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SPECIAL ISSUE: Human Factors in Aviation

Don Harris ;Neville A. Stanton. *Aviation as a system of systems : preface to the special issue of human factors in aviation. Pages 145 – 148.*

- Bez abstraktu a klíčových slov

Joachim Vogt ; Jörg Leonhardt ; Birgit Köper ;Stefan Pennig. *Human factors in safety and business management. Pages 149 – 163.*

Human factors in safety is concerned with all those factors that influence people and their behaviour in safety-critical situations. In aviation these are, for example, environmental factors in the cockpit, organisational factors such as shift work, human characteristics such as ability and motivation of staff. Careful consideration of human factors is necessary to improve health and safety at work by optimising the interaction of humans with their technical and social (team, supervisor) work environment. This provides considerable benefits for business by increasing efficiency and by preventing incidents/accidents. The aim of this paper is to suggest management tools for this purpose. Management tools such as balanced scorecards (BSC) are widespread instruments and also well known in aviation organisations. Only a few aviation organisations utilise management tools for human factors although they are the most important conditions in the safety management systems of aviation organisations. One reason for this is that human factors are difficult to measure and therefore also difficult to manage. Studies in other domains, such as workplace health promotion, indicate that BSC-based tools are useful for human factor management. Their mission is to develop a set of indicators that are sensitive to organisational performance and help identify driving forces as well as bottlenecks. Another tool presented in this paper is the Human Resources Performance Model (HPM). HPM facilitates the integrative assessment of human factors programmes on the basis of a systematic performance analysis of the whole system. Cause-effect relationships between system elements are defined in process models in a first step and validated empirically in a second step. Thus, a specific representation of the performance processes is developed, which ranges from individual behaviour to system performance. HPM is more analytic than BSC-based tools because HPM also asks why a certain factor is facilitating or obstructing success. A significant need for research and development is seen here because human factors are of increasing importance for organisational success. This paper suggests integrating human factors in

safety management of aviation businesses - a top-ranking partner of technology and finance - and managing it with professional tools. The tools HPM and BSC were identified as potentially useful for this purpose. They were successfully applied in case studies briefly presented in this paper. In terms of specific safety-steering tools in the aviation industry, further elaboration and empirical study is crucial. **Statement of Relevance:** The importance of human factors is recognised by operators at the sharp end of aviation, where flights are conducted or coordinated. At the blunt end, measurement tools are needed to manage operational resources.

- **Keywords:** balanced scorecard; human factors; human resources performance; management; safety; soft facts

M. C. Leva ; J. Cahill ; A. M. Kay ; G. Losa ;N. McDonald. *The advancement of a new human factors report – 'The Unique Report' : facilitating flight crew auditing of performance/operations as part of an airline's safety management system. Pages 164 – 183.*

This paper presents the findings of research relating to the specification of a new human factors report, conducted as part of the work requirements for the Human Integration into the Lifecycle of Aviation Systems project, sponsored by the European Commission. Specifically, it describes the proposed concept for a unique report, which will form the basis for all operational and safety reports completed by flight crew. This includes all mandatory and optional reports. Critically, this form is central to the advancement of improved processes and technology tools, supporting airline performance management, safety management, organisational learning and knowledge integration/information-sharing activities. Specifically, this paper describes the background to the development of this reporting form, the logic and contents of this form and how reporting data will be made use of by airline personnel. This includes a description of the proposed intelligent planning process and the associated intelligent flight plan concept, which makes use of airline operational and safety analyses information. Primarily, this new reporting form has been developed in collaboration with a major Spanish airline. In addition, it has involved research with five other airlines. Overall, this has involved extensive field research, collaborative prototyping and evaluation of new reports/flight plan concepts and a number of evaluation activities. Participants have included both operational and management personnel, across different airline flight operations processes. **Statement of Relevance:** This paper presents the development of a reporting concept outlined through field research and collaborative prototyping within an airline. The resulting reporting function, embedded in the journey log compiled at the end of each flight, aims at enabling employees to audit the operations of the company they work for.

