CAP716 (Chapters only)
Aviation Maintenance Human Factors
(EASA / JAR145 Approved Organisations)

Guidance material on the UK CAA interpretation of Part-145 human factors and safety management requirements

Note: There may be very minor differences between this document and the published version.

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Explanatory note

This document is aimed primarily at organisations approved in accordance with Annex 2 (Part-145) of the Commission Regulation (EC) No. 2042-2003 "Continuing airworthiness of aircraft - previously JAR145. It is aimed at organisations approved by UK CAA Aircraft Maintenance Standards Department (AMSD), to help them meet the error management and human factors requirements within EASA Part-145 (originally introduced as NPA12 to JAR 145, and subsequently as amendment 5 to JAR145). It contains guidance material which, if applied appropriately within maintenance organisations, should help reduce the risks associated with human error and human factors, and improve safety.

References throughout the document will primarily be to "Part-145", which is the requirement, "AMC-145", which is the acceptable means of compliance, and "GM-145", which is guidance material. References will also be made to Part-66, Part-147 and Part-21, which are the parts of the EASA Implementing Rule (IR) equivalent to JAR66, JAR147 and JAR21. Occasional references are made to JARs for historical purposes, or where JARs are still current (eg. JAR-OPS). There are no fundamental differences between the JAR and EASA requirements, as far as the human factors elements are concerned.

This is a living document and will be revised at intervals to take into account changes in regulations, feedback from industry, and recognised best practices. This document was originally issued as the CAA Maintenance Human Factors Handbook, and subsequently published, in support of NPA12 to JAR145, as CAP 716 issue 1. It has now been up-issued to Issue 2, incorporating additional and revised guidance material based on industry experience obtained since JAR 145 amendment 5 was implemented on 1st January 2003. It is envisaged that the document will eventually be up-issued to Issue 3, once further best practice emerges with long term experience of working with the new human factors requirements.

Updates to this and other documents will be notified via the CAA website. You may register to receive automatic notifications of any updates by accessing www.caa.co.uk/publications and selecting "human factors". The document is free to download from the website, or printed copies may be purchased.

If you have any comments concerning this document, or any proposals for Issue 3, please pass them back to the CAA Aircraft Maintenance Standards Department, the address of which can be found on the website, or direct to the editor at osdhf@srg.caa.co.uk.

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Acknowledgements

Foreword

 CAP 716 provides guidance material for Part-145 approved organisations on how to apply human factors best practice in organisational processes and procedures.

A separate document, CAP715, written primarily from the perspective of the individual licensed engineer, addresses human performance and limitations, and is in support of Part-66 (module 9).

CAP 712 addresses safety management from an organisational perspective and describes the elements of a Safety Management System. The emphasis within CAP 716 is upon a human factors and error management programme which should form a significant part of an organisation's Safety Management System. Readers are encouraged to read CAP 712 in conjunction with CAP 716.

CAP 716 is written primarily for large aircraft maintenance organisations (Part-145 'A' rated organisations). The principles and practices described within this document are also likely to apply to engine and component maintenance organisations (Part-145 'B' and 'C' rated organisations), and other Part-145 approved organisations (category D). However, it is recognised that some of the guidance within this CAP will not be applicable to, or practical to apply in, some companies, particularly 'D' rated organisations and small Part-145 approved organisations. Companies should, therefore, be prepared to tailor the guidance material to suit the size of the organisation and nature of their business.

This CAP is structured around the main syllabus topics in EASA GM-145.A.30(e). However, the CAP is not written as a training text. It concentrates upon the elements of the human factors and safety management programme required by Part-145 and AMC-145, rather than the detailed human factors training requirement subject matter. The document could be used as a basis for training Module 10 of the GM-145.A.30(e) syllabus, and some of the other modules, but further source material would be needed in order to train the remaining syllabus topics. Potential sources of further information, including videos, are given in Appendix Z.

Glossary of Terms

AAIB	Air Accidents Investigation Branch
AANC	(US) Ageing Aircraft Inspection Validation Centre
ACJ	Advisory Circular (Joint) (JAA)
ADAMS	(Human Factors) in Aircraft Dispatch and Maintenance
ADREP	Aviation Data Reporting (ICAO)
AMC-	Acceptable Means of Compliance
AME	Aircraft Maintenance Engineer
AMSD	Aircraft Maintenance Standards Department (UK CAA)
AMT	Aircraft Maintenance Technician
AOG	Aircraft On the Ground
ASA	Aeroskills Alliance
ASAP	Aviation Safety Action Programme (US)
ASRS	Aviation Safety Reporting System (USA)
ATA	Air Transport Association of America
ATA	Aviation Training Association (UK)(no longer in existence)
ATC	Air Traffic Control
AWN	Airworthiness Notice
BASIS	British Airways Safety Information System
BASIS MEI	BASIS Maintenance Error Investigation
BCAR	British Civil Airworthiness Requirements
CAA	(UK) Civil Aviation Authority
CAAP	CAA Paper
CAIR	Checklist for Assessing Institutional Resilience
CAMC-	Canadian Aviation Maintenance Council
CAP	Civil Aviation Publication (UK CAA)
CASA	(Australian) Civil Aviation Safety Agency
CBT	Computer Based Training
cd	candela
CEO	Chief Executive Officer
CFS	Chronic Fatigue Syndrome
CMI	Computer Managed Instruction
CRM	Crew Resource Management
CRMI	CRM Instructor
CRMIE	CRM Instructor Examiner
DI	Duplicate Inspection
Dti	Department of Trade and Industry
EASA	European Aviation safety Agency
EC	European Commission
ECCAIRS	European Coordination Centre for Aviation Incident Reporting System
ERNAP	Ergonomics Audit Programme
ETOPS	Extended Twin Operations
EU	European Union
FAA	(US) Federal Aviation Authority
FAQ	Frequently Asked Questions

FEMA	Failure Modes and Effects Analysis
fL	footLambert
FODCOM	Flight Operations Department Communication
GAIN	Global Aviation Information Network
GM	Guidance Material
HAZOP	Hazard and Operability study/ assessment
HF	Human Factors
HFRG	(UK) Human Factors in Reliability Group
HRA	Human Reliability Assessment
HSE	(UK) Health and Safety Executive
IBT	Internet Based Training
ICAO	International Civil Aviation Organization
IEM	Interpretative/ Explanatory material (for JARs)
IES	(US) Illuminating Engineering Society
IFA	International Federation of Airworthiness
IFE	In-Flight Entertainment (systems)
IMIS	Integrated Maintenance Information System
IR	Implementing Rule
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement
JAROPS	Joint Aviation Requirement ([Flight] Operations)
LAE	Licensed Aircraft Engineer
LAME	Licensed Aircraft Maintenance Engineer
lm	lumen
LOFT	Line Oriented Flying Training
LOSA	Line Operations safety Audit
lux	lumens/m²
MARSS	Maintenance and Ramp Safety Society
MEDA	Maintenance Error Decision Aid
MEMS	Maintenance Error Management System
MESH	Maintenance Engineering Safety Health
MHF	Maintenance Human Factors
MHFWG	(JAA) Maintenance Human Factors Working Group
MM	Maintenance Manual
MOE	Maintenance Organisation Exposition
MOR	(UK) Mandatory Occurrence Report
MORS	Mandatory Occurrence Reporting System
MRM	Maintenance Resource Management (training)
NAA	National Aviation Authority
NASA	(US) National Aeronautics and Space Administration
NASA TLX	NASA Task Loading Index
NDI	Non-Destructive Inspection
NDT	Non-Destructive Testing
NPA	Notice of Proposed Amendment (for JARs)
NTSB	(US) National Transportation Safety Board
OEM	Original Equipment Manufacturer

OJT	On-the-Job Tuition
OMS	Occurrence management System
ORS	Occurrence Reporting System
OSHA	(US) Occupational Safety and Health Administration
PC	Personal Computer
PRA	Probablistic Risk Assessment
PSA	Probablistic Safety Assessment
REM	Random Eye Movement
ROI	Return on Investment
SA	Situational Awareness
SEMTA	Science, Engineering and Manufacturing Technologies Alliance
SHEL Model	Software, Hardware, Environment, Liveware
SHoMe	Safety Health of Maintenance Engineering (tool)
SIE	Safety Information Exchange
SMM	Shift Maintenance Manager
SMS	Safety Management Systems
SRG	Safety Regulation Group (UK CAA)
STAMINA	(Human Factors) Safety Training for the Aircraft Maintenance Industry
SWAT	Subjective Workload Assessment Technique
TC holder	Aircraft Type Certificate holder
TGL	Temporary Guidance Leaflet (for JARs)
TNA	Training Needs Analysis
TQM	Total Quality Management
TWA	Time Weighted Average sound level
UK HFCAG	UK Human Factors Combined Action Group
UK OTG	UK Operators' Technical Group
UK RAF SAM	UK Royal Air Force School of Aviation Medicine
VIRP	(US) Visual Inspection Research Programme

Chapter 1. Introduction

This document is aimed primarily at Part-145 approved organisations, to help them meet the Part-145 requirements concerning human factors. This UK Civil Aviation Publication (CAP) is <u>not</u> designed as study material for Part-66 Module 9, although there are some areas common to both Part-145 and Part-66. A separate document, CAP 715 "An Introduction to Aviation Maintenance Human Factors for JAR66", addresses the human performance and limitations aspects covered in module 9 of Part-66.

It is recommended that CAP 716 be read in conjunction with CAP712, "Safety Management Systems for Commercial Air Transport Operations", since human factors should be regarded as part of a Safety Management System for an organisation, and not as a separate, self-contained initiative. There are some common areas, in particular safety culture and safety data reporting, investigation, analysis and action.

CAP 716 is divided into three parts: (i) human factors organisational requirements in Part-145 (in particular, those introduced in amendment 5 to JAR145 - see Table 1) and how to meet them, (ii) guidance material on the maintenance human factors training requirements in Part 145.A.30(e), and (iii) appendices containing further guidance, background and reference information on human factors in maintenance, should this be required.

The emphasis is upon practical guidance material for real-world situations, acknowledging (but not condoning) the fact that sometimes people fail to comply with procedures, albeit often with the best of intentions. It recognises that organisations operate within a competitive commercial environment, and concentrates upon risk and error *management* rather than risk and error *elimination*.

An organisation can minimise its vulnerability to human error and reduce its risks by implementing human factors best practice described within the document. This will help enable the Part-145 Accountable Manager to meet his responsibilities as signatory to the Maintenance Organisation Exposition, which includes the company safety and quality policy, and to make sure that the company policies, processes and procedures, and their implementation, are effective in addressing the potentially high risk area of human factors.

Reference is made throughout the document to a "human factors programme". A human factors programme is something that every organisation should have in place on a permanent basis, as an integral part of their safety and quality management process.

It should be stressed that this CAP concentrates upon the potential implications of human error and human factors failings upon aviation safety and not on how human factors affects the individual's efficiency or well-being. However, if good human factors principles are applied within maintenance and engineering in order to improve safety, there should also be associated benefits that can be realised for the individual. It should also be stressed that this document addresses aviation safety, rather than the safety of the individual at work, although it is often the case that good practices for aviation safety will also be good practices for

health and safety, and vice versa. Note: there is separate guidance material published by the UK Health and Safety Executive which addresses human factors from a health and safety perspective[1].

All the principles described in this CAP are applicable to all Part-145 organisations (and certain sections are also applicable to JAROPS, Part-21 and Part-147 organisations). However, it is recognised that the mechanisms to enable these principles to be put into practice may differ in terms of their appropriateness to the size and nature of the organisation.

