HILAS Flight Operations Research: Development of Risk/Safety Management, Process Improvement and Task Support Tools

Joan Cahill[1], Nick Mc Donald[1], Pernilla Ulfvengren[2], Franklyn Young[3], Yeray Ramos[4], and Gabriel Losa[5]

[1] Aerospace Psychology Research Group, Trinity College College Green, Dublin 2, Ireland
[2] Royal Institute of Technology, INDEK, KTH, Stockholm, S-10044 Sweden
[3] Rockwell Collins, Suttons Business Park, Reading, Berkshire, RGB, 1LA LK, England
[4] Facultad de Psicologia, Campus de Guajara S/N, La Laguna-Sta Cruz de Tenerife, 38205 Spain
[5] Iberial Airlines, PO Box E-28042, Azi Ni Barajas - Edif., Operaciones 114 Madrid, Spain
cahilljo@tcd.ie

Abstract. This paper reports on flight operations research, conducted as part of the work requirements for the Flight Operations Strand of the Human Integration into the Lifecycle of Aviation Systems (HILAS) project. Specifically, it presents a provisional framework for a suite of integrated Flight Operations tools developed in this research. It is anticipated that these tools will be used by different airline personnel to gather integrate, analyze and communicate data in relation to risk/safety management and process improvement. Further these tools will provide customized task support for different management and operational personnel.

Keywords: Flight Operations, Safety, Performance Monitoring, Risk Management, Process Improvement, Information Flow, Task Support, Human Performance.

1 Introduction

Given the continuing growth in passenger movement, there will be a doubling of air traffic within Europe by 2020 [7]. It is likely that this will lead to an increase in accident numbers. Unsurprisingly, this is unacceptable for the traveling public. Various explanations for air accidents have been propounded. Individualistic explanations focus on problems related to crew situation awareness [4], [5], task management [1], [6], crew co-ordination and communication, automation, fatigue and complacency. Systemic explanations concentrate on the different organizational factors which contribute to incidents and/or accidents. This includes commercial pressures, information failures [11], [12], poor safety culture, problems with training and process design and weaknesses in tool design. A review of specific accident reports suggests a conflux of individual and organizational factors.

Until recently, airline approaches to safety have reflected a reactive model (e.g. complying with regulatory requirements and prescribing measures to prevent the

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recurrence of undesirable events). Current models follow a more proactive safety management approach. According to the international civil aviation organization (ICAO), this is characterized by a number of factors including [9],

- The application of scientifically-based risk management methods
- Senior management's commitment to the management of safety
- A non-punitive environment to foster effective incident and hazard reporting
- Systems to collect, analyze, and share safety-related data arising from normal operations
- Sharing safety lessons learned and best practices through the active exchange of safety information

From ICAO's perspective, this is supported by the development of appropriate safety management systems (SMS), defining the required organizational structures, accountabilities, policies and procedures [9]. In this regard, most airlines have developed (or are in the process of developing) safety/risk management systems in accordance with regulatory guidance. This is complemented by the application of a range of system performance monitoring/evaluation tools. Currently, airlines use a range of paper and technology based tools to monitor and evaluate human performance (and by implication organizational/system safety). Feedback from these tools is used to direct system safety improvements (e.g. process/procedures re-design, enhanced training and so forth). Traditionally, these tools have divided into two types: those that focus on gathering human performance information using either self report or observer based methodologies (e.g. Air Safety Reports, Non Technical Skills Evaluation, Line Checks and Line Operations Flight Training) and those that focus gathering aircraft performance information (e.g. Flight Operations Quality Assurance). Crucially, these tools fail to provide a continuous picture of routine operations supporting predictive risk management. Further, the use of many discrete tools presents certain information management challenges. Much valuable data is gathered about the operation. Yet this data is gathered, analyzed and stored in different formats. As such, it is difficult to obtain an overall integrated safety/risk picture. Although useful from a data gathering perspective, these tools fall short of providing adequate data integration and analysis support. To this end, airlines are interested in developing tools which provide a continuous (and potentially real-time) picture of routine operations. Further, many airlines are focusing on improving knowledge integration both internally (e.g. within airline) and externally (e.g. with authorities, other airlines etc). As such, new technology concepts and information sharing practices are required to facilitate the gathering, integration, analysis and communication of all airline information (e.g. both commercial, operational and safety). From a safety management perspective, this will support the analysis of information related to ongoing management of operational risks (e.g. real time/tactical) and strategic safety/process improvement iniatives. Further, it is anticipated that this will improve airline safety culture (specifically in relation to the reporting and sharing of safety information).