- **Keywords:** accident reporting; aviation psychology; flight plan; human factors; incident reports; line operations safety audit; performance management; safety management system; threat and error management

Guy H. Walker ; Neville A. Stanton ; Chris Baber ; Linda Wells ; Huw Gibson ; Paul Salmon ;Daniel Jenkin. *From ethnography to the EAST method : a tractable approach for representing distributed cognition in Air Traffic Control. Pages 184 – 197*

Command and control is a generic activity involving the exercise of authority over assigned resources, combined with planning, coordinating and controlling how those resources are used. The challenge for understanding this type of activity is that it is not often amenable to the conventional experimental/methodological approach. Command and control tends to be multi-faceted (so requires more than one method), is made up of interacting socio and technical elements (so requires a systemic approach) and exhibits aggregate behaviours that emerge from these interactions (so requires methods that go

beyond reductionism). In these circumstances a distributed cognition approach is highly appropriate yet the existing ethnographic methods make it difficult to apply and, for non-specialist audiences, sometimes difficult to meaningfully interpret. The Event Analysis for Systemic Teamwork method is put forward as a means of working from a distributed cognition perspective but in a way that goes beyond ethnography. A worked example from Air Traffic Control is used to illustrate how the language of social science can be translated into the language of systems analysis. **Statement of Relevance:** Distributed cognition provides a highly appropriate conceptual response to complex work settings such as Air Traffic Control. This paper deals with how to realise those benefits in practice without recourse to problematic ethnographic techniques.

- **Keywords:** distributed cognition; air traffic control; command and control; situational awareness

T. G. C. Griffin ; M. S. Young ; N. A. Stanton. *Investigating accident causation through information network modelling. Pages 198 – 210.*

Management of risk in complex domains such as aviation relies heavily on post-event investigations, requiring complex approaches to fully understand the integration of multi-causal, multi-agent and multi-linear accident sequences. The Event Analysis of Systemic Teamwork methodology (EAST; Stanton *et al.* 2008) offers such an approach based on network models. In this paper, we apply EAST to a well-known aviation accident case study, highlighting communication between agents as a central theme and investigating the potential for finding agents who were key to the accident. Ultimately, this work aims to develop a new model based on distributed situation awareness (DSA) to demonstrate that the risk inherent in a complex system is dependent on the information flowing within it. By identifying key agents and information elements, we can propose proactive design strategies to optimize the flow of information and help work towards avoiding aviation accidents. **Statement of Relevance:** This paper introduces a novel application of an holistic methodology for understanding aviation accidents. Furthermore, it introduces an ongoing project developing a nonlinear and prospective method that centralises distributed situation awareness and communication as themes. The relevance of findings are discussed in the context of current ergonomic and aviation issues of design, training and human-system interaction.

- **Keywords:** aviation accident; communication; networks; distributed situation awareness; complex systems

G. Grote ; M. Kolbe ; E. Zala-Mezö ; N. Bienefeld-Seall ; B. Künzle. *Adaptive coordination and heedfulness make better cockpit crews. Pages 211 – 228.*

Team coordination during a simulated clean approach performed by 42 civil aviation cockpit crews was analysed. Several hypotheses regarding the adaptive use of implicit and explicit coordination, leadership and heedful interrelating were tested. The results indicate the adaptiveness of coordination to different levels of standardisation and task load and the general importance of explicit coordination for good performance. Leadership seems to be required mainly for work phases with little standardisation. In exploratory lag sequential analyses, heedful behaviour in the seven best and six worst performing crews was examined. The coordination sequences in high performance crews were found to be more succinct and well balanced, indicating that a shared sense of heedfulness is crucial for effectiveness. Theoretical implications for the conceptualisation of adaptive coordination and heedfulness and practical implications for improving crew training are discussed. **Statement of Relevance:** Analyses of team coordination during a simulated clean approach performed by civil aviation cockpit crews demonstrated the occurrence and effectiveness of adaptive coordination in response to different levels of task load and standardisation. Results also indicated the importance of heedful

interrelating, both as a form of coordination and as a way of regulating the adaptiveness of coordination efforts. These findings have important implications for improving crew training, leadership practices and possibly also standard operating procedures.

- **Keywords:** adaptive coordination; explicit coordination; implicit coordination; heedful interrelating; leadership; standardisation; task load; cockpit crews

T. Tiewtrakul ;S. R. Fletcher. *The challenge of regional accents for aviation English language proficiency standards : a study of difficulties in understanding in air traffic control–pilot communications. Pages 229 – 239.*