Table 1 A summary of human factors changes in Part-145, AMC-145 and GM-145 (for Part-145 approved maintenance organisations)

Human factors/ error management issue	Part-145 ref	EASA AMC-145 ref	EASA GM-145 ref
Facility requirements	145.A.25	145.A.25	
Manpower / man-hour plan	145.A.30(d)		
Competence in human factors*	145.A.30(e)	see below	
Human factors training for certifying staff	145.A.35(d)	145.A.35(d)	
Human factors training for all staff*		145.A.30(e)	
Human factors training syllabus*			145.A.30(e)
Availability of equipment and tools	145.A.40(a)		
Procedure for reporting poor or inaccurate maintenance data*	145.A.45(c)		
Availability of maintenance data	145.A.45(f)	145.A.45(f)	
Production planning*	145.A.47(a)	145.A.47(a)	
Production planning taking into account fatigue*	145.A.47(b)	145.A.47(b)	
Task and shift handover*	145.A.47(c)	145.A.47(c)	
Occurrence reporting and investigation*	145.60(b)	145.60(b)	
Safety and Quality policy*	145.A.65(a) 145.A.70(a)	145.A.65(a)	
Procedures to take into account human factors*	145.A.65(b)	145.A.65(b)(1)	
Design and presentation of procedures*		145.A.65(b)(1)	
Error capturing*	145.A.65(b)	145.A.65(b)(3)	
Signing off tasks*		145.A.65(b)(3)	
MOE additions*	145.A.70	145.A.70(a)	

* new or changed by amendment 5 to JAR145, 1/1/03

Table 2 A summary of human factors changes in Part-145, AMC-145 and GM-145 (for competent authorities)

Human factors/ error management issue	Part-145 ref	EASA AMC-145 ref	EASA GM-145 ref
Appropriate training	145.B.10	145.B.10(3)	

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[1] HSG65 Successful Health and Safety Management. 1997. HSE Books

Note: whilst the training requirement for competent authorities does not specifically itemise human factors training, the implication is that such training would need to be included since the requirements states that staff should "be appropriately qualified and have all necessary knowledge, experience and training to perform their allocated tasks" (Part 145.B.10).

Further Reading

1. Commission Regulation (EC) No. 2042-2003 "Continuing airworthiness of aircraft" Appendix 2 (Part-145, AMC-145, GM-145)

2. JAR145 amendment 5

3. JAA Maintenance Human Factors Working Group report (www.jaa.nl)

4. CAP 455 UK CAA Airworthiness Notices

5. CAP 712

6. CAP 715

7. ICAO. Human Factors Training Manual, Doc 9683-AN/950 (Edition 1 1998)(amendment 1, 30/9/03)

8. ICAO. Human Factors in Aviation Maintenance. Doc 9824-AN/450. (2003)

Chapter 2. Safety Culture and Organisational Factors

1. Introduction

An organisation with a good safety culture is one which has managed to successfully institutionalise safety as a fundamental value of the organisation, with personnel at every level in the organisation sharing a common commitment to safety.

One of the key elements is effective support from the top levels of the organisation, for safety. It is necessary for senior management to demonstrate their commitment to safety in practical terms, not just verbally or only as long as safety is a no-cost item. It is all very well for an organisation to commit to putting in place, for example, a safety reporting and investigation scheme but if such a scheme is not resourced properly, or if safety recommendations are not acted upon, it will be ineffective. It is also important that such commitment to safety is long-term, and that safety initiatives are not the first items to be cut in terms of financial support when the organisation is looking for cost savings. Safety management within an organisation should be addressed with as much commitment as financial management tends to be. CAP 712[2] describes the elements of a Safety Management System which should, if implemented properly and supported, lead to a good safety culture.

A good safety culture needs to be nurtured, and is not something which can be put in place overnight, or with a training course alone. It can be improved in the short term by putting staff through a training course dealing with the elements of safety culture. However, the improvement will only be sustained if the types of behaviours conducive to safety are rewarded and poor safety behaviour is not condoned, or even punished (in the extreme cases). This relies on staff at all levels within the organisation, especially middle management and supervisory levels, (i) recognising what good and bad safety behaviour is, (ii) good safety behaviour being encouraged, and (iii) poor safety behaviour being discouraged. Sometimes the opposite occurs in that staff are rewarded for cutting corners in order to meet commercial deadlines and, in a few cases, punished for complying with procedures (eg. refusing to sign off work which they have not had the opportunity to check[3]). This is characteristic of a poor safety culture. A good safety culture is based on what actually goes on within an organisation on a day-to-day basis, and not on rhetoric or superficial, short term safety initiatives.

It is possible to measure the safety culture of your organisation by using a safety culture questionnaire survey (Appendix M). Care should be taken with the timing of such a survey, in that it may be positively or negatively affected by specific recent events such as industrial action, training courses, etc. It is important to be sure that you are measuring behaviour, attitudes and fundamental beliefs, rather than morale.

Table 1. Key Elements Contributing Towards a Good Safety Culture.

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[2] CAP 712. Safety Management Systems for Commercial Air Transport Operations. June 2001.
[3] CHIRP reports

> - Support from the top
> - A formal safety policy statement
> - Awareness of the safety policy statements and buy-in from all levels within the organisation
> - Practical support to enable the workforce to do their jobs safely, eg. in terms of training, planning, resources, workable procedures, etc.
> - A just culture and open reporting
> - A learning culture and willingness to change when necessary
> - Corporate and personal integrity in supporting the safety policy principles in the face or potentially conflicting commercial demands

A more detailed description of the elements which contribute towards a good safety culture can be found in Annex G of CAP 712.

2. Maintenance Organisation Safety Policy

A company should establish a "safety and quality policy" (Part-145.A.65(a)). This should be part of the Maintenance Organisation Exposition. The safety policy should define the senior management's intentions in terms of commitment to ensuring that aircraft are returned to service after maintenance in a safe condition. Example safety policies can be found in Appendix F.

An organisation should list (ideally in the MOE) the processes which contribute towards safety, including (i) quality processes, (ii) reporting scheme(s) for defects, hazards, safety concerns, occurrences, quality discrepancies, quality feedback, maintenance errors, poor maintenance data, poor procedures, poor work instructions, (iii) appropriate training (including human factors training), (iv) shift/task handover procedures (see Table 2). The organisation should state how it addresses, or plans to address, these issues.

The accountable manager should be responsible for establishing and promoting the company safety policy. This safety policy should include a commitment to addressing the human factors elements within the organisation. In addition to defining top level responsibility, specific roles and responsibilities at other senior and middle management levels within the company should be clearly defined, with individuals being clear as to their roles in implementing the company safety policy. It is not realistic to place sole responsibility for safety on one individual, since safety is affected by many factors, some of which may be outside their control. However, it *is* realistic to place responsibility upon the accountable manager to ensure that the organisation has in place the training, processes, tools, etc. which will promote safety. If the accountable manager, and other staff to whom he has devolved responsibility for action, find themselves in a situation where commercial and safety priorities potentially conflict, they should remind themselves of the content of the organisation's safety policy which they have committed to support.

Table 2. Examples of items which should be listed in the MOE

> - Safety Policy
> - Manpower resources
> - Control of man-hour planning versus scheduled maintenance work

- Procedures to detect and rectify maintenance errors
- Shift/task handover procedures
- Procedures for notification of maintenance data inaccuracies and ambiguities to the type certificate holder
- Human factors training procedure

The wording of the safety and quality policy is important. The actual wording will probably vary between organisations. As a minimum, the policy should commit to:

- recognising safety as a prime consideration at all times
- applying human factors principles
- encouraging personnel to report maintenance related errors/ incidents without fear of automatic punitive action

In addition, it should include the need for all personnel to comply with procedures, quality standards, safety standards and regulations.

It is all very well having a policy which states all the right things, but all staff (senior management, certifying staff, mechanics, planners, stores staff, contractors, etc) have to actually subscribe to it and put it into practice in order to achieve the aims of having such a policy in the first place. Evidence[4] indicates that actual practice does not always reflect policies and procedures. Ultimately it is the responsibility of the accountable manager to see that practice, procedures and policies do not conflict. Double standards, where senior or middle management claim to require strict adherence to procedures by staff on the one hand, whilst 'turning a blind eye' or even unofficially condoning 'work-arounds'[5] (involving some form of procedural violation) on the other hand, are unacceptable. If the procedures are good, then staff should work to them and receive management support to do so; if the procedures are poor then it is the responsibility of management to try to improve them.

Senior management should also look closely at the performance indicators which they set, and which are set for them, and highlight any potential conflictions between these performance indicators and safety objectives. Performance indicators on which bonuses or penalties are set are more often commercially based than safety based, and may result in safety being compromised in order to meet performance targets.

CAP 712 (Safety Management Systems) states: "*The safety policies of a company define the senior management's intentions in safety matters. These policies document the fundamental approach to be taken by staff and contractors towards safety. The policies should be based on a clear and genuine Board-level commitment that, for the company, the management of aviation safety is paramount. To this is added a commitment to best practice and compliance with aviation regulations. The achievement of the policies can be implemented through suitable organisational arrangements and management systems. These provide the focus for all staff to enact their management's policies. The administrative arrangements that are in place for*

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[4] ADAMS report. www.tcd.ie

[5] "Work around" is the term used for situations where procedures are not followed to the letter; this will often (but not always) involved procedural violations.

Quality Management should be used to provide the audit and follow-up processes required by safety management."

3. An integrated approach to Human Factors and Safety

Human factors initiatives will be more effective if they are integrated within existing company processes, and not treated as something additional or separate or short-term. Human factors initiatives have sometimes failed in the past because they have been marginalised and regarded as a temporary 'fashion'. Much of human factors, in the context of maintenance organisations and Part-145 requirements, is common sense, professionalism, quality management, safety management – ie. what organisations should already have been doing all along.

The "human factors" initiatives in the context of Part-145 are really "safety and airworthiness" initiatives, the aim being to ensure that maintenance is conducted in a way that ensures that aircraft are released to service in a safe condition. The organisation should have a safety management system in place, many of the elements of which will need to take into account human factors in order to be effective.

Ideally, human factors best practice should be seamlessly and invisibly integrated within existing company processes, such as training, quality management, occurrence reporting and investigation, etc. Sometimes it is a good idea to re-invent an initiative under a new name if it has failed in the past, but you should be cautious about unnecessarily duplicating functions which may already exist (eg. occurrence reporting schemes / quality discrepancy reporting/ etc). It may only be necessary to slightly modify existing processes to meet the Part-145 human factors requirements.
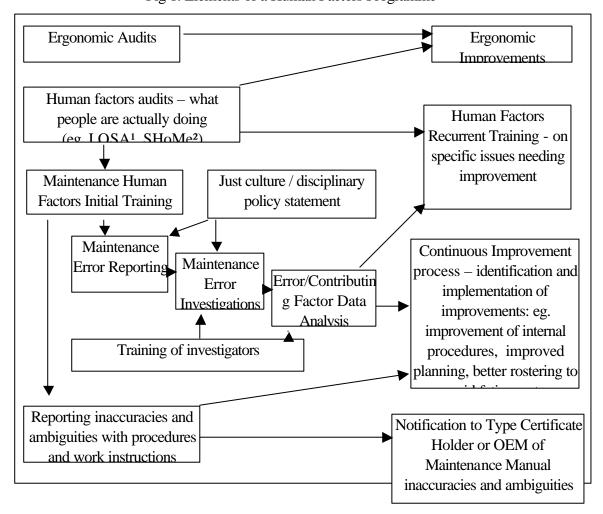
Human factors training is probably an exception to the advice given above, in that it is usually so new and different to any existing training that it warrants being treated as a separate entity, at least for initial training. Recurrent training, however, is probably better integrated within existing recurrent training. Human factors initial and recurrent training are discussed in Chapter 11.

Having stated that it doesn't matter what you call the initiatives, as long as they are done, this report will go on to refer to a "human factors programme" only in as far as it is a useful term to cover the elements which need to be established within an organisation to address human factors issues. The majority of these elements are addressed by Part-145 or the JAA MHFWG report.