In parallel, new cockpit technologies are being developed to improve flight safety. Supplemental flight information (traditionally presented in paper format and carried in the pilot's flight bag) is now being presented in digital format. This digital medium is termed the Electronic Flight Bag (EFB). Typical EFB functionality includes electronic maps and documents, performance calculations, ground/air messaging and crew reporting. Synthetic vision technologies are being developed to enhance Flight Crew situation awareness and assist with navigation guidance and control tasks. Also, task management tool concepts, providing real-time workload assistance are being advanced [6]. Further, research is also focusing on enhancing overall cockpit information management, given the volume of information provided to Flight Crew. From a theoretical perspective situation awareness is likened to information awareness. The safety issue (and design problem) becomes one of providing crews with the right information at the right time. In this regard, timeline based information displays presenting navigational information have demonstrated safety improvements [10].

Although these tools support flight safety, they are not linked to broader airline safety/risk management tools and processes. Arguably, little or no attention has been paid to the development of cockpit task support tools which enhance (a) real-time communication between Flight Crew and other operational roles, (b) provide performance feedback (e.g. both real time and after flight) and (c) embed crew reporting in Flight Crew tasks (linking to airline safety/risk monitoring and process improvement activities). This requires redress – flight deck and airline safety practices and technologies must be integrated.

In traditional industries the need for continuous improvements in products and processes is widely recognized. Typically, this is facilitated by the development of tools and methods to increase worker satisfaction along with organisational efficiency. Airlines need to develop lean and cost-effective flight operations processes in order to increase competitiveness, while maintaining or enhancing safety and reliability. Tools and methodologies are required to acquire human factors related information from the operators, and use this information to continuously improve the process. Research suggests that the design of such tools takes second place to continuous improvement behaviour itself. This involves a suite of behaviours which evolve over time rather than a single activity [2]. These behaviours cluster around several core themes - for example; systematic finding, solving of problems, monitoring, measuring processes and strategic targeting.

2 Introduction to HILAS Flight Operations Research

2.1 Introduction to HILAS

The Human Integration into the Lifecycle of Aviation Systems (HILAS) project is part of the Sixth Framework Programme for aeronautics and space research, sponsored by the European Commission. The HILAS project will develop a model of good practice for the integration of human factors across the life-cycle of aviation systems. The project contains four parallel strands of work: the integration and management of human factors knowledge; the flight operations environment and performance; the evaluation of new flight deck technologies, and the monitoring and assessment of maintenance operations [8].

The Flight Operations strand comprises seven European airlines, human factors researchers and technology partners. The critical objective of this strand is to develop and implement a new methodology for monitoring and evaluating overall system performance to support flight safety, operational risk management and process improvement.

2.2 Flight Operations High Level Research Plan

The flight operations research plan involves seven sequential research phases. These include:

- Phase 1: Identifying the high level requirements for the proposed system.
- Phase 2: Defining the user requirements for the proposed system.
- Phase 3: Building Version One toolset.
- Phase 4: Implementing/trialing Version One toolset with HILAS airlines.
- Phase 5: Building Version Two toolset, taking into account feedback from the different airline trials.
- Phase 6: Implementing/trialing Version Two toolset with HILAS airlines.
- Phase 7: Updating the tool framework and technologies and dissemination

Currently, phase two is nearly complete.

2.3 Overview of Phase One and Two Methodologies

The first phase of human factors research involved (a) an extensive literature review of state of the art performance monitoring and risk management tools, (b) airline process mapping (e.g. flight operations process), (c) interviews with safety and operational personnel and (d) flight operations observations. This resulted in the identification of the high level tool framework and objectives. The specific findings of phase one research have been reported in an earlier paper [3].

