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Human Factors Group: Engineering (HFG:E)

First Eleven – Design Organisation Guidance for Delivering Enhanced Human Performance in Maintenance

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Note: The views expressed in this paper are those of the author and not necessarily those of LR Scandpower or the Royal Aeronautical Society.

Overview

The "First Eleven" guidance is a set of practical and pragmatic steps to enable aircraft design and supplier organisations to deliver safer, more effective and reliable aircraft through improved design for maintenance. This guidance has been developed through consultation with the aviation industry and is applicable to design of components, systems and whole aircraft.

Aircraft safety and in-service maintenance performance can be significantly improved through integrating maintenance human factors (HF) principles into aircraft design and into the creation of appropriate engineering / maintenance documentation. Research shows that many aircraft incidents and accidents are caused or contributed to by maintenance errors that are induced or aggravated by aircraft design and technical documentation. Improved, user-centred design and documentation reduces maintenance error and its consequences.

Many design organisations already recognise that maintainability of their products can be improved through applying HF principles to reduce in the probability and consequences of maintenance errors, reduce lifecycle costs and improve operational reliability / availability. However, research by the HFG:E suggests that identifying practical steps to realise these benefits remains a significant challenge for many design organisations.

The First Eleven are a series of practical activities that a design organisation can take to effectively integrate maintenance HF principles into their designs and technical documentation. The activities are also intended to help organisations address the barriers to gaining buy-in across their organisation to deliver human-centred designs and procedures for effective and efficient maintenance.

The First Eleven are ordered in a general sequence for implementation that starts with foundation activities. Maximum benefit is possible if all principles are adopted. However, most activities can be implemented independently.

This guidance can also be used as the basis for an audit of an organisation's maintenance HF integration capability, either conducted internally or by an external organisation.

These are the 'First' Eleven because striving for enhanced maintenance human performance should be a continuously evolving process.

Note: The First Eleven activities were developed to address the common gaps found in many organisations that are a barrier to effective design for maintenance. However, other gaps and barriers will certainly exist, some that are unique to individual organisations, aircraft development programmes, or other design activity. In all cases, the First Eleven guidance may provide a baseline solution, but any intervention should be assessed to ensure all risks during design are effectively managed.

No.	Title	Guidance
1	Design Process Stakeholder Engagement	Identify appropriate engagement activities to develop buy-in from key stakeholders across the organisation for maintenance HF integration, including senior management / CEO
2	Design For Maintainability Policy Development	Generate a Design for Maintainability policy that defines how maintenance HF will be integrated into the design stream for products and supporting documentation (i.e. content, structure, formatting & delivery method). The Design for Maintainability policy should be based on a best practice model that identifies all aspects to be covered by the document, e.g.: - Applicable standards - Applicable regulations - Process owners, stakeholders (including customers) - Compliance with policy by suppliers - Processes and tools Processes may also include steps to identify effective solutions through a user-centred design process (e.g. flowchart defining user-centred design guidance and expert HF input as required) and design and technical documentation validation procedures. Consideration may also be given to in-service feedback processes for maintenance HF-related issues – these should involve design and technical documentation personnel to ensure rapid identification and generation of appropriate modifications.
3	Design Standards & Guidance Material Adoption / Development	Develop / select and adopt design standards for use by designers and maintainability engineers during design and design assessment processes to drive effective consideration of maintenance HF. The material must be usable by designers during day-to-day design activities. The implementation of standards must be supported by appropriate training at practitioner and management level. The guidance should include: - Prompts to identify design features that are a threat to reliable maintenance performance and personnel safety during maintenance within the reasonably foreseeable maintenance environment - Design solutions compliant with human factors and ergonomic principles appropriate for the aviation context

No.	Title	Guidance
4	Piggy-Back Process Identification	Identify common existing design processes (including those currently required by regulation), upon which maintenance HF processes can be piggy-backed or integrated into throughout the design process, including: - Concept - Design development - Design review - Maintainability assessment - Assurance / verification & validation - Procurement - Certification (e.g. common mode analysis, particular risk analysis)
5	Maintenance HF Design Training	Develop introductory training suitable to different levels and roles within the organisation that are owners or stakeholders of maintenance HF integration and technical documentation. Training should be delivered to stakeholders throughout the design supply chain (and be linked to the Design for Maintainability Policy - see Item 2). Minimum requirements are: - **"Introduction to Maintenance HF" course for designers**, including: Use of user-centred design principles, processes and standards; identification of maintenance error-inducing design and determining effective and appropriate mitigations; and means to access additional HF expert support where required - **"Introduction to Maintenance HF" course for technical documentation authors and managers**, including: use of user-centred documentation design principles, processes and standards; identification of maintenance error-inducing procedures and determining effective and appropriate mitigations; and means to access additional HF expert support where required - **"Introduction to Maintenance HF Management" course for engineering management**, including: Role and responsibilities for ensuring team capability to manage maintenance error risk through design; facilitation of effective maintenance error identification during designs; and understanding of the impact of design trade-offs on the reliability of maintenance performance
6	Maintenance HF Hazard Prioritisation	Develop a shortlist of critical systems and frequent / high-hazard maintenance error types. Use these to prioritise maintenance HF activities based on in-service accident and incident data from internal occurrence databases and industry sources

No.	Title	Guidance
7	Critical Component / Systems Identification & Analysis	Components and systems that provide critical functions should be identified for maintenance HF analysis. FMEA / expert review based methods should be advocated to identify critical systems as early in the design process as possible. Human error analysis (ideally exploiting maintenance task analyses developed for existing maintainability assessments such as maintenance cost estimation and maintenance manual development) should be used to identify potential maintenance errors and contributing factors. This analysis should be used to support the identification and development of economical and effective design changes
8	HF Integration into Technical Documentation	Develop / select, validate and apply technical documentation standards to support the development of user-centred maintenance documentation to facilitate reliable maintenance performance. Standards should support: - Processes underpinning the development of technical publications - Technical documentation content development in line with HF best practice - Technical documentation formatting standards for electronic and/or paper delivery that is appropriate for environments where the procedure will foreseeably be accomplished - Technical documentation delivery method selection that is appropriate for environment where the procedure will foreseeably to be accomplished The material must be usable by technical documentation authors. The implementation of processes and use of standards must be supported by appropriate training at practitioner and management level
9	User Testing	User testing should be conducted when design standards or requirements are not fully achievable and for any safety critical / high error risk systems or components
10	Maintenance HF Integration (HFI) Economic Cost / Benefit	Develop cost / benefit measures for maintenance HF integration over the design lifecycle and disseminate the output to key stakeholders (e.g. owners, operators, continuing airworthiness management organisations and maintenance organisations)
11	HFI Promotion	Integrate Design for Maintainability HF activities into product and capability marketing activities to promote the positive link between maintenance HF integration in design and operational performance, i.e. reduced error rates and consequences during maintenance and reduced aircraft lifecycle costs