Although English has been the international aviation language since 1951, formal language proficiency testing for key aviation personnel has only recently been implemented by the International Civil Aviation Organization (ICAO). It aims to ensure minimum acceptable levels of English pronunciation and comprehension universally, but does not attend to particular regional dialect difficulties. However, evidence suggests that voice transmissions between air traffic controllers and pilots are a particular problem in international airspace and that pilots may not understand messages due to the influence of different accents when using English. This study explores the potential impact of 'non-native English' in pilot-air traffic control transmissions using a 'conversation analysis' technique to examine approach phase recordings from Bangkok International Airport. Results support that communication errors, defined by incidents of pilots not understanding, occur significantly more often when speakers are both non-native English, messages are more complex and when numerical information is involved. These results and their possible implications are discussed with reference to the development of ICAO's new language proficiency standards. **Statement of Relevance:** This study builds on previous work and literature, providing further evidence to show that the risks caused by language and linguistics in aviation must be explored more deeply. Findings are particularly contemporary and relevant today, indicating that recently implemented international standards would benefit from further exploratory research and development.

- **Keywords:** air traffic control communications; language proficiency; conversation analysis; aviation language; communication analysis

K. Wolfgang Kallus ; Peter Hoffmann ; Hildegard Winkler ; Elisabeth M. Vormayr. *The Taskload-Efficiency-Safety-Buffer Triangle : development and validation with air traffic management. Pages 240 – 246.*

The Taskload-Efficiency-Safety-Buffer Triangle (TEST) was developed as a new computerised scaling tool for quickly visualising changes in and trade-offs between the three critical factors that determine the work situation of air traffic management (ATM), i.e. taskload, efficiency and safety-buffers. Based on a task analysis of ATM and backed up by the stress-strain model, an easy-to-interpret triangle was constructed and validated both in simulated and real ATM workplaces. Results from the validation studies show that TEST does not only reflect the most relevant task characteristics, but also provides additional insights in the controllers' working styles. The TEST tool can make ATM safety surveys more efficient and help supervisors to decide about optimal times for opening or closing additional sectors. **Statement of Relevance:** TEST is a new tool to assess taskload, efficiency and safety-buffers in a joint scaling. It reflects increases in taskload and effects of taskload on safety-buffers and efficiency, as well as trade-offs in opposite directions. This tool might be very useful to check sector capacity in ATM and other high risk environments.

- **Keywords:** assessment of taskload; safety; efficiency; air traffic management; stress; strain

Marie Ward ; Nick McDonald ; Rabea Morrison ; Des Gaynor ; Tony Nugent. *A performance improvement case study in aircraft maintenance and its implications for hazard identification. Pages 247 – 267.*

Aircraft maintenance is a highly regulated, safety critical, complex and competitive industry. There is a need to develop innovative solutions to address process efficiency without compromising safety and quality. This paper presents the case that in order to improve a highly complex system such as aircraft maintenance, it is necessary to develop a comprehensive and ecologically valid model of the operational system, which represents not just what is meant to happen, but what normally happens. This model then provides the backdrop against which to change or improve the system. A performance report, the Blocker Report, specific to aircraft maintenance and related to the model was developed gathering data on anything that 'blocks' task or check performance. A Blocker Resolution Process was designed to resolve blockers and improve the current check system. Significant results were obtained for the company in the first trial and implications for safety management systems and hazard identification are discussed. **Statement of Relevance:** Aircraft maintenance is a safety critical, complex, competitive industry with a need to develop innovative solutions to address process and safety efficiency. This research addresses this through the development of a comprehensive and ecologically valid model of the system linked with a performance reporting and resolution system.

- **Keywords:** aircraft maintenance; performance modelling; performance improvement; hazard identification

Matt Ebbatson ; Don Harris ; John Huddleston ; Rodney Sears. *The relationship between manual handling performance and recent flying experience in air transport pilots. Pages 268 – 277.*

Modern jet transport aircraft are typically flown using the on-board automation by the pilot programming commands into the auto-flight systems. Anecdotal evidence exists suggesting that pilots of highly automated aircraft experience manual flying skills decay as a result of a lack of opportunity to practise hand-flying during line operations. The ability of a pilot to revert to basic manual control is essential, for example, in cases where the aircraft's automatic capability is diminished or when reconfiguring the automatics is an ineffective use of crew capacity. However, there is a paucity of objective data to substantiate this perceived threat to flight safety. Furthermore, traditional performance measurement techniques may lack the ability to identify subtle but significant differences in pilots' manual handling ability in large transport aircraft. This study examines the relationship between pilot manual handling performance and their recent flying experience using both traditional flight path tracking measures and frequency-based control strategy measures. Significant relationships are identified between pilots' very recent flying experience and their manual control strategy. **Statement of Relevance:** The study demonstrates a novel application of frequency analysis, which produces a broader and more sensitive analysis of pilot performance than has been offered in previous research. Additionally, the relationships that are found to exist between recent flying experience and manual flying performance will help to guide future pilot assessment and training.