4. Elements of a Human Factors Programme

Fig 1 (adapted from ATA Specification 113: Maintenance Human Factors Program Guidelines) shows how the various elements of a human factors programme should interact:

Fig 1. Elements of a Human Factors Programme

[1] LOSA - Line Operations Safety Audit
[2] SHoMe - Safety Health of Maintenance Engineering survey

The key elements of a human factors programme are:

1. Top level commitment to safety and human factors.
2. A company policy on human factors.
3. Human factors training (of all appropriate personnel, including managers - not just certifying staff).
4. Reporting, investigation and analysis scheme(s) which will allow reporting of errors, actual & potential safety risks, inaccuracies and ambiguities with Maintenance Manuals, procedures or job cards (not just those which have to be reported as Mandatory Occurrence Reporting (MOR)s).

5. A clear disciplinary policy stressing that genuine errors will not result in punishment.

6. Human factors and ergonomics audits / Line Operations Safety Audits (LOSA) (of workplaces, lighting, noise, tooling, adequacy of procedures, actual compliance with procedures, manpower, adequacy of planning, etc).

7. The resources and willingness to act upon the findings arising from occurrence reports and audits, and to provided fixes where appropriate.

8. A mechanism for reporting problems to the Type Certificate Holder.

9. A mechanism for ensuring that internal procedures and work instructions are well designed and follow best practice.

10. A means of providing feedback to staff on problems and fixes.

11. Abolition of any 'double standards' concerning procedural violations.

12. A policy for management of fatigue.

13. Motivation of staff to support the initiatives.

Health and safety would normally be considered separate[6] to human factors, at least in the UK, although there are many areas of overlap, particularly when looking at safety management from an organisational perspective.

5. Further reading

1. CAP 712 Safety Management Systems for Commercial Air Transport Operations. June 2001.

2. HSG 65. Successful Health and safety Management. 1997. HSE Books.

3. Eiff, G. *Safety Cultures: Missing the Mark*. 15th Symposium on Human Factors and Maintenance. 2001.

4. ADAMS report (contact Trinity College Dublin for details, or consult www.tcd.ie/aprg)

5. ATA Specification 113 for Maintenance Human Factors Program Guidelines

6. People, Practices and Procedures in Aviation Engineering and Maintenance: A Practical Guide to Human Factors in the Workplace. 1999

7. ICAO. Human Factors in Aviation Maintenance. Doc 9824-AN/450. (2003)

8. Maurino, D., Reason, J., Johnston, N., & Lee, R. Beyond Aviation Human Factors. (1995). Ashgate

9. Managing Maintenance Error. Reason and Hobbs. 2003. Ashgate.

10. Safety Management Systems. TP13739. Transport Canada.

11. Systems of Safety Management. CASA.

12. Managing the Risks of Organisational Accidents. Reason. 1997. Ashgate.

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[6] Health and Safety, and Aviation Safety and Human Factors, tend to be considered separately within the UK due to the fact that they fall under separate regulatory regimes.

Chapter 3. Errors, Violations and non-compliance with Procedures

1. Errors and Violations

A working definition of "human error" (including violations) is *"those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency"*[7]

It is useful to distinguish, right from the outset, the difference between "human error" and "system error". Whilst it is always a human being who commits the error, there are two approaches to looking at error: (i) from the point of view of the individual and (ii) from the point of view of the whole system, of which the individual technician is only one part. The concept of "maintenance error" is sometimes equated to "system error".

Another useful way of looking at error (and violations) is in terms of system component failure, where human actions are part of the system and need to be engineered such that they are resistant to error and, in the case of failure, error detection and alerting mechanisms built into the system.

People often think of "human error" as an erroneous action made by the last person to touch the aircraft before it went wrong! It may well be the case that there was an erroneous action on the part of a maintenance technician, but it is important to look at this in the context of the whole system and organisational factors which may have contributed to that error.

The reader is encouraged to read CAP 715 which contains a succinct description of types of errors and violations, or to refer to Professor James Reason's book "Human Error" for a more detailed description and discussion of the subject. A good understanding of the causes of errors and violations is necessary in order to address them. All too often, the 'blame and train' approach is used inappropriately to address error.

It is important to understand the root causes behind errors and violations, and whether an error is a 'one off' or a more systemic problem which may re-occur, and whether it is a problem with an individual technician or with the system.

Human Factors training will help individuals recognise the factors which may lead to errors and violations and to avoid error provoking situations and behaviour as far as possible. However, this can only have limited effectiveness without the whole maintenance system being designed to be error resistant, eg. well-written procedures, good planning, mechanisms for detecting and highlighting errors when they do occur, etc.

Human error is inevitable and can never be totally eliminated. The emphasis within a maintenance organisation should be upon pro-active error management. The processes and

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[7] Reason. Human Error. 1990. Cambridge University Press

mechanisms described within the CAP should help an organisation to better manage its errors, violations and error potential.

2. Non-compliance with procedures

Evidence indicates that maintenance personnel often fail to comply with procedures. Part-145 necessarily requires, and assumes, compliance with procedures, but also addresses some of the issues which lead to non-compliance (eg. poorly written procedures, unavailability of appropriate maintenance data or tooling, time pressure, etc).

There have been several studies looking at why people do not follow procedures. The results of one of these studies are summarised in Table 1.

Table 1: Why people don't follow procedures

"Procedures are not used because...		%agreeing
Accuracy	..they are inaccurate	21
	..they are out-of-date	45
Practicality	..they are unworkable in practice	40
	..they make it more difficult to do the work	42
	..they are too restrictive	48
	..they are too time consuming	44
	..if they were followed 'to the letter' the job couldn't be done in time	62
Optimisation	..people usually find a better way of doing the job	42
	..they do not describe the best way to carry out the work	48
Presentation	..it is difficult to know which is the right procedure	32
	..they are too complex and difficult to use	
	..it is difficult to find the information you need within the procedure	42
		48
Accessibility	..it is difficult to locate the right procedure	50
	..people are not aware that a procedure exists for the job they are doing	57
Policy	..people do not understand why they are necessary	40
	..no clear policy on when they should be used	37
Usage	..experienced people don't need them	19
	..people resent being told how to do their job	34
	..people prefer to rely on their own skills and experience	72
	..people assume they know what is in the procedure	70

Human Reliability Associates Ltd.

One of the reasons for procedural non-compliance identified in a recent European study[8] is that there are better or quicker ways of doing the job. Some of these methods may be safe; others may not. It is important to determine and document the best procedures, and to establish a situation whereby the best, quickest and safest way of doing the job is to follow

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[8] Aircraft Dispatch and Maintenance Safety (ADAMS)study, 1999.

the established procedures, abolishing the 'need' to work around procedures in order to get the job done.

Many procedural non-compliances are due to problems with the procedures themselves. These issues are addressed in Chapter 6.

3. Error reporting

It is an ICAO standard for all organisations involved in the design, production, operations and maintenance of aircraft to have an occurrence reporting system. Part-145.A.60 requires all Part-145 approved organisations to report occurrences meeting certain criteria[9] to the competent authority, state of registry and organisation responsible for the design of the aircraft. Whilst this requirement is primarily intended for technical problems affecting aircraft, it also extends to errors where these have resulted in "any condition of the aircraft or component....that has resulted, *or may result*, in an unsafe condition that hazards seriously the flight safety" (Part-145.A.60(a)). This could include, for instance, failure to refit O-ring seals when replacing chip detectors.

In any case, each Part-145 approved organisation is required to have in place a system for the reporting, collection and evaluation of occurrences, the aim being "to identify the factors contributing to incidents and to make the system resilient to similar errors" (AMC-145.A.60(b)(1)). This covers "any (potentially) safety related occurrence" (AMC-145.A.60(b)(2)), which means that the problem or error does not necessarily have to have resulted in an outcome meeting the criteria for formal external occurrence reporting. Organisations are not expected to report and investigate every minor error that occurs, but should have a procedure explaining what they would expect to be reported and investigated, and what they wouldn't. The procedure, or system, is likely to be two-tier, covering both internal and external reporting. The JAA MHFWG report refers to such a system as an "Occurrence Management System" (OMS). An alternative term which is often used is a "Maintenance Error Management System" (MEMS), although this term is generally applied to occurrences which involve, or are likely to have involved, human factors. Further information on MEMS can be found in Chapter 10.

It may sometimes be difficult to judge when an error warrants formal external reporting as an occurrence, or just internal reporting. The decision is up to the person in the company responsible or occurrence reporting, and should be based upon formal occurrence reporting criteria plus common sense in determining whether value may be gained from reporting externally. If in doubt, report the occurrence externally - what you may think is a 'one-off' error may be happening in other organisations, and could be a flaw in the design or Maintenance Manual.

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[9] as detailed in the EU Directive on Occurrence Reporting in Civil Aviation, (2003/42/EC)

4. Avoiding and capturing errors

Whilst the system should aim for error avoidance, it is not always possible to prevent errors from happening, in which case, the next best thing is to detect them and prevent them from resulting in harm.

The only sure way to be totally safe is to keep aircraft on the ground, but this is only an option in very extreme cases (where the safety regulator withdraws or suspends a company's approval because it has failed to comply with safety requirements). In normal operations, circumstances known to be vulnerable to error can often be avoided, or additional checks put in place to capture errors if they do occur. One example is work carried out when maintenance personnel are likely to be less alert, where the risks can be reduced if safety critical tasks are rescheduled for other times. Another example is where warnings can be printed on workcards where there have been previous incidents involving a particular task or procedure. It is particularly important to learn (from your quality system, MEMS, or feedback from human factors training, etc) which situations are particularly vulnerable to error, and to implement measures to guard against error in these areas.

Error capturing forms an important part of the safety net. There are many types of error capturing mechanisms, including functional checks, leak checks, inspection of tasks before signing for work done by others, independent Duplicate Inspections (DIs), pilot pre-flight checks, etc. AMC-145.A.65(b) highlights tasks particularly vulnerable to error, where special attention should be given to error capturing mechanisms. It does not specify what those mechanisms should be, and different countries and companies have their own preferred methods, eg. duplicate inspections are used by many UK companies as an error checking mechanism with respect to safety critical tasks.

Another mechanism, not so much for capturing error, but more to prevent repeated errors from having catastrophic failures, is that of disturbing only half the systems on an aircraft at any one time, where safety critical systems are involved. For instance, ETOPS principles stagger work on engines such that a similar error (eg. failing to close oil filler caps) would not occur on both engines at once[10]. Maintenance staff should be made aware in their human factors training that there are very good reasons for procedures such as these, and the importance of applying such error capturing and prevention mechanisms in maintenance.

4.1. Functional Checks

Functional checks are error capturing mechanisms in some instances since they will detect, if properly actioned, if something is not installed, secured properly, adjusted correctly or meets specified criteria in the manuals. This is true for most systems and is an inherent part of the maintenance process. It is, in the majority of cases, impossible to carry out a duplicate inspection on a flying control without a functions check since the range of movement, control stop clearances, control system friction or loading checks cannot be determined otherwise.

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[10] AN72

The problem is that since they are regarded as an inherent part of the system, complacency can set in concerning their purpose and value. It is only when the function checks or ground runs are not carried out and an incident occurs, (eg. the well publicised double engine oil loss on a 737-400 at Daventry, UK[11]) that their benefit in error prevention or error capture is properly realised.

It is important to carry out the functional check carefully, and to observe and note the consequences. There have been several instances where the actions of a check procedure have been carried out but not the observations. It is also important to carry out the check correctly. An incident occurred were the left hand stick in an aircraft functioned incorrectly due to a cross-connection error during maintenance. However, the functional check was carried out on the *right hand* stick, therefore failed to detect the problem, See Appendix D for further details of both incidents.