Phase two research involved more in depth Human Factors case studies with airline partners. HF researchers conducted extensive field research (e.g. interviews and observations) with operational and management staff involved in each of the airlines three Flight Operations sub processes. This includes flight planning, the active flight operation and the quality/improvement/safety process. In addition, technology partners conducted research in relation to airline technologies (e.g. platforms, message protocols and so forth) and tool integration requirements.

3 High Level Overview of Key Findings

This section presents a high level synthesis of field research findings with five partner airlines.

3.1 Overall Flight Operations Process Model

HILAS research shows that the Flight Operations process is structured into three related sub-processes: (a) Flight Planning, (b) Active Flight Operation and (c)

Quality/Safety/Improvement process.[1] Each sub process is divided into a series of process phases with specific critical points/states. The transition from one critical point/state (e.g. process state/aircraft state/information state) to the next requires the accomplishment of work both on an individual and team level. HILAS research indicates that Flight Operations is a complex and dynamic process subject to contingency. In this regard, the Flight Plan and associated flight context is managed by both back-office personnel (e.g. Flight Operations Control, Dispatch, Flight Planning), and front line personnel (e.g. Flight Crew, Co-ordinator, Cabin Crew, Maintenance) at different points in the flight operation. Critically, this research indicates that in certain cases, issues which arise in the active flight operation result from problems originating in the other two sub-processes (e.g. problems in the production of the flight plan, or problems handling safety or other operational feedback about specific flights/airports). This is in addition to a range of internal and external problems that can occur in real-time[2]. Crew interviews and observations suggest that some of these issues might be predicted before flight, and as such managed either before or during flight. Other issues are less predictable given the level of variability and complexity in the process. In relation to this, HILAS research suggests that there is no ‘normal’ operation, but rather a spectrum of operational and environmental complexity that constitutes normal. Further, research indicates that certain flights have higher levels of operational and environmental complexity, and for this reason may have a higher risk profile. To this end, these flights need to be managed carefully to mitigate risks.

3.2 Information Sharing/Knowledge Integration

Across the HILAS airline partners, it was noted that improved information sharing practices and technology would result in significant safety and process improvements. Overall, it was suggested that tools might facilitate both strategic and real time information sharing across the three flight operations processes. Interviews with a range of organizational functions/roles indicate that different organizational function/roles have information that is relevant to other organizational function/roles (inputs/outputs), but information sharing is not happening, or what is happening is not adequate. Participants noted that different organization functions/roles may require information in different formats, depending on the nature of their work/objectives. In relation to the production process (e.g. flight planning and active flight operations process), it seems that all roles would benefit from enhanced information sharing both from a task support and reporting perspective. Currently, it seems that information

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[1] From a production perspective, the flight operations process is divided into two sequential sub processes e.g. (a) flight operation planning process and (b) the active flight operation process. A third sub process (c) the change/improvement process is linked to the other two sub processes, but is a quality/improvement process. This sub process is ongoing and runs in parallel to the other two processes. The overall flight operations process links to other processes (e.g. the aircraft turnaround/technical signoff which is part of the active flight operation links to the Line Maintenance process - part of the overall Maintenance Process).

[2] For example problems that arise due to crew errors, organization problems that arise given changes to operational context (e.g. crew changes, aircraft changes) and external problems that arise in real-time (e.g. weather, traffic, ATC restrictions).

handover is weak. Further, there is poor understanding both individually and collectively in relation to role task information requirements and constraints. In relation to safety and improvement activities, formal methods (committee meetings, report writing, email) and informal methods (private conversations, email) were identified. Nonetheless, it seems that much important information sharing occurs informally. On the whole, the possibility of sharing information between different organization functions (both for purposes of task support and process improvement) was favorably perceived. It was noted that there would be certain organizational barriers to this (e.g. attachment to the old way of doing things, preference for informal process, people being protective/territorial about information given commercial issues etc). Further, many organizational barriers in relation to performance reporting were observed. In all airlines, Pilots noted that they were unlikely to provide feedback about their own performance, unless they had to (e.g. mandatory Air Safety Reports). Pilots clearly expressed the requirement for anonymous or confidential reporting. Pilots also noted that they are not motivated to report if they do not receive feedback about the status of their reports, or if it is perceived that recommendation are not given appropriate consideration by management. Lastly, Pilots observed that the have little time for reporting. It is anticipated that issues related to confidentiality might be handled by the development of appropriate data management/protection functionality in the proposed HILAS toolset. Further, data transformation requirements might be facilitated by specific data filtering and presentation intelligence. Moreover, clever task support technologies, easily accessible to crews might reduce reporting times. Management commitment to safety and the development of a non punitive reporting culture (e.g. confidential reporting systems) is also required.

