the cockpit : Will they ever be a thing of the past?* Pages 417-423.

Changes in aviation over the last 30 years have dramatically affected the way that flight crews fly aircraft. The implementation and evolution of the glass cockpit, however, has happened in an almost *ad hoc* fashion, meaning that it does not always properly support the flight crew in carrying out their tasks. In such situations, the crew's mental model of what is happening does not always match the real state of affairs. In other words, there is a cognitive mismatch. An initial taxonomy of cognitive mismatches is defined, and the problem illustrated using an example from an aviation accident. Consideration is then given to how cognitive mismatches can be managed. A call is made for the development of an integrated cockpit architecture that takes better account of human capabilities and allows for new developments to be added to the cockpit in a more seamless manner.

- **Keywords:** Cognitive mismatches; Flight deck systems; Human–machine interaction

Gemma Cox, Sarah Sharples, Alex Stedmon and John Wilson. *An observation tool to study air traffic control and flightdeck collaboration*. Pages 425-435.

The complex systems of the flightdeck (FD) and the Air Traffic Control Centre (ATC) are characterised by numerous concurrently operating and interacting communication channels between people and between people and machines/computer systems. This paper describes work in support of investigating the impact of changes to technologies and responsibilities within this system with respect to human factors. It focuses primarily on the introduction of datalink (text-based communication rather than traditional radio communication) and the move towards freeflight (pilot-mediated air traffic control). Air traffic management investigations have outlined these specific changes as strategies to enable further increases in the volume of air traffic.

A systems approach was taken and field studies were conducted. Small numbers of domain experts such as air traffic controllers (ATCOs) were involved in the field-based observations of how people interact with systems and each other. This paper summarises the overall research approach taken and then specifically reports on the field-based observations including the justification, development, and findings of the observation tool used. The observation tool examined information propagation through the air traffic control-flightdeck (ATC–FD) system, and resulted in models of possible information trajectories through the system.

- **Keywords:** Air traffic control; Flightdeck; Qualitative methods; Distributed cognitive systems

Rob C.J. Ruigrok and Jacco M. Hoekstra. *Human factors evaluations of Free Flight : Issues solved and issues remaining*. Pages 437-455.

The Dutch National Aerospace Laboratory (NLR) has conducted extensive human-in-the-loop simulation experiments in NLR's Research Flight Simulator (RFS), focussed on human factors evaluation of Free Flight. Eight years of research, in co-operation with partners in the United States and Europe, has shown that Free Flight has the potential to increase airspace capacity by at least a factor of 3. Expected traffic loads and conflict rates for the year 2020 appear to be no major problem for professional airline crews participating in flight simulation experiments. Flight efficiency is significantly improved by

user-preferred routings, including cruise climbs, while pilot workload is only slightly increased compared to today's reference.

Detailed results from three projects and six human-in-the-loop experiments in NLR's Research Flight Simulator are reported. The main focus of these results is on human factors issues and particularly workload, measured both subjectively and objectively. An extensive discussion is included on many human factors issues resolved during the experiments, but also open issues are identified.

An intent-based Conflict Detection and Resolution (CD&R) system provides "benefits" in terms of reduced pilot workload, but also "costs" in terms of complexity, need for priority rules, potential compatibility problems between different brands of Flight Management Systems and large bandwidth. Moreover, the intent-based system is not effective at solving multi-aircraft conflicts. A state-based CD&R system also provides "benefits" and "costs". Benefits compared to the full intent-based system are simplicity, low bandwidth requirements, easy to retrofit (no requirements to change avionics infrastructure) and the ability to solve multi-aircraft conflicts in parallel. The "costs" involve a somewhat higher pilot workload in similar circumstances, the smaller look-ahead time which results in less efficient resolution manoeuvres and the sometimes false/nuisance alerts due to missing intent information.

The optimal CD&R system (in terms of costs versus benefits) has been suggested to be state-based CD&R with the addition of intended or target flight level. This combination of state-based CD&R with a limited amount of intent provides "the best of both worlds". Studying this CD&R system is still an open issue.