4.2. Duplicate Inspections

Duplicate Inspections are inspections where the task or process is performed by one person, a first check carried out by that person (if qualified to self-certify) or by a supervising certifying engineer, and then independent checks carried out by a second suitably qualified person. Both the first and second checks should be thorough and, in the case of control systems, ensure that they include functional checks for freedom and full range of movement.

There is no universally agreed list of tasks or points against which duplicate inspections should be carried out. Some National Authorities have requirements for duplicate inspections or required inspection items; others do not. This reflects the different perception of the value of duplicate inspections or simply a cultural belief, whether right or wrong, that the normal inspection process cannot fail. The tasks and criteria in Table 2 should help determine which tasks might warrant duplicate inspections.

It is important to consider (i) the criticality of the task and consequences of failure, (ii) the vulnerability of the task to human error (which might be determined by previous incidents, a risk assessment, etc) and (iii) the presence or absence of other checks (eg. functional checks). However, one should not assume that just because other checks are present in the procedures or aircraft systems, that they will be effective. It is generally better to have several mechanisms for detecting error and not to rely on just one, or to relax checks (eg. duplicate inspections) on the assumption that a problem will be detected by one of the other error detection mechanism (eg. pre-flight checks by pilots).

Table 2. Tasks which may warrant Duplicate Inspections[12].

- Installation, rigging and adjustments of flight controls
- Installation of aircraft engines, propellers and rotors
- Overhaul, calibration or rigging of components such as engines, propellers,

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[11] AAIB report 3/96

[12] JAR145 NPA-12. AMC--145.65(b)(4)(b)

transmissions and gearboxes
Note: this list is merely guidance and is by no means a comprehensive listing of all tasks which may benefit from a DI.

Avoid overuse of duplicate inspections. Overuse, combined with inadequate manpower, can result in checks being skimped and reduce the effectiveness of the duplicate inspection as an error capturing mechanism. It is easy to be lulled into a false sense of security simply because DIs have not found a mistake on a particular system or an individual has not previously made an error.

The UK CAA requirements concerning duplicate inspections are found in:
(i) BCAR A6-2 (A5-3 for vital points) and
(ii) CAAIP part 2, IL 2-13 Control Systems.
The latter describes best practice when carrying out duplicate inspections, and contains detailed information. The major points are summarised in table 3.

In many respects the onus of responsibility for determining what work requires a duplicate inspection rests with the certifying engineer. For aircraft manufactured more recently it has been a requirement that the manufacturer identify vital points in the aircraft and its systems. Such vital points are points or areas in the design where it has not been entirely possible to eliminate through design the possibility of failure by a single item or incorrect assembly. The philosophy is identified in BCAR A5-3 and whilst not specified it is felt appropriate that such vital points are the subject of independent inspections as if duplicate inspections were applicable.

Table 3   Duplicate Inspection 'best practice'

• Both parts of the duplicate inspection must be carried out by suitably qualified persons
• The second part of the duplicate inspection should be carried out by a person not involved in the original task
• Inspection and checks should be carried out thoroughly, and not influenced by any knowledge concerning the competence of the original technician who did the work of the certifying technician who carried out the first check. Thoroughness of inspection should not be interpreted as a lack of trust in the accuracy of the original work.
• It should take place as soon as possible after the task has been completed and the original inspection has taken place, with the dates and times of both inspections recorded.
• For control systems, the duplicate inspection should cover checks for full and free movement (freedom and range of movement).
• Measurements should be taken, eg. range of movement, clearances, tensions, operating performance, etc., compared against required figures (maintenance manual limits) and recorded.
• Avoid just recording "complied" or "satis" as results of checks; record the nature and extent of the movement or result of the inspection observed during each step of the check.

The effectiveness (or otherwise) of duplicate inspections has been debated at length. There have been several incidents where DIs have been ineffective and incidents or accidents have resulted. On the other hand, there is a great deal of evidence from communications with maintenance personnel[13] to indicate that DIs are effective in most cases. The evidence tends only to be anecdotal because occasions where problems have been picked up by a second independent inspection have invariably been rectified and therefore not resulted in an incident or formal report.

Concerns which have been expressed as to why DIs might not be effective are that (i) the technician may do the task less diligently if he thinks that someone else will check it and pick up any errors, (ii) over-use of DIs may result in the independent inspections being carried out less thoroughly, and (iii) the lack of finding errors or faults can introduce complacency. The results of the informal survey carried out by the JAA MHFWG during 2000 indicated that the first concern was not generally supported by industry experience or opinion and that, far from being *less* diligent, a technician was likely to be even *more* diligent if he knew that his work would be inspected.

In summary, an independent inspection is likely to be more effective than a second inspection carried out by the person doing the task. Duplicate Inspections are considered to be an effective mechanism for trapping errors, but should not be relied upon as the only mechanism since they are not always 100% successful.

4.3. Pilot pre-flight checks

Whilst not specifically intended as a mechanism for capturing maintenance errors, nevertheless pilot pre-flight checks should act as another barrier to prevent such an error from resulting in an accident. A well publicised incident involving an Airbus 320[14] at Gatwick where the spoilers were left in maintenance mode, might have been prevented had the pilots noticed that the flight controls were not responding correctly during the pre-flight checks.

4.4. Design for error resistance

This CAP will not go into detail concerning design for error resistance, since the document is not intended for designers and manufacturers. However, it is useful for maintenance personnel to be aware of where design improvements might be made, such that, if they have an opportunity to highlight poor design or areas where design might be improved, they should be encouraged to do so. An example of such an opportunity might be during an incident investigation, where there is scope for identifying design issues which contributed towards the incident or error, and/or potential design solutions.

Examples where design might be improved include[15]:

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[13] An informal survey was carried out by the JAA MHFWG during 2000.
[14] AAIB report 2/95 (see Appendix D)
[15] Courteney, H. Human Centred Design for Maintenance. 2000. 15th HFIAM Symposium.
hfskyway.faa.gov

- designing out cross-connectability, eg. by having parts which cannot physically fit incorrectly, colour coded parts, part numbers well labelled, staggered position of similar parts, leads that are too short to fit to the wrong connector, etc.
- cockpit warning lights for unlatched cowlings
- paint finishes and colours that aid in crack and flaw detection
- accessible inspection panels
- design such that it is obvious whether something is open or closed
- good use of placards
- guarding of moving parts or areas where snagging or chafing might occur

There are often known areas on certain aircraft where design provision for maintenance activities is not ideal. These need to be made known to technicians, both via training and by publishing warning notices in the procedures or information used by technicians on the job. It would be beneficial to share[16] such information between maintenance organisations.

It is important to feedback knowledge concerning poor design to the manufacturer in order that problems can be rectified or, if not feasible or economical, they can be highlighted in Maintenance Manuals and avoided in future designs.

The design of maintenance manuals themselves is also an area where improvements can be made. This is discussed further in Chapter 6 and Appendix S.

5. Further reading

1. Reason, J. Human Error. Cambridge University Press. 1990
2. Reason, J and Hobbs, A. Ashgate. 2003
3. Human-Centred Management Guide for Aircraft Maintenance: Aircraft Dispatch and Maintenance Safety (ADAMS). (2000)
4. CAP 715 An Introduction to Aviation Maintenance Human Factors for JAR66. 2001
5. ICAO. Human Factors in Aviation Maintenance. Doc 9824-AN/450. (2003)
6. AN72
7. BCAR A6-2; BCAR A5-3
CAAIP part 2, IL 2-13

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[16] See www.chirp.co.uk/mems for further details of the UK industry data sharing initiative (and Appendix L)

Chapter 4. Factors Associated with the Individual

1. Introduction

CAP 715 addresses human performance an limitations, therefore this chapter will not go into too much detail in these areas except where topics are particularly relevant to organisational human factors (eg. taking into account fatigue when planning maintenance tasks), or to specific requirements in Part-145.

Error and violations, whilst factors associated with the individual, are covered separately in Chapter 3, but again from an organisational perspective rather than from a theoretical human performance and limitations perspective. Further information on the theory of error may be found in CAP 715.

Generally when we talk about factors associated with the individual, we are talking about influences which may lead to a person making errors or mistakes. These factors can be both internal and external, and include influences such as physical fitness, fatigue, stressors, noise, distraction, etc. There are also factors which may possibly be associated with violations, such as personality type, assertiveness, etc.

Factors potentially influencing performance include:
1. Physical fitness
2. Physiological characteristics such as visual acuity, colour vision, hearing, etc.
3. Personality
4. Attitude, professional integrity, motivation
5. Arousal level, low arousal (boredom), excessively high arousal (stress), stressors
6. Alertness, fatigue, tiredness, shiftwork, sleep, circadian rhythms
7. Distractability, attention span, concentration, multi-tasking ability, situation awareness
8. Information processing capability, memory, perception, intelligence
9. Knowledge level, awareness of knowledge level, experience, recency
10. Cultural influences, company culture, national culture, norms

Further information concerning most of these factors may be found in basic textbooks on human factors and psychology and in CAP 715. However, a couple of the topics are discussed in greater detail below (and in the associated appendices), where they are particularly pertinent to organisational human factors and safe operations.

2. Fitness for Work

Certifying staff working on a JAR66/Part-66 license "*must not exercise the privileges of their certification authorisation if they know or suspect that their physical or mental condition renders them unfit to exercise such privileges*". This includes blood-alcohol level, drugs & medication, eyesight, colour vision and psychological integrity.

Worthy of particular mention is that there is now UK legislation[17] in place to allow police to conduct drink and drugs tests on anyone performing a safety critical role in UK civil aviation, including flight crew, air traffic controllers and licensed aircraft engineers. The limit for aircraft maintenance engineers is 80 milligrams of alcohol per 100 millilitres of blood, ie. the same as the blood/alcohol limit for driving a car.

Readers are referred to Appendix N which contains a copy of AN47. Note: AN47 may be updated from time to time therefore readers are advised to consult CAP 455, or the CAA website, for the latest issue of AN47.

3. Shiftwork and fatigue

Fatigue has been reported as one of the factors contributing towards maintenance errors.

Part-145 requires planners to take into account human performance limitations when organising shifts and planning work. AMC-145.A.47(a) includes "scheduling of safety critical tasks during periods when staff are likely to be most alert" as one of the items which should be taken into account during planning. The AMC also states that "Limitations of human performance, in the context of planning safety related tasks, refers to the upper and lower limits, and variations, of certain aspects of human performance (circadian rhythm/ 24 hour body cycle) which personnel should be aware of when planning work and shifts."

The JAA MHFWG report provides some limited guidelines for minimising fatigue and its impact. More comprehensive guidance is also provided in Appendix P of CAP 716, and in CAP715.

The UK implementation of the EU Working Time Directive applies to the majority of aviation maintenance personnel (non-mobile workers) and provides working time limitations including limits on:
- maximum hours per week (48)
- night work
- rest time and holiday

However, staff may agree to opt out of these limits under certain circumstances and to work longer hours if they wish. Further details are given in Appendix P, but readers are referred to the primary legislation for definitive information. Note: It should be remembered that the EU Directive was based upon health and social needs, and not upon aviation safety needs.

The CAA recently sponsored a study concerning best practice for shiftwork and work hours. This study was carried out by Professor Simon Folkard, and the results have been published in CAAP 2002/06 "Work Hours of Aircraft Maintenance Personnel" (March 2003), and are summarised in Appendix P.

At the time of writing this document, Transport Canada were in the process of drafting an NPA on management of fatigue within the context of a Safety Management System. Further details will be available, in due time, on www.tc.gc.ca.

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[17] http://www.railways.dft.gov.uk/safetybill/pdf/safetybill.pdf

Fatigue and shiftwork are discussed further below, much of the information having been extracted and adapted from some of the sources referenced in Appendix Z.