3.3 Task Support (For All Users)

Research suggests that operational and management personnel across the three flight operations process require task support (e.g. Flight Crew, Cabin Crew, Co-ordinator, Safety Department, Flight Planning, Dispatch, Flight Operations Control, Maintenance and so forth). Task support involves supporting the safe, competent, effective and timely execution of individual and collaborative work tasks/activities in relation to the achievement of the operational goal (e.g. flight planning and flight operations process) and quality/safety activities (e.g. quality/improvement process). This requires the development of tools (both technology and non technology tools), to provide information relevant to the task performance, to share information about performance, to assist in task performance and to provide feedback.

3.4 Flight Crew Task Support

Flight Crew field research shows that Flight Crew operate in a multiple task environment. Critically, they act as a coordinating interface between multiple operational roles, with different and often conflicting constraints. Although Flight Crew tasks and workflow are structured according to the logic of the operational process/timeline, actual task demands and workflow vary according to context. In this regard, Flight Crew operate at the ‘sharp end’ of the operation and require considerable task support in terms of managing operational complexity and change. HILAS research suggests that Flight Crew task performance is shaped by the quality and availability of tools and information to hand. In this regard, Flight Crew would benefit from improved information sharing with a range of roles (e.g. Maintenance, Dispatch, Flight Planning and Flight Operations Control), both in relation to the management of operational risks, and specific collaborative task information inputs/outputs. Ideally, Flight Crew might obtain information about operational risks to be managed before flight (e.g. linked to Flight Plan). Further, Flight Crew might receive additional decision support from Operations Control, if their flight has a high risk profile, or if requested by Flight Crew. Jump seat observations of Flight Crew reveal that the quality and nature of information sharing with different operational roles varies according to social relations and context. Further, much information sharing is informal and opportunistic (e.g. Flight Crew ring Co-ordinator for flight updates using mobile phone). Flight Crew would benefit from performance feedback both in real-time and post flight. That said, this must not interfere with the primary task of flying the aircraft safely. Further, research indicates that there is limited time available for reporting. To this end, reporting should be embedded in the Flight Crew task and crews should only be required to report on safety critical events.

3.5 Process Improvement

In interviews it was clear that reporting is not an integral part of a Pilots everyday work. Yet Pilots have a lot to say about the operation and are not intimidated about speaking up. HILAS research suggests that the major barriers to reporting are lack of trust in management and insufficient time. Research suggests that reporting has the potential to be meaningful part of a Pilots job, given management commitment. All pilots agreed that they would consider reporting, if user friendly reporting tools were available during flight, and if management provided better feedback about the relationship between reporting and organisational changes. Therefore the organisation needs to:

- Regain Pilot trust (e.g. feedback from pilots is vital for process improvement).
- Handle incoming reports which facilitate learning and feedback to the operation.
- Give feedback upon receiving the report (e.g. make visible what happens with the information, how it is used and the importance of getting it).
- Clearly state who has mandate to make a change in what area.
- Give captains time during work to file reports.
- Communicate clear strategic goals and focus on improvements that are prioritised.
- Allocate resources for handling reporting and feedback process

3.6 Organizational Requirements and Culture

HILAS research suggests for the successful implementation of organisational improvement strategies, it is necessary to take into account the organisational and implementation culture. Organisational culture is manifested in shared values and meanings, and in a particular organisational structure and processes (e.g. policies, strategies, goals and practices, and leadership styles). To date, the research indicates that HILAS airlines reflect a spectrum of openness to change and innovation of rules and procedures. Significant differences were identified in relation to organisational identity, commitment to safety, safety culture and communication strategies. This will be taken into account in the trials of the proposed toolset.