- **Keywords:** decay; flying; manual; performance; pilot; simulator; skill

Andreas Mierau ; Michaela Girgenrath. *Exaggerated force production in altered Gz-levels during parabolic flight : the role of computational resources allocation. Pages 278 – 285.*

The purpose of the present experiment was to examine whether the previously observed exaggerated isometric force production in changed-Gz during parabolic flight (Mierau *et al.* 2008) can be explained by a higher computational demand and, thus, inadequate allocation of the brain's computational resources to the task. Subjects (n = 12) were tested during the micro-Gz, high-Gz and normal-Gz episodes of parabolic flight. They produced isometric forces of different magnitudes and directions, according to visually prescribed vectors with their right, dominant hand and performed a choice reaction-time task with their left hand. Tasks were performed either separately (single-task) or simultaneously (dual-task). Dual-task interference was present for both tasks, indicating that each task was resources-demanding. However, this interference remained unaffected by the Gz-level. It was concluded that exaggerated force production in changed-Gz is probably not related to inadequate allocation of the brain's computational resources to the force production task. **Statement of Relevance:** The present study shows that deficient motor performance in changed-Gz environments (both micro-Gz and high-Gz) is not necessarily related to inadequate computational resources allocation, as was suggested in some previous studies. This finding is of great relevance not only for fundamental research, but also for the training and safety of humans operating in changed-Gz environments, such as astronauts and jet pilots.

- **Keywords:** dual-task; force production; parabolic flight; reaction time; resources

Rebecca L. Wilson ;Helen C. Muir. *The effect of overwing hatch placement on evacuation from smaller transport aircraft. Pages 286 – 293.*

Overwing exits are installed on a number of smaller transport aircraft. With a traditional overwing exit, once released, the hatch is not attached to the fuselage and will fall into the cabin. To operate, the hatch has to be brought inwards, manoeuvred and placed in a location where it does not obstruct egress. Accidents and experimental studies have shown that the hatch is not always disposed of into an appropriate location. Evacuation trials from a smaller transport aircraft cabin were conducted. The placement of the exit hatch was manipulated. The results indicated that hatch placement had a significant effect on passenger evacuation rates from a smaller transport aircraft, with the internal placement tested resulting in slower evacuation rates. The study has highlighted the importance of operators disposing of the hatch into a location whereby it does not impede egress. One way to ensure this would be the installation of an automatically disposed hatch. **Statement of Relevance:** It is important that all occupants can evacuate an aircraft rapidly if required. The influence of overwing hatch placement on evacuation from smaller transport aircraft was addressed. Evacuation trials concluded that an inappropriately placed hatch can negatively influence evacuation rates. Improvements to exit design and passenger education were suggested.

- **Keywords:** aircraft emergency evacuation; smaller transport aircraft, overwing Type III exits; exit hatch placement

Steve Jarvis ;Don Harris. *Development of a bespoke human factors taxonomy for gliding accident analysis and its revelations about highly inexperienced UK glider pilots. Pages 294 – 303.*

Low-hours solo glider pilots have a high risk of accidents compared to more experienced pilots. Numerous taxonomies for causal accident analysis have been produced for powered aviation but none of these is suitable for gliding, so a new taxonomy was required. A human factors taxonomy specifically for glider operations was developed and used to analyse all UK gliding accidents from 2002 to 2006 for their overall causes as well as factors specific to low hours pilots. Fifty-nine categories of pilot-related accident causation emerged, which were formed into progressively larger categories until four overall human factors groups were arrived at: 'judgement'; 'handling'; 'strategy';

'attention'. 'Handling' accounted for a significantly higher proportion of injuries than other categories. Inexperienced pilots had considerably more accidents in all categories except 'strategy'. Approach control (path judgement, airbrake and speed handling) as well as landing flare misjudgement were chiefly responsible for the high accident rate in early solo glider pilots. **Statement of Relevance:** This paper uses extant accident data to produce a taxonomy of underlying human factors causes to analyse gliding accidents and identify the specific causes associated with low hours pilots. From this specific, well-targeted remedial measures can be identified.

- **Keywords:** gliding; glider pilots; accident; taxonomy; inexperienced; approach judgement; final approach