3.1 Fatigue

The term 'fatigue' has many meanings[18] and can include *physical* fatigue (eg. muscle soreness, oxygen debt, or extreme tiredness caused by sleep deprivation, illness or poor nutrition), *mental* fatigue (eg. associated with tasks demanding intense concentration, rapid or complex information processing and other high level cognitive skills) or *emotional* fatigue (the wearying effect of working under trying conditions or performing psychologically disagreeable tasks). There is often no clear distinction between these types of fatigue, and it is probably more useful to look at fatigue in terms of the various criteria by which it is recognised.

The concept of fatigue is more easily understood through common experiences than through quantitative research. It is not possible to measure fatigue directly, as one might measure blood pressure or the length of a person's hand. Fatigue is indirectly measurable through its effects. For example, you can measure the number of errors committed per unit time on a particular task. If the person doing that task continues without rest long enough, the number of errors he or she commits increases. At some point, you would conclude that the person is fatigued. Working long hours, working during normal sleep hours, and working on rotating shift schedules all produce fatigue-like effects, although the mechanisms are different for each situation.

Symptoms of fatigue (in no particular order) may include:
- a lack of awareness
- diminished motor skills
- diminished vision
- slow reactions
- short-term memory problems
- channelled concentration - fixation on a single possibly unimportant issue, to the neglect of others and failing to maintain an overview
- easily distracted by unimportant matters, or, in the other extreme, impossible to distract
- increased mistakes
- poor judgement
- poor decisions, or no decisions at all
- abnormal moods - erratic changes in mood, depressed, periodically elated and energetic
- diminished standards

AWN 47 (Appendix N) provides the following advice concerning fatigue:
"Fatigue: Tiredness and fatigue can adversely affect performance. Excessive hours of duty and shift working, particularly with multiple shift periods or additional overtime, can lead to problems. …Individuals should be fully aware of the dangers of impaired performance due to these factors and of their personal responsibilities."

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[18] Stokes, A., Kite, K. Flight Stress: Stress, Fatigue and Performance in Aviation. 1994.

Table 2. Fatigue management

Shift personnel fatigue may be minimised by:
- Avoiding excessive working hours
- Allowing as much regular night sleep as possible;
- Minimising sleep loss;
- Giving the opportunity for extended rest when night sleep has been disrupted;
- Taking into account reduced physical and mental capacity at night;
- Taking into account individual circumstances;
- Providing organisational support services;
- Giving the opportunity for recovery.
- Rotating shifts toward the biological day, i.e., rotate to later rather than earlier shifts.
- Minimising night shifts through creative scheduling
- Providing longer rest periods following night shifts
- Within a week providing longer continuous rest periods when the week includes more than 2 night shifts

The impact of fatigue may be minimised by:
- Allocating more critical tasks during day shifts when staff are likely to be more alert
- Ensuring that appropriate checks are carried out after night shift work
- Breaking up lengthy repetitive tasks into smaller tasks, with breaks in between

The best cure for acute fatigue is sleep - and this means restful sleep, not disturbed by the effects of alcohol or caffeine. Chronic long-term fatigue may take longer to eliminate, and may require professional advice.

3.2 Shiftwork

The central problem in aviation maintenance is that many, perhaps most, routine tasks are performed during night-time hours, when people are more prone to errors, so that the aircraft can fly and produce revenue during the daytime. In addition, maintenance tasks often span more than one shift, requiring information to be passed from one shift to the next. Shift handover is the source of many errors.

The length of each work period also affects the error-producing effects of fatigue. In some industries, work periods are longer than in others. For example, workers in nuclear power plants are commonly scheduled to work 12-hour shifts. Whilst longer shifts may result in greater fatigue, the disadvantages may be offset by the fact that fewer shift changeovers are required (ie. only 2 handovers with 2 twelve hour shifts, as opposed to 3 handovers with 3 eight hour shifts). However, if personnel rotate between shifts, shorter shifts may allow for greater flexibility in shift rotation, than longer shifts.

There is a great deal of research on shiftwork and what are good and bad shifts from the purely scientific perspective. However, one must take into account the whole context when considering shift patterns, including what is acceptable to the staff and management within an organisation, the trade-off between length of shift and number of handovers, the pattern of

work to be done, etc. There is no single ideal shift system. Organisations must select whatever shift system is most appropriate to the company and staff, but should take into account the scientific advice which is available.

The EU Working Time Directive states:
"*..research has shown that the human body is more sensitive at night to environmental disturbances and also to certain burdensome forms of work organization and that long periods of night work can de detrimental to the health of workers and can endanger safety at the workplace.*"

The connections among shiftwork, morale, productivity and safety are not simple. The shift patterns which would appear to be the best 'scientifically', may be unpopular among workers and the poor morale which may arise if these are implemented may outweigh the benefits to the individual in terms of physiological adaptation. However, safety should always be the overriding factor when choosing shift patterns and rosters, taking into account all possible factors which may affect vulnerability to error. It is important that organisations and shift workers fully appreciate this.

From a human factors perspective, we are especially interested in shift- and schedule-related problems that are reflected in degraded maintenance performance. Listed below are some of the most common issues and problems which may occur. It is stressed that these issues and problems are neither necessarily nor entirely caused by shiftwork or scheduling. Many work-related and personal factors can contribute to most of the items described below.

- Higher Absentee Rate
    Particular shifts and schedules can cause workers to be away from work more often than people who work on more "normal" schedules. There are several factors that contribute to higher absenteeism. Shift workers tend to have more health problems than non-shift workers. A fairly innocuous cold, when coupled with the increased fatigue due to night work, can cause increased use of sick leave. Family-related issues, such as childcare and companionship, can cause workers to take short periods of time off. More serious incidents, such as an extended sickness in the family, can force shiftworkers to juggle their personal and work lives.

- Higher Error Rate
    Elevated error rates are directly associated with mental and physical fatigue. Shiftwork and shift schedules can contribute to fatigue by disrupting normal wake-sleep cycles, forcing extended working hours, and increasing personal and family-related stress. The first abilities to be compromised by fatigue are those related to cognitive processing, decision making, and judgement. Unfortunately, these are the very abilities that come into play when making safety-related maintenance decisions. In addition, the fact that aviation maintenance organisations tend to be 24-hour operations means that some tasks are inevitably distributed across multiple shifts. Poor shift turnover procedures, especially the communication aspect of shift turnover, has been implicated in a number of serious aviation accidents. The fatigue

that accompanies working on the night shift causes shift handover procedures to assume added importance.

The unavoidable fact is that most aviation maintenance occurs during night-time hours, which we know to be especially conducive to human error. There is nothing we can do to fundamentally alter human physical and psychological responses to night work, at least in the long term. We should expect, therefore, to experience many human errors and must tailor our procedures to provide ample opportunities to catch and fix these errors before they affect our workers or the flying public.

- Physical and Psychological Problems

    There are many studies linking shiftwork, especially rotating shiftwork and especially working at night, to a variety of physical, emotional, and psychological problems. Because aviation maintenance workers tend to be permanently assigned to a specific shift, it is reasonable to be concerned about the long-term effects of night work. Unfortunately, we have very few answers in this regard. We can't even say with certainty that working on the night shift causes the problems with which it is statistically associated.

    About the best we can do to address this issue is to provide coping processes that allow night-time workers to maintain a semblance of normal sleeping patterns and then closely monitor their physical and psychological conditions.

- Increased Injuries

    Most athletes understand that their risk of injury increases when they are tired or not paying attention. This is also true for industrial workers. Just as cognitive (thinking) errors increase with increased fatigue, so do physical errors, which result in personal injuries. All of the elements that we described above, such as loss of judgement, contribute to the increased likelihood that a worker will be injured.

- Dissatisfaction and Poor Morale

    The combination of long hours, disrupted wake-sleep cycles, increased instances of domestic conflict, and higher workloads is an obvious source of poor morale and dissatisfaction among shift workers. As a performance shaping factor, emotional issues are potent causes of poor job performance.

- Lower Productivity

    One of the primary reasons for working on shifts and longer hours on each shift is to utilise human and capital resources more efficiently. For example, expensive hangar and maintenance equipment isn't earning a return if it is idle. Also, working slightly longer shifts reduces the amount of non-productive time at the beginning and end of each shift. It is somewhat ironic that engaging in a practice that can increase productivity when used sparingly can actually decrease productivity when used excessively. To use an extreme example, people cannot produce twice as much output if they work 24 instead of 12 hours. Planning and production managers should take this into account.

- Higher Attrition Rate

Humans can only take so much physical and mental stress. Many workers may opt to simply go elsewhere rather than endure a shift schedule that causes constant fatigue and family stress. It is costly and wasteful to lose skilled aviation maintenance workers.

4. Fatigue and shiftwork models

A few models have been developed, based on sound scientific principles and research, which attempt to highlight when workers are likely to reach unacceptable levels of fatigue. They generally require, as an input, roster details. The model developed by the Centre for Sleep Research (University of Southern Australia) is one example. Further details can be obtained from *www.unisa.edu.au/sleep* and a demonstration copy of the fatigue model can be downloaded from *http://www.interdyne.com.au.*

There is also a CAA sponsored[19] fatigue model which has been developed by the Centre for Human Sciences, at QinetiQ, primarily for flight crew. The "System for Aircrew Fatigue Evaluation" may also be applicable to ground personnel, but at the time of writing this document, the model had only been applied to, and validated on, flight crew and flight operations, nor had it yet been formally released for use.

5. Further Reading:

1. CAP 715
2. AN 47
3. ICAO Human Factors Training Manual - Doc 9683-AN/950. 1998
4. Folkard, S. "Work Hours of Aircraft Maintenance Personnel" CAAP 2002/06 March 2003. CAA.
5. Directive 2003/42/EC of the European Parliament and of the Council of 13 June 2003 on "Occurrence reporting in civil aviation", published in the Official Journal of the EU on 4/7/2003.
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9. Morgan, D. Sleep Secrets for shift workers and people with off-beat schedules. 1996 Whole Person Associates
10. Shift Wise: a shiftworker's guide to good health. Transport Canada. TP11658E. March 1993
11. CSR. Learning from others [shiftwork case studies]. University of South Australia. Centre for Sleep Research. www.unisa.edu.au/sleep
12. CSR. Living with Shiftwork. University of South Australia. Centre for Sleep Research. www.unisa.edu.au/sleep

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[19] Contact the CAA Research Management Department for further details.

13. CSR. Understanding Shiftwork. University of South Australia. Centre for Sleep Research. www.unisa.edu.au/sleep

14. Fatigue management model – free demonstration version downloadable *http://www.interdyne.com.au*

15. System for the Evaluation of Aircrew Fatigue (SAFE) - contact CAA Research Management Department for further details.

16. Anon. Better Shift Systems? article in the Chemical Engineer, 11 September 1997, based on the work of Ronnie Lardner (Keil centre) and Bob Miles (HSE)

17. Caldwell, J.L. Managing Sleep for Night Shifts requires Personal Strategies. Flight Safety Foundation, Human Factors and Aviation Medicine, v46, No.2, March-April 1999

Chapter 5. Environmental Factors, Tooling and Ergonomic Audits

1. Introduction

Part-145 makes certain provisions in terms of facilities and work environment, although guidance tends to be general rather than specific. The requirements and associated AMC-s are summarised in table 1.

Table 1. Facility requirements (Part-145)

Hangars	should be available for base maintenance; optional for line maintenance, but hangar availability during inclement weather is recommended. Hangars should be large enough to accommodate aircraft on planned base maintenance.
Protection against contaminants	minimised to below visible level.
Temperature	adequate for personnel to carry out work without undue discomfort
Lighting	adequate to ensure each inspection and maintenance task to be carried out
Noise	below distraction level, where possible; otherwise below distraction level with ear plugs/ ear muffs.
Equipment/ tools	all equipment, tools and material should be made available when needed.

