An European Approach to the Integrated Management of Human Factors in Aircraft Maintenance: Introducing the IMMS*

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Abstract. Previous research in aviation maintenance has highlighted the need to understand normal practice in order to advance the potential impact of Human Factors and bring aviation to a new safety level. What to do with this information then is crucial. What is presented here is an approach to do this, to use this information in such a way that it becomes key to safety and process improvement. This approach is currently being developed within the European funded HILAS project.

Keywords: Aviation Maintenance, Human Factors Lifecycle, Operational Process Model.

1 Introduction

The HILAS (**H**uman **I**ntegration into the **L**ifecycle of **A**viation **S**ystems) project is developing a model of good practice for the integration of Human Factors across the lifecycle 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. This paper reports on work carried out within the Maintenance Strand and the development of an Integrated Maintenance Human Factors Management System (IMMS).

1.1 Understanding Normal Practice

Human Factors has moved beyond analysing human fallibility and related performance deficits. It is increasingly addressing how people behave in normal operational contexts and how performance in such contexts can be better supported by design for use, by better planning and operational management and by quality and safety management systems.

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Methodologies such as NOTECHS (non-technical skills) [4] and LOSA (Line Operational Safety Audit) have developed out of this awareness. Researchers have gone further and argued that the reasons for the failure of Human Factors research to eliminate what Reason had referred to 10 years earlier as ‘latent pathogens’ was that people were not observant enough to the ‘softer issues’ that were happening in organisations and in particular to management’s ability to manage these softer issues (Westrum, 2001) [8.]. He argued that there was a need to begin to understand the dynamics of organisations at this level, a belief supported by Johnston [3], Pelegrin [5] and Troadec [6]. Recent research has confirmed this view that while Aircraft Maintenance Engineers (AMEs) are at the coal face of aircraft maintenance, and thus often of incident investigations, it is often these ‘softer’ issues and issues that are ‘upstream’ from this coal face that cause the problems and where Human Factors could potentially have a large impact ([7], [1]). Ward’s (2005) research across four aircraft maintenance organisations demonstrated, for example, that the softer issues are what affect people on a day to day basis [7]. Personal relationships and genuineness can facilitate performance and if trust is lacking between people and departments then sharing of information is difficult and work deteriorates.

1.2 Human Factors - A Lifecycle Approach

Understanding these issues is the first step, what happens to that knowledge is the second step. This requires an integrated approach, which systematically generates knowledge about the human aspects of the system at the operational end and transforms this ‘knowledge about’ into an active knowledge resource for more effective management and operational systems and better, more innovative, design. The challenge is to develop and demonstrate a model of Human Factors research, practice and integrated application, linking design and operation – in a ‘system lifecycle approach’. What is being proposed here is such a model of Human Factors.

Human beings are involved in all aspects of organisational life in some way or another. There is thus a lifecycle of application of Human Factor initiatives that follows this involvement throughout the organisation. Any Human Factors model needs to take this into account. However this is something that has been neglected in Human Factors over the years. Often Human Factor initiatives have focused on one or some aspects of this lifecycle, e.g. analysing incidents, creating awareness, making recommendations. Thus a lifecycle approach to the application of Human Factors needs to be taken moving right through the cycle from initial data gathering to implementation, change and innovation. Table 1 presents some of the elements that may go towards representing this lifecycle of the application of Human Factors in the organisation. These are broken into the following categories; task support, organisational learning and human resources, risk management and finally innovation. What needs to be explored is how current initiatives fit in with this lifecycle and then where any possible gaps might exist.

Table 1. Elements of a Human Factors Lifecycle

HF Role - general category	HF Role - lower level category	HF Role - specifics
Task support	Planning	Requirements, Documentation, Customised documentation / Personal notes, Allocation of tasks, How to do it, Overview of task planning
	Task Management	Anticipate critical path, Manage conflicting resources, Communication / information exchange in real time, Co-ordinate with parallel tasks, Management of parts / tools, Current technical data e.g. BITE Data
	Feedback	Sign-off task completion, Handover incomplete tasks, Review and/or report problems, Feed forward potential risk, Task surveys
Organisational Learning & Human Resources	Competence Requirements	Training needs, Initial training, Recurrent training, Embedded / OJT training
	Selection	Task descriptions, Competence Requirements, Assessment Scenarios, Career Framework
	Mentoring	Task and role models, Appraisal and feedback criteria, Learning Objectives, Problem focused support
	Performance Management	Performance indicators for individual and groups, Performance and process outcomes, Evaluation criteria, Establishing performance targets
	Partnership	Common framework for operational analysis (see also risk management), Communication forum, Agreeing programme of action, Implementation and review of action
	Feedback	
Risk Management	Gathering Normal performance data	Performance reports, Suggestions for improvement, Audits
	Gathering non-normal performance data	Incident reporting, Confidential reporting, Quality Discrepancy Reporting
	Managing data	Analysis and diagnosis, Risk assignment, Recommendations
	Decision process	Prioritising actions including CBA to meet competitive requirement
	Planning Change	Deriving requirements for operational change, Deriving requirement for HR development, Achieving consensus, Implementation plan, Developing mgt role to facilitate change
	Managing Implementation	Preparatory and supporting actions e.g. training, Monitoring implementation of decisions, Managing change process to maintain coherence
	Evaluating Change	Evaluation criteria, Reports on implementation progress, Assessment of change
Innovation	Managing Information to Requirements	Sharing Information, Transforming Information, Deriving Requirements
	Implementing Requirements in Design	Transforming HF requirements into system design requirements, Tracking Requirements in Design Process, Evaluation of prototypes / new design
	Certification	Evaluation of new applications of technologies