4 Overview of Tool Framework and User Requirements

To date, HILAS field research findings have been translated into a high level tool framework and specific tool user requirements. The proposed HILAS system comprises four related tools (e.g. Tools A, B, C & D) – see table 1 below. All tools link to the operational process/risk model (integrating information across the three sub processes e.g. flight planning, active operational process and change/improvement process). Tools A, B and C are technology tools. Each of these tools has a specific remit in terms of the tool objective (e.g. process improvement, risk management and task support). Tool D is a non technology tool and refers to the organizational requirements for implementing Tools A, B and C within an airline. In particular, Tool D defines the information flow for other tools.

Table 1. Description of HILAS Tools A, B, C & D

Tool	High Level Function	Users	Device
A	Human factors tools providing (1) task support, (2) performance feedback and (3) reporting capability.	Crew, Cabin crew, Maintenance, Co-ordinator	EFB, PC in Office, PDA, Mobile Phone
B	Ground server and database supporting data integration – aircraft technical data and all relevant/obtainable flight/aircraft data.	N/A	N/A
C	Data analysis and reporting tool – supporting (1) risk analysis, (2) process improvement and (3) information flow analysis.	Safety,Training, Planning,Ops,Control, Maintenance,Fuel dpt	Workstation in office
D	Organisational System. This is the overall organisational system (not a technology tool). This tool defines safety management/process improvement procedures, roles and responsibilities.	All	N/A

Tools A and C feature a range of modules. The specific functionality of each module will vary according to user role and task, user location, point in flight operations process/timeline etc. In terms of the implementation trials, airlines might choose to implement a subset of these modules. Further, individual tool modules/applications can be modified by partner airlines in line with their technology maturity and organizational environment.

HILAS airlines are at different levels of technical maturity. Further, different airlines use a range of technologies to capture data/information. In this regard, the EFB provides a platform to facilitate ground/air communications and integrate information. In order to integrate data in a common database, the server storing the

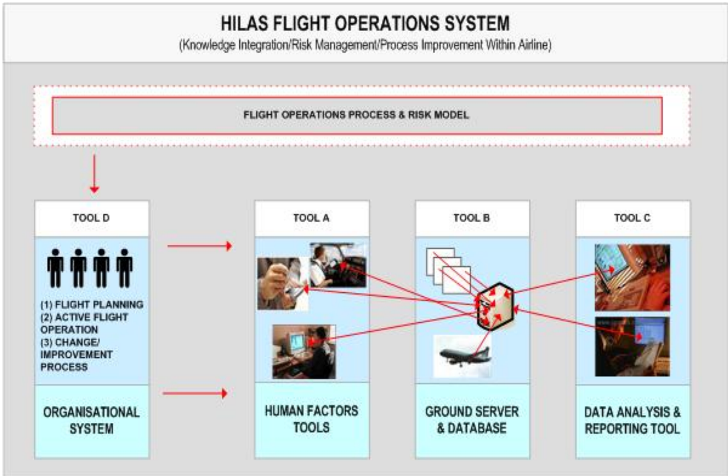

Fig. 1. HILAS Flight Operations Tools Information Flow

data will use a range of protocols to communicate with other airline systems/servers and the EFB. Data will be collected in a set of linked data records, which shall be described by a data model. The data model shall be designed to support the understanding of the system information flow at different points in the flight operations timeline – linking to the flight operations process/risk model.

5 Next Steps

The next steps involve defining the functional requirements for the proposed system (sub-set of user requirements) and developing each of the technology tools. Participatory design techniques will be used to develop the user interaction model and screen layouts for the different applications in Tools A and C. This will be conducted in parallel to application development. Also, simulations (using low and high fidelity prototypes) will be run to evaluate tool concepts. Further, additional organizational research will be conducted in relation to Tool D (e.g. organizational requirements for implementing Tools and constraints therein). Once complete, the tool-set will be trailed with partner airlines. Feedback will be elicited and a second trial conducted.

6 Conclusions

If Flight Operations is characterized by a level of risk/variability, then technology tools and organizational processes must be devised to understand the nature of these risks and identify when and how unacceptable risks/problems arise. In particular, tools must be developed to predict potential operational risks, so that safety critical events are avoided. This requires the development of knowledge integration/ information sharing tools to gather, integrate, analyze and communicate data in relation to real time aswell as strategic safety management/oversight. It is anticipated that the suite of tools developed in this research will facilitate this.

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