There has been a great deal of research carried out in North America[20] concerning environmental factors such as temperature, noise, lighting, etc. and a detailed Ergonomic Audit tool (ERNAP[21]) developed appropriate for aviation maintenance, which can assist in the evaluation of work environments, tooling and documentation. Further details may be found in Appendix Q. The Safety Health of Maintenance Engineering (SHoMe) tool (Appendix M) also looks at aspects associated with the working environment and tooling, although not in any great detail.

It is appreciated that aircraft maintenance takes place in many different locations and environments, and that it is not always possible to carry out maintenance in a hangar maintained at a comfortable temperature, with adequate lighting and noise levels, etc. However, it should be recognised that environmental factors can contribute towards errors and efforts made to ensure that the environment is as 'work-friendly' as reasonably possible, eg. putting an aircraft into a hangar, if space is available, rather than carrying out the work on the apron, where appropriate, even though this may take slightly longer to arrange a tow.

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[20] for details, see *hfskyway.faa.gov*
[21] ERNAP - Ergonomic Audit Programme - *hfskyway.faa.gov*

The Health and Safety Executive (HSE) publish several useful documents which include guidance on the working environment. As a rule of thumb, what is good practice from a health and safety perspective is also likely to be good practice from an aviation safety perspective (albeit with a few debatable areas, such as wearing ear protection and being able to communicate adequately at the same time). Readers are referred to these publications for more general, non-aviation guidelines.

2. Further reading:

1. ICAO. Human Factors in Aviation Maintenance. Doc 9824-AN/450. (2003)
2. Human Factors Guide for Aviation Maintenance. Version 3.0 (1998). Editor. Dr. Michael Maddox.
3. ERNAP Tool. http://hfskyway.faa.gov
4. HSG65 Successful Health and Safety Management. HSE books. 1997. ISBN 0 7176 1276 7
5. HSG48 Reducing Error and Influencing Behaviour. HSE Books. 1999. ISBN 0 7176 2452 8
6. Improving Maintenance; a guide to reducing human error. HSE Books. 2000. ISBN 0 7176 1818 8

Chapter 6. Procedures, Documentation and Maintenance Data

1. Introduction

Procedures fall into two categories: those produced by the manufacturer and those produced by, and within the control of, the maintenance organisation or aircraft operator. The former will be referred to as Maintenance Data; the latter will be referred to as procedures and work instructions. This CAP provides guidance on the design and presentation of procedures, and how to identify procedures where there is scope for improvement. This guidance is aimed at Part-145 companies, but would also apply to JAR21 and JAROPS organisations.

2. Maintenance Data

2.1 Access and Availability

Part-145 requires that maintenance data is readily available for use, available in close proximity to the aircraft being maintained, and that there should be an adequate number of computer terminals, microfilm/ microfiche readers, and printers.

2.2 Inaccuracies, ambiguities and gaps

It is recognised that some maintenance manuals provided by the manufacturers often offer scope for improvement. Ideally, maintenance manuals should be validated when first written, for each new aircraft type and variant, but this is a task which is rarely carried out as thoroughly as it might be, if at all. Accordingly, it tends to be left to operational experience to pick up the inaccuracies, ambiguities or missing information in maintenance manuals. In addition, the information in the maintenance manual is not necessarily always in an appropriate form to be used in a maintenance environment, and some translation may be required to make this data more usable.

Maintenance organisations must have in place a procedure whereby such inaccuracies, ambiguities[22] or missing information are recorded and reported to the type certificate holder. Staff should be encouraged to report such problems, but it should be borne in mind that they will only continue to do so if they believe that the problems are being addressed. Type certificate holders and owners of maintenance data should act upon reported defects, and update the manuals quickly. There is currently no requirement for TC holders to validate Maintenance Manuals or to ensure that they are 'user friendly'.

EASA Part-21/ JAR21 contains a requirement for a Type Certificate (TC) holder (or other manufacturer) to have a system for collecting and analysing reports of, and information related to, failures, malfunctions, defects or other occurrences which might cause adverse effects on the continuing airworthiness. Whilst this does not specifically refer to Maintenance

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[22] Note: CAP562 (CAAIP leaflet 11-22 appendix 4-1) highlights the problem of ambiguities in maintenance data, and asks technicians to report these to the organisation responsible for publishing the information.

Manuals, it should include problems reported by maintenance organisations concerning the data related to their aircraft, engines or product, and they should be obliged to fix any inaccuracies. It is not clear as to whether this obligation would also apply to ambiguous data, or data which is difficult to use, although if a good argument can be made that such data is likely to "cause adverse effects on continuing airworthiness" then this data should also be fixed. Whether the TC holder can then levy a charge for such rectifications, is a matter for negotiation between the various organisations, and forward thinking on the part of the various contracts departments. It is a good argument as to why contracts and commercial staff should also be included in the human factors training provided to all 145 personnel - so that they can appreciate the implications of some of the problems that sometimes arise, or can only be fixed, by commercial agreements between manufacturers, operators and maintainers.

It is good human factors practice for manufacturers to ensure that maintenance manuals are correct, complete, unambiguous and 'user friendly', both from the outset and on a continuing basis.

Further information on systems for reporting poor maintenance data (among other things) can be found in Chapter 10. Data sharing[23] will help build up a larger database of deficiencies, which in turn places more pressure on the TC holders to fix problems. Two of the larger aircraft manufacturers have indicated that they are keen to receive such data and to act upon it.

The remainder of this chapter will concentrate upon how organisations can improve the content and presentation of data over which they have control or influence.

3. Procedures and work instructions

A work instruction is what you should do, whereas a procedure is how you should do it. Job cards are usually work instructions; procedures generally originate from the Maintenance Manual.

3.1 Writing procedures and work instructions

As well as maintenance data and procedures provided by the manufacturer having scope for improvement, there is also often a better way of writing or presenting technical procedures and work instructions which are produced by, and used within, a maintenance organisation. Obviously the fundamental elements of the procedures should not deviate from the manufacturer's requirement, but there is often scope for presenting that information in such a way that it is more easily understandable and usable. Guidance material is provided in Appendix S to help ensure that procedures and work instructions are written well. Indeed, the FAA has sponsored the development of a "Document Design Aid" (DDA) to help organisations apply these guidelines when writing procedures. The main points from Appendix S are summarised in table 2.

Table 2. Guidelines for designing procedures

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[23] eg. the MEMS-CHIRP initiative in the UK (see Appendix L for details)

1. Procedure design and changes should involve maintenance personnel who have a good working knowledge of the tasks.
2. All procedures, and changes to those procedures, should be verified and validated before use where practicable
3. Ensure procedures are accurate, appropriate and usable, and reflect best practice
4. Take account the level of expertise and experience of the user; where appropriate provide an abbreviated version of the procedure for use by experienced technicians
5. Take account of the environment in which they are to be used
6. Ensure that all key information is included without the procedure being unnecessarily complex
7. Where appropriate, explain the reason for the procedure
8. The order of tasks and steps should reflect best practice, with the procedure clearly stating where the order of steps is critical, and where the order is optional.
9. Ensure consistency in the design of procedures and use of terminology, abbreviations, references, etc.
10. Provide training on the use of technology to access and print procedures and maintenance data.
11. Ensure that printing and copy quality is good, and that there are enough printers, copiers, etc.

Organisations should advise the type certificate holder of any improvements which they have implemented regarding maintenance manuals.

3.2 Reporting discrepancies

In addition to an occurrence reporting system, where a problem has resulted in some soft of event, there should be an internal occurrence/discrepancy reporting system whereby staff can report inaccuracies or ambiguities in procedures, or, indeed, suggest better ways of doing particular tasks, such that procedures can be frequently updated and improved. This system must result in actions and improvements to the procedures, otherwise it will not be used by the workforce. AMPOS is an example of such a system (see Appendix S).

3.3 Consistency

Consistency is important, and whilst it is beyond the scope for Part-145 to require greater consistency between Manufacturers' Manuals (eg. Airbus and Boeing), there is plenty of scope within a Part-145 maintenance organisation to provide consistency in its documentation. Indeed, Part-145 requires organisations to provide a common workcard or worksheet system for use throughout relevant parts of the organisation.

4 Access

The best designed procedures are of little use unless they can be accessed and used by the engineers and technicians in real working environments. Organisations should ensure that they have an adequate number of microfiche readers, computer terminals, printers, photocopiers, etc. to allow ready access to all necessary data and for that data to be

printed. There are further guidelines concerning access to information in hfskyway.faa.gov, including details of a project which designed information accessible via hand held computers.

5. Further Reading

1. JAA MHFWG report (Appendix A)
2. Documentation Design Aid. *http://hfskyway.faa.gov*
3. Drury, C. Effective Documentation Techniques. Proceedings of the 17th Safety Management and Aviation Maintenance Symposium, Toronto, September 2003.
4. Human Centred Management for Aircraft Maintenance. Report of the ADAMS work. 1999.
5. CAP 676. Guidelines for the Presentation of Aircraft Checklists.
6. ICAO Human Factors in Aviation Maintenance Manual. 2003
7. FAA reports on http://hfskyway.faa.gov

Chapter 7.   Communication, Handovers and Sign-offs

1. Introduction

This document does not discuss teamwork or communication in detail in the main text, although some further information is provided in Appendix T. It concentrates instead on task and shift handovers, and on written communication of information. Sign-offs are discussed within this chapter since they are particularly important when tasks are handed over from one person to another, particularly when this was unplanned and there is no formal handover.

The guidance in this chapter and Appendix T is also echoed in Chapter 3 of ICAO's "Human Factors in Aviation Maintenance Manual" (2003).

2. Task and Shift Handovers

The primary objective of handovers is to ensure that all necessary information is communicated between the out-going and in-coming personnel. Effective task and shift handover depends on three basic elements:

* The outgoing person's ability to understand and communicate the important elements of the job or task being passed over to the incoming person.
* The incoming person's ability to understand and assimilate the information being provided by the outgoing person.
* A formalised process for exchanging information between outgoing and incoming persons and a place and time for such exchanges to take place.

Organisations should have a recognised procedure for task and shift handovers which all staff understand and adhere to. This procedure should be listed in the MOE.

Whilst there is no specific requirement in Part-145 for time to be specifically rostered in to allow for an overlap of 20 or 30 minutes whilst a shift handover takes place, this would be considered good human factors practice.

It would also be good practice for the outgoing shift supervisor to leave a contact telephone number with the incoming shift, in case they have any queries after a handover has taken place.

Further detailed information is provided in Appendix T concerning task and shift handovers, and appropriate ways of recording information for handover. Whilst all essential information (especially the detailed status of tasks) should be recorded in written form, it is also important to pass this information verbally in order to reinforce it. This is known as redundancy, or the 'belt and braces' approach.

3. Sign-offs

Research indicates that many maintenance tasks are signed off unseen. In order to prevent omissions, mis-installations, etc., every maintenance task or group of tasks should be signed-off. To ensure the task or group of tasks is completed, sign-off should only take place after completion and appropriate checks. Work by non-competent personnel (i.e. temporary staff, trainee, etc) should be checked by authorised personnel before they sign-off. The grouping of tasks for the purpose of signing-off should allow critical steps to be clearly identified.

Note: A "sign-off" is a statement by the competent person performing or supervising the work, that the task or group of tasks has been correctly performed. A sign-off relates to one step in the maintenance process and is therefore different to the release to service of the aircraft.

Signing off small groups of tasks will help prevent situations where a technician is called away from one task to do another, and the person picking up the previous task has no record of what has been completed and what has not. If there are accepted break points at frequent intervals during each main task (ie. the sign-off points), technicians should be encouraged to continue with the task up to the next break point without interruption, and only after the sign-off allow themselves to be diverted onto another task if this is required.