1.3 Objectives of the HILAS Strand Maintenance Project

The HILAS Maintenance Strand hopes to address some of the areas of the above lifecycle that may not be addressed with current Human Factor initiatives. Many

Human Factor tools and approaches have been developed in previous research projects, for example, AMPOS, AITRAM, ADAMS 1 & 2. HILAS will integrate these tools and add to them if necessary to provide a system that will manage as many of these functions as possible which manage the human component of the system. This system then needs to be evaluated including the effectiveness of the resulting impact on systems, processes and performance. A standardisation process across companies and countries will take place to explore how this system could provide a comprehensive means of compliance with current and future regulatory requirements.

1.4 Organisations Involved in the Research

All of this work is being carried out as part of the HILAS project which runs from 2005-2009 with 39 partner across Europe and China. The partners involved in the Maintenance Strand of the HILAS project are the outlined in Table 2.

Table 2. HILAS Maintenance Research Partners

Industrial Partners	Research Partners	IT Partners
Maintenance Organisations		
Adria Airways, Slovenia	CAUC, China	KITE Solutions, Italy
Atitech, Italy	CERTH / HIT, Greece	
Eurofly, Italy	ICCS, Greece	
SR Technics, Ireland	IFF, Germany	
Manufacturing Organisations	JRC, Italy	
Selex Communications, Italy	NLR, Netherlands	
Thales Avionics, France	TCD, Ireland	
Turbomeca, France		

2 The Integrated Maintenance Human Factors Management System (IMMS)

The following are some key objectives, that were agreed by all Strand partners in advance of a User Forum that took place in September 2006, of the system being developed – the IMMS. These objectives, while proving a challege and setting a large agenda for the IMMS, are what the Users have expressed as their need from the system.

- Improve operational performance; improve the functionality of tasks and processes
- Improve safety performance; reduce Human Factor related risks and increase Human Factor predictability of events
- Improve quality; improve innovation in processes, efficiency and effectiveness of processes
- Improve business performance; cost reduction, recoverability, new means of compliance.

2.1 Initial Design Considerations for the IMMS

It is hoped that the IMMS will work in a number of ways. Firstly through 'front applications' the IMMS will support and gather data from the Aircraft Maintenance Engineers (AMEs), Approved Engineers (AEs) and Inspectors working at the coal face of operations and also from all people engaged in the support of these. Thus there are two types of front application. The first (A1 in the Table 3) is for AMEs and will provide them with improved task support, through a portable handheld device, using new technologies such as Virtual Reality (VR) and Radio Frequency Identification (RFID). Additionally the 'Sensor' functionality of this front application will collect routine information on; task completion times, information sources consulted, track interruptions, etc. automatically. Short digital questionnaires will also be provided to consult AMEs during their work on Human Factor issues like experience, encountered problems etc. Front application A2 is for all of the support functions and will both provide information to them on how to manage the 'softer' aspects of managing the check and any problems encountered. It will also provide a means of allowing personnel to create an 'Alert' if anything is going wrong with the progress of the check to allow for better measures and contingency plans to be taken downstream and alleviate any potential problems that will arise as a result.

Component B (Universal Collector and Processing Engine) of the system will gather data from these two front applications and also data from currently operating systems within the organisation, for example, planning, engineering and quality systems. Component B will allow all of these system to talk to each other and will allow for interrogation and analysis of the data.

All of this data will feed into and continuously update Component C which is the suite of Human Factor Tools and Methods that will manage the human component of the system. These tools as noted above have been developed in previous research projects such as AMPOS, AITRAM, ADAMS 1 & 2 but will be presented here in a complementary suite and a common web environment. A core part of this Component C is the 'Operational Process Model'. Development on this model began in ADAMS2 and is continuing today, being populated by extensive fieldwork in the HILAS project and the TATEM project. Operational systems involve technologies managed by humans (directly or indirectly) to produce some transformation – in manufacture, transport or service. Such systems commonly function in ways which are quite divergent from their specified procedures. They are also quite resistant to change, and those who design such systems often do not understand how they are normally operated. Thus, if we are to be able to better design, manage or improve operational systems, we need to be able to construct models of those systems as they normally function. Such models should include the functional relationships between humans and technologies which enable the system to be activated. Key processes across the line, hangar and OEM operations are being modelled providing data on the normal technical, information and social relational processes of everyday operational life. This model will provide a means of structuring data and will enable the description and diagnosis of the operational system to support requirements for improvement and change in procedures, facilities, technology and human resources.