- **Keywords:** Free Flight; Human factors; Real-time simulations

Alastair P. Nicholls, Anne Melia, Eric W. Farmer, Gareth Shaw, Tracey Milne, Alex Stedmon, Sarah Sharples and Gemma Cox. *Changing the role of the air traffic controller : How will free flight affect memory for spatial events?* **Pages 457-463.**

At present, air traffic controllers (ATCOs) exercise strict control over routeing authority for aircraft movement in airspace. The onset of a free flight environment, however, may well result in a dramatic change to airspace jurisdictions, with aircraft movements for the large part being governed by aircrew, not ATCOs. The present study examined the impact of such changes on spatial memory for recent and non-recent locations of aircraft represented on a visual display. The experiment contrasted present conditions, in which permission for manoeuvres is granted by ATCOs, with potential free flight conditions, in which aircrew undertake deviations without explicit approval from ATCOs. Results indicated that the ATCO role adopted by participants impacted differently on short-term and long-term spatial representations of aircraft manoeuvres. Although informing participants of impending deviations has beneficial effects on spatial representations in the short term, long-term representations of spatial events are affected deleteriously by the presentation of subsequent information pertaining to other aircraft. This study suggests strongly that recognition of the perceptual and cognitive consequences of changing to a free flight environment is crucial if air safety is not to be jeopardised.

- **Keywords:** Air traffic controller; Spatial memory; Free flight

Catherine A. Adams, Jennifer L. Murdoch, Maria C. Consiglio and Daniel M. Williams. *Incorporating data link messaging into a multi-function display to support the Small Aircraft Transportation System (SATS) and the self-separation of general aviation aircraft.* **Pages 465-471.**

One objective of the Small Aircraft Transportation System (SATS) Project is to increase the capacity and utilization of small non-towered, non-radar equipped airports by transferring traffic management activities to an automated system and separation responsibilities to general aviation (GA) pilots. This paper describes the development of a research multi-function display (MFD) to support the interaction between pilots and an automated Airport Management Module (AMM). Preliminary results of simulation and flight tests indicate that adding the responsibility of monitoring other traffic for self-separation does not increase pilots' subjective workload levels. Pilots preferred using the enhanced MFD to execute flight procedures, reporting improved situation awareness (SA) over conventional instrument flight rules (IFR) procedures.

Alex W. Stedmon, Sarah Sharples, Robert Littlewood, Gemma Cox, Harshada Patel and John R. Wilson. *Datalink in air traffic management : Human factors issues in communications*. Pages 473-480.

This paper examines issues underpinning the potential move in aviation away from real speech radiotelephony (R/T) communications towards datalink communications involving text and synthetic speech communications. Using a novel air traffic control (ATC) task, two experiments are reported. Experiment 1 compared the use of speech and text while Experiment 2 compared the use of real and synthetic speech communications. Results indicated that generally there were no significant differences between speech and text communications and that either type could be used without any main effects on performance. However, a number of specific differences were observed across the different phases of the scenarios indicating that workload levels may be more varied when speech communications are used. Experiment 2 illustrated that participants placed a greater level of trust in real speech than synthetic speech, and trusted true communications more than false communications (regardless of whether they were real or synthetic voices). The findings are considered in terms of datalink initiatives for future air traffic management, the importance placed on real speech R/T communications, and the need to develop more natural synthetic speech in this application area.

Jan Notes. *Energy management display : A new concept for the civil flight deck*. Pages 481-489.

There exists a strong rationale for an energy management system onboard civil aircraft; this is based on a global move towards greater energy consciousness and more specific reasons relating to safety and efficiency in the airline industry. This paper considers the design of an interface for an energy management system. It reports the development of a number of display designs within the requirements and constraints of the flight deck context. Three designs are evaluated both with student participants and senior airline pilots. It was found that those displays with predictive information elements produced the most accurate decisions concerning aircraft energy states. Further investigation into the function of these predictive elements (within real-time flight scenarios) is required in order to evaluate their efficacy with the end-user group of airline pilots.