Sign-off points would be determined by the maintenance organisation as appropriate to the nature of their work.

Sign-offs should be considered a mechanism for helping to ensure that all steps have been carried out, and carried out correctly, and not primarily as a mechanism for identifying the responsible person in the event of something going wrong. It is understood that, in some cases, the person signing-off the task or groups of tasks will be unable to view or inspect, in detail, the work which has been carried out, but it is important that that person has a high degree of confidence that the work has been carried out correctly. If sign-offs end up as purely a paper exercise, where the person signing off the tasks has little idea whether they have been carried out correctly, the whole point of the sign-off mechanism will have been lost. It is appreciated that signing off tasks generates a certain workload, but considered that the safety benefits outweigh the disbenefits.

4. Further Reading

1. ICAO. Human Factors in Aviation Maintenance. Doc 9824-AN/450. (2003)
2. Human Centred Management for Aircraft Maintenance. Report of the ADAMS work. 1999.
3. FAA Human Factors Guide for Aviation Maintenance (1998). Chapter 4 Shiftwork and Scheduling Guidelines. Author - Michael E Maddox
4. Offshore Technology Report - OTO 96 003. Effective Shift Handover - A Literature Review. Health and Safety Executive. Author - Ronny Lardner

5. Guidelines in producing an effective shift and task handover system. R Miles (UK Health And Safety Executive) Proceedings of the Twelfth Meeting on Human Factors Issues in Aircraft Maintenance and Inspection, 1998

Chapter 8.   Planning, Preparation and Teamwork

1. Planning and Preparation

Planning is critical to human factors in that it should aim to ensure that there are adequate appropriately qualified and alert personnel, tools, equipment, material, maintenance data and facilities at the right place, at the right time, for the scheduled (and, as far as is possible, unscheduled) tasks. Indeed, Part-145 states that an organisation may only maintain an aircraft (or aircraft component) when all necessary facilities, equipment, tooling, material, maintenance data and certifying staff are available.

It is not the purpose of this CAP or of Part-145 to tell planners how to do their jobs but, rather, to highlight some of the human factors issues which they should be taking into account in the planning process, such as human performance limitations when working shifts and long hours.

Depending on the amount and complexity of work generally performed by the maintenance organisation, the planning system may range from a very simple procedure to a complex organisational set-up including a dedicated planning function in support of the production function.

The production planning function includes two complimentary elements:
- scheduling the maintenance work ahead, to ensure that it will not adversely interfere with other maintenance work as regards the availability of all necessary personnel, tools, equipment, material, maintenance data and facilities.
- during maintenance work, organising maintenance teams and shifts and provide all necessary support to ensure the completion of maintenance without undue time pressure.

When establishing the production planning procedure, AMC-145.A.47(a)(3) states that consideration should be given to the following:
- logistics,
- inventory control,
- square meters of accommodation,
- hangar availability
- man-hours estimation,
- man-hours availability,
- preparation of work,
- co-ordination with internal and external suppliers, etc.
- scheduling of safety-critical tasks during periods when staff are likely to be most alert, and avoiding periods when alertness is likely to be very low, such as early mornings on night shifts.

Further information concerning fatigue and shiftwork can be found in chapter 4.

Part-145 requires an organisation to have a maintenance man-hour plan showing that the organisation has sufficient staff to plan, perform, supervise, inspect and quality monitor the organisation. In addition, the organisation must have a procedure to reassess work intended to be carried out when actual staff availability is less than the planned level for any particular work shift or period.

It is important that planners attend human factors training, in order to better appreciate how good or bad planning can potentially affect human performance and, ultimately, safety and airworthiness.

2. Management, supervision and leadership

This chapter will not go into details concerning management styles and techniques, nor the theories of leadership and followership - these are all covered more than adequately in various management texts, and also in James Taylor's book "Maintenance Resource Management". Instead, it stresses the importance of getting people at management and supervisory level to understand what the human factors programme is all about, and on getting 'buy-in' at senior management level.

Top level management support is crucial to the success of a company human factors and error management programme. It is also particularly important to get middle management and supervisors on-board for the programme to be successful, and for them to demonstrate commitment to the programme to the staff. Supervisors are particularly important in the success or failure of a human factors programme, since it is they who set the standards which others are likely to follow. If, for instance, a supervisor condones the release of an aircraft without all the work having been checked and appropriately signed off, it is likely that this will become a norm, and no amount of human factors training for other staff is likely to result in a safety culture. It is crucial that senior management visibly support the safe practices and principles endorsed by the human factors programme and training, eg. management supporting a certifying engineer who refuses to sign off a CRS, rather than firing him!

3. Teamwork

This CAP does not address teamwork since there is adequate guidance material existing elsewhere (eg. James Taylor's book "Maintenance Resource Management"), and because it is not specifically featured in any of the human factors changes introduced in amendment 5 to JAR145. Nevertheless, teamwork is an important issue, and should be addressed within human factors training. However, care should be taken to address teamwork issues in context, and not to try to impose possibly inappropriate concepts developed in other areas of aviation (such as CRM) or even non-aviation applications. Teamwork is not the same across industries. There are good lessons to be learned from CRM, and some areas which apply both to the flightdeck and hangar floor, but the differences between the two contexts should not be under-estimated.

4. Further Reading

1. Airline Maintenance Resource Management; Improving Communication. Taylor, J C., Christensen, T D.
2. CAP 737 Crew Resource Management.
3. Human Factors Guide for Aviation Maintenance. Version 3.0 (1998). Editor. Dr. Michael Maddox.

Chapter 9.   Professionalism and integrity

This is included as a very short chapter in CAP 716 because it is a module in the GM-145.A.30(e) syllabus. Various Airworthiness notices address some of the issues associated with professionalism and personal responsibility, as does CAP 715 to some extent. However, what is most important is to emphasise the combined responsibility of the organisation, its management and supervisors, its processes and procedures, as well as the individual responsibility of each employee (not just certifying engineers) towards safety.

Table 1 includes some examples of good and bad professionalism, to illustrate why the subject is included within the human factors syllabus.

Table 1. Examples of good and bad professionalism

Good	*Bad*
management, on discovering corner cutting to get work done, being prepared to ground an aircraft until all the appropriate checks have been made	management condoning corner cutting to get work done
Refusing to sign off tasks not seen	signing off tasks not seen
admitting to being fatigued and negotiating a change in tasking, to work on non critical tasks instead	turning up to work, or accepting an additional shift or overtime, when fatigued (even though the motivation may be altruistic - to help out)
turning up to work fully rested	using off-duty time to do another job, or to take on domestic commitments which result in you being unduly fatigued when turning up to work.
Moderating alcohol intake the evening before work	overindulgence in alcohol the night before an early shift
reporting alternative (and possibly better) ways of doing tasks, and getting them accepted as official alternative procedures	use of a 'black-book'
Use of documentation, even for familiar tasks	reliance on memory for familiar tasks
Planning work to allow adequate time and resources	Planning work without allowing adequate time for it to be done properly
etc	etc

Everyone has their own idea of what constitutes "professional" behaviour. Human factors training, and a company human factors programme can help set and maintain standards for professional behaviour, and provide staff with the mechanisms and support to enable them to work professionally. The problem might be that although staff know full well what they ought to be doing in keeping with professional standards, they are prevented from behaving

as they would wish by organisational problems (eg. poor procedures, commercial pressures, unavailability of correct tooling, etc.).

When the subject of professionalism is addressed in a company human factors training course, it is up to the trainer to determine whether any problems which might exist are with the lack of professionalism of individuals, or more systemic issues, and to 'pitch' the training accordingly.

It should be remembered that professionalism is not something which is only necessary for LAEs or managers; it is important for all personnel whose actions (or non-action) can potentially affect safety and airworthiness, whether directly or indirectly. This also applies to personnel who work outside a Part-145 organisation, including the Operator, airport and ground staff, manufacturers and regulators. It is often said that the aviation industry is as safe as it is in large part due to the professionalism of the people who work within the industry. Appropriate training can re-reinforce the need to maintain such professional standards for all personnel.

Chapter 10. Organisation's Error Management Programme

1. Occurrence Reporting

A key element of a human factors programme is a system whereby problems, or potential problems, can be reported and dealt with. Many organisations already have some form of reporting system for technical issues or discrepancies, but this may need to be expanded, or additional system(s) put in place, to allow for the reporting of human errors, ambiguities with procedures, mismatches between required and actual practice, etc. Chapter 3, paragraph 3 describes such systems.

A Mandatory Occurrence Reporting (MOR) scheme already exists within the UK, whereby organisations and individuals are required to report occurrences meeting the MOR criteria, to the CAA[24]. Also, there is a national confidential occurrence reporting scheme (CHIRP) to which individuals can report.

This chapter refers to *internal* company reporting schemes which may or may not already exist, in order to ensure that there is a mechanism for all safety related concerns to be reported, recorded, investigated, analysed and appropriate action taken.

The Part-145 requirement is for an organisation to have in place an internal occurrence reporting scheme to enable the collation of occurrence reports, including the assessment and extraction of relevant information in order to identify adverse trends or to address deficiencies in the interests of safety. This system should include evaluation of known, relevant information relating to occurrences and promulgation of such related information.

The recently published ICAO Manual "Human Factors in Aviation Maintenance" (Doc 9824-AN/450) contains a wealth of useful information on error management systems.

2. Key elements for the establishment of an internal Occurrence Management Scheme (OMS).

An Occurrence Management Scheme should contain the following elements:
- Clearly identified aims and objectives
- Demonstrable corporate commitment with responsibilities for the Occurrence Management Scheme clearly defined
- Corporate encouragement of uninhibited reporting and participation by individuals
- Disciplinary policies and boundaries identified and published
- An occurrence investigation process
- The events that will trigger error investigations identified and published

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[24] CAP381

- Investigators selected and trained
- Occurrence Management Scheme education for staff, and training where necessary
- Appropriate action based on investigation findings
- Feedback of results to workforce
- Analysis of the collective data showing contributing factor trends and frequencies

The aim of the scheme is to identify the factors contributing to incidents, and to make the *system* resistant to similar errors. Whilst not essential to the success of an Occurrence Management Scheme, it is recommended that for large organisations a computerised database[25] be used for storage and analysis of occurrence data. This would help enable the full potential of such a system to be utilised in managing errors.

The following elements of an Occurrence Management Scheme are covered in more detail later in this chapter:

- An occurrence management system should enable and encourage free and frank reporting of any (potentially) safety related occurrence. This will be facilitated by the establishment of a just culture. An organisation should ensure that personnel are not inappropriately punished for reporting or co-operating with occurrence investigations.
- A mechanism for reporting such occurrences should be available.
- A mechanism for recording such occurrences should be available.
- Significant occurrences should be investigated in order to determine causal and contributory factors, ie. why the incident occurred.
- The occurrence management process should facilitate analysis of data in order to be able to identify patterns of causal and contributory factors, and trends over time.
- The process should be closed-loop, ensuring that actions are taken to address safety hazards, both in the case of individual incidents and also in more global terms.
- Feedback to reportees, both on an individual and more general basis, is important to ensure their continued support for the scheme
- The process should enable data sharing, whilst ensuring confidentiality of sensitive information.

2.1 Just culture code of practice

Organisations are encouraged to adopt the following code of practice to establish a just culture and encourage occurrence reporting:

Where a reported occurrence indicates an unpremeditated or inadvertent lapse by an employee, as described below, an organisation would be expected to act reasonably, agreeing that free and full reporting is the primary aim in order to establish *why* the event happened by studying the contributory factors that led to the incident, and that every effort should be made to avoid action that may inhibit reporting.