Finally Component D of the system is concerned with implementation on two levels, firstly on the level of implementing the actual recommendations that come out of the system and secondly with the implementation of system itself. Previous research has highlighted that it is often at the level of development and implementation of recommendations that Human Factor initiatives fail [7]. There can be an assumption that Human Factor issues are similar to Technical issues and can be dealt with in a similar manner, however this is not the case as usually they are much more complex. Special focus will be given to the development and implementation of recommendations and the tracking and monitoring of the success of the recommendations in dealing with the problem that they were meant to. The latter part of Component D will be dealt with in the next section.

These components of the IMMS are further outlined in Table 3 along with who will be the potential users of each aspect of the system.

Table 3. Components of the IMMS

IMMS	Front Applications	Users
A1	The 'Front Application' of the IMMS relevant to e.g. AMEs	Aircraft Maintenance Engineers, Approved Engineers, Inspectors Connection to other users: Needs to link with B & C
A2	The 'Front Application' of IMMS relevant to Operational Management and to Support functions, e.g Quality, Engineering, Planning etc.	Users: Operational Management Person power Scheduling and Positioning, HR & Personnel, Customer Relations Manager, Environmental Protection, Training & Learning, Knowledge Mgt, Quality, Operational Planning, Engineering, Safety Management System, HF Analysts, Supply Chain, Workshop, Strategic Planning OEM Users: To be defined Connection to other users: Needs to link with A & C

IMMS	Back Applications	
B	Universal Collector and Processing Engine	User – Administrator Connection to other Systems – A&B&D plus Financial systems, HR & personnel systems, Customer Relations Management Systems, Environmental Protection Management Systems, Training & Learning, Knowledge Mgt, Planning, Engineering systems, Safety Management Systems (including Risk Analysis / Management systems), Quality systems (event, incident reports, auditing systems), Supply Chain systems, Workshop Systems, Maintenance Systems - aircraft documentation systems, job performance data, job card system, MPD, Environmental Conditions, Flight systems, Airport Authority Computer Systems, OEM Systems
C	Suite of Human Factor Tools and Methods Operational Process Model	Users: Human Factor Analysts, Business Analysts Connection to other systems: C

IMMS	Organisational Support for Implementation	
D	Organisational Support for the Implementation of recommendations and the IMMS itself. Organisational Learning and Inter-Organisational Sharing of Information and Learning.	Users: Human Factor Analysts, Safety Management System, Quality Dept, Organisational Learning, Training, Business Analysts Connection to other systems: C

3 Organisational Support for Implementation

Component D of the system will also address the wider issue of organisational support. It was felt important to build this into the system and develop ‘system requirements’ for this as well in order to ensure that it was a priority throughout project development. Sometime issues around implementation can be left to the end of the project which is not sufficient to ensure success.

A key element of any organisational change is the existence of an appropriate organisational culture [2]. The following are necessary in order to evaluate the capacity of an organisational change:

- The theoretical concept of organisational culture should include both concrete and tacit aspects.
- Organisational as well as individual variables must be taken into account.
- The first stage of the culture and change research should include evaluating the organisational capacity to mobilise energy and commitment towards the change implementation.
- The type of change that will be implemented needs to be defined. This information will help to define what organisational and cultural dimensions need to be evaluated and the scope of the proposed implementation culture model. Specifically, two characteristics are important to be clarified: (1) The rate of occurrence; for example: discontinuous, incremental, continuous, etc. (2) More important, the type of change characterised by how it comes about; for example: planned, emergent, contingency or choice.

Also it is important to note that a change or Human Factors initiative often is a chance for people to have a ‘voice’. It gives people a chance to say how their work is going for them at the moment [7]. It is thus important in a change initiative to work through some of the existing problems first before embarking on the change initiative or else the initiative can become jeopardised by these existing problems. In order to do this the project is supporting the development and implementation of a systemic approach to learning, innovation and continuous improvement, based on best practice approaches to Organisational Learning enhanced by focused research and development in Human Factors. New knowledge and insights gained will feed into the Operational Process Model continuously creating a viable model of normal practice. This will also contribute to basic and applied Human Factors training.

4 Conclusion and Future Steps

What has been presented here is a high level overview of what we are trying to achieve within the Maintenance Strand of the HILAS project. The overall project has four stands and the objective of looking at the lifecycle of aviation (as opposed to the Human Factors lifecycle). To achieve this, the Maintenance Strand and the Flight Operations Strand have been working in parallel to develop a system that will have applications in both areas and feed forward into new design. The next step involves collaboration with Flight Operations to develop the System Requirements Specification for the elements that are common to both systems and then within Maintenance developing the System Requirements Specification for the other elements. The Knowledge Integration Strand of the project has played a crucial role in enabling this process.

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