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[25] There is free software available. For a copy, please contact the CAA at osdhfs@srg.caa.co.uk

It is recognised that whilst the majority of actions should not incur remedial or punitive action, there will be some situations where such action is necessary. A rule of thumb is to use the 'substitution test' whereby if, under similar circumstances, another individual who was similarly trained and experienced would probably have made the same error, then punitive action is generally inappropriate. Each organisation should establish a code of practice, and publish this to employees. An example of such a code of practice is given in Appendix I.

The UKCAA has published AN71 which explains the key elements of a just culture code of practice (Appendix H).

2.2 Processes for reporting occurrences

Incidents, occurrences, errors and potential safety hazards may be identified as a result of an event (an incident, air turnback, rework, etc) or by a report submitted by a staff member (eg. reporting an error made by themselves or a colleague which was detected and did not result in an event).

The reporting mechanism should be made as easy as possible for reportees, requesting as much key information as is necessary whilst not placing an undue burden upon reportees to give too much detail. Avoid requesting unnecessary information. Avoid unnecessary duplication of forms. The reporting mechanism should be as flexible as possible to encourage employees to report (eg. via free-text letter, structured paper forms, via computer, via e-mail, via phone, face-to-face, etc), whilst taking into account the requirements of those who may need to investigate the incident or analyse the data. Inevitably a compromise will be necessary.

It is likely that a reporting mechanism will already be prescribed, partially or wholly, by the existing mandatory reporting requirements or by an existing company reporting scheme. A company may wish to utilise this for all reporting, or may wish to have a separate reporting scheme for maintenance errors.

Reporting should be confidential but not anonymous, since it may be necessary to contact the reportee to obtain more information about the occurrence.

Further guidance as to appropriate mechanisms for reporting, and how to ensure confidentiality, may be obtained from various sources, including organisations which have successful schemes in place, the Global Aviation Information Network (GAIN) programme (www.gainweb.org), and Appendices H, J and K.

2.3 Processes for recording occurrences

There are numerous processes and tools in existence to assist with the recording of occurrence data. These generally involve some form of classification scheme or taxonomy, such that the information may be recorded in a structured fashion. These range from processes which record just basic data, such as date, time, location, etc., leaving the

remaining data in free text form, to processes where there are many specific categories and keywords, with all the data being classified according to a rigid structure.

Existing schemes for general occurrence data recording include: ICAO's ADREP, ECCAIRS, UK CAA's MORS, USA's ASRS, USA's ASAP, UK's CHIRP, etc.

The most commonly used scheme for recording of maintenance-related occurrences would appear to be the Maintenance Error Decision Aid (MEDA) (see Appendix K). The ADAMS project has also developed a taxonomy, which it has further developed in ADAMS 2 (due to be published in 2004).

When choosing a process, organisations should take into account many factors such as:
(a)   is one general process, suitable for recording all occurrences, required?
(b)   what level of detail of recording is necessary?
(c)   is compatibility with any other scheme (eg. NAA) necessary?
(d)   analysis needs - what you want to get out may dictate how you code the data in the first place
(e)   links with other company processes, eg. health and safety monitoring, Quality Assurance, etc.
(f)   existing products/ tools, and their cost.

The prime criterion for the selection of an occurrence recording process should always be to enable an organisation to better understand safety hazards in order to be able to better control the risks.

2.4 Investigation of occurrences

The reporting scheme should encourage reportees to try to identify causes and contributory factors, but further investigation will be necessary in some cases. Ideally, all those occurrences for which the cause or contributory factors are not known, should be investigated. However, this may be too resource intensive, so an organisation should set certain criteria, usually related to the significance of the incident, to determine which occurrences are investigated, eg. rework costing more than £500, air turnbacks, delays more than 60 minutes, etc.

Investigation processes can vary considerably in depth and nature. Aircraft maintenance organisations are encouraged to adopt the MEDA investigation process as a model, since this is the most widely used process in the maintenance industry currently. Further information can be obtained from Appendices J and K and from the references in Appendix Z. For those maintaining components, the principles of MEDA still apply but some adaption may be required.

2.5 Data analysis

Analysis of occurrence data is encouraged in order to better identify patterns of causal or contributory factors, and to determine trends over time. An electronic database can assist greatly in this process.

2.6 Managing identified hazards

Once hazards are identified (including both actual and potential hazards), a risk assessment should be made of the causes and contributory factors, and a decision made as to whether action is required. Action may be in the form of a change (eg. to a procedure, issue of a notice, personnel action, etc) or merely monitoring the situation to determine that the risk is controlled. Changes should address both the root causes of hazards and the detection and trapping of problems before they can jeopardise flight safety. Actions which are inappropriate to the cause of the problem (eg. 'blame and train') may result in the occurrence reporting system losing credibility among staff. The occurrence management process should be closed-loop in order to ensure that actions are identified and carried out.

An Occurrence management System should record actions taken in respect of previous occurrences, so that managers may look at the effectiveness (or otherwise) of the remedial action(s) in the event of a repetition of an occurrence. Alternative action may be appropriate if the remedial action has previously been ineffective.

2.7 Feedback

Feedback should be given to the workforce and to original reportees concerning actions, to encourage continued future reporting. A magazine can be an effective way of providing feedback to the workforce in general, although care needs to be taken not to breach confidentiality and to disidentify occurrences. The most effective feedback is that which shows that something has been changed for the better as the result of an occurrence report or investigation.

2.8 Sharing of results

Information should be effectively promulgated to those individuals and organisations who may need to act upon the results, including own employees, contracted staff, sub-contracted organisations, operators, suppliers, manufacturers and regulators.

Organisations are encouraged to share their occurrence analysis results with other maintenance organisations.. However, it is appreciated that some information in an occurrence database may be considered sensitive to the organisation affected, and may need to be dis-identified before being shared with other organisations.

Information sharing may be accomplished on an informal or formal basis, and can range from regular discussions between organisations concerning possible common problems, to electronic data exchange arrangements, whereby all the organisations who have agreed to exchange data can look at one another's databases (usually at a level where confidential details are disidentified).

Further information concerning data exchange on a global basis can be obtained from Global Aviation Information Network (GAIN)[26]. The more modest UK initiative for data sharing can be found on www.chirp.co.uk/mems, with some further information in Appendix L.

2.9 Applicability according to size of organisation

Whilst all the principles described above are applicable to all Part-145 approved organisations, it is recognised that the mechanisms to enable these principles to be put into practice may differ in terms of their appropriateness to different sized organisations. For example, it would be appropriate for a large organisation to have a computerised database, but this my not be necessary for a small organisation. The important point is to ensure that occurrences are reported, investigated, risks identified and action taken to control those risks; how this may best be accomplished may vary from organisation to organisation.

3. Further Reading

1. ICAO. Human Factors in Aviation Maintenance. Doc 9824-AN/450. (2003)
2. Human Factors Process for Reducing Maintenance Errors. Allen J., Rankin W, Sargent B
3. Learning from our mistakes: A review of Maintenance Error Investigation and Analysis Systems. Marx D Jan 1998.
4. AN71, CAA CAP455
5. The Directive on Occurrence Reporting in Civil Aviation, 2003/42/EC. Official Journal of the EU, 4 July 2003.

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[26] http://www.gainweb.org

Chapter 11. Human Factors Training for Personnel involved in Maintenance

1. Introduction

This chapter provides details of the UK CAA interpretation of the Part-145.A.30(e) requirement and associated AMC-145.A.30(e), and guidance as to how this requirement might be met. However, there is no 'one size fits all' solution, so the guidance in this chapter would need to be tailored according to the size and type of organisation to which it is applied. The emphasis is upon practical human factors training as part of a company human factors and error management system. This sentiment is echoed in the ICAO manual "Human Factors in Aviation Maintenance" Doc 9824-AN/450.

2. Origin of the requirement

Knowledge of human performance and limitations (HPL) has been an ICAO SARP for many years now in ICAO Annex 1. This has been addressed in the UK and JAA by including, within the basic license requirements, examinations in HPL for pilots (JAR FCL) and licensed engineers (JAR 66/ Part-66). However, these are not *training* requirements. The human factors initial and recurrent training requirement for pilots is known as Crew Resource Management (CRM) and is required by JAROPS; the human factors recurrent training requirement for certifying engineers is required by JAR145/Part-145. There was, until recently, no requirement for initial human factors training.

More recently, amendment 5 to JAR145 expanded the training requirement to extend to all staff as well as certifying staff, and to include initial as well as recurrent training. The justification for this change is explained in the section dealing with the Requirement.

This change has now been incorporated into the EASA requirements, virtually unchanged from JAR145 apart from compliance dates. The compliance date for JAR145.30 (e) was 1 July 2005; the compliance date for the EASA equivalent requirement (Part 145.30(e)) is 28 September 2006. The compliance dates indicate the date by which all 145 approved organisations should have in place a procedure for human factors training, and by which all appropriate staff should have received initial human factors training.

3. Context of Human Factors Training

Maintenance human factors training is part of a total system in managing human error, and discouraging procedural violations, in a maintenance organisation. It is an essential part of this system aimed at individuals engaged in 'hands-on' maintenance, support or management. Without proper training, other initiatives related to error management and safety improvement (such as error reporting and investigation, better shift and task handover procedures, improvements in procedure design, etc.) will probably not be effective in the long term. An integrated approach, linking human factors training with organisational safety management and error management initiatives, is essential.

Human factors training should not be something radically new - it covers basic safety principles and practices which should already be incorporated within a safety management and quality system, and how to ensure that work is carried out in a professional manner such that aircraft are released to

service in a safe and airworthy condition. However, evidence from accidents, incidents and studies indicates that some of the processes and training which ought to achieve this are weak or non-existent. The rest of CAP 716 describes how some of these processes should be improved; Chapter 11 describes the training required to enable staff to work with these *organisational* processes, or even help design them, as well as being aware of *individual* human performance and limitations and how to avoid and manage errors. It should also be closely integrated with the company Maintenance Error Management System (MEMS), staff being fully conversant with the company just culture/ disciplinary policy and how they are expected to interface with MEMS.

Various terms are sometimes used to describe the training mentioned above. Within CAP 716 we refer to "human factors training". It may also be described as "error management training". "Maintenance Resource Management" training is a term, originating in North America, to describe human factors training where the primary emphasis is upon teamwork and communication. It doesn't really matter what you call it, as long as it is done!

4. Aims and Objectives

The objectives of Human Factors training, within a human factors and error management programme, should be to
improve safety
decrease organisational exposure to risk,
reduce errors,
capture errors,

These objectives may vary in detail from company to company, but should cover the key points listed in Reason and Hobbs CAIR checklist (see Appendix M).

The aim of human factors training should be to help achieve these objectives by means of:
imparting knowledge on human factors and safety, and details of how the company human factors programme works,
developing skills (where appropriate),
influencing people's attitudes and
influencing behaviour.

5. Requirements

The Part-145.A.30(e) requirement (previously NPA12 to JAR145) was introduced as a result of the work of the Training sub-group of the JAA Maintenance Human Factors Working Group (MHFWG). Further details concerning the composition of this group, and the rationale for expanding human factors training from only certifying staff, to all staff within the organisation "whose error or poor decision could affect safety or compliance with JAR145/[Part-145]", are contained in the JAA MHFWG report (Appendix A).

Part-66 already includes a requirement to demonstrate knowledge of Human Factors elements which are included in Part-66 Module 9. However, this only applies to licensed engineers and is *not* a requirement for training. The knowledge may be acquired by several means, one option being self-study, and is tested by means of examination. A good appreciation of the *practical application* of

human factors can only be obtained by training, ideally within the context of the organisation within which the people work. Furthermore an examination in isolation cannot really assess certain aspects such as "skill" and above all "attitude", which are two of the training objectives discussed above. Training in human factors is, therefore, important in order not only to help people understand what the issues are, but how to adopt good human factors practice in all aspects of work. Such training is appropriate for all staff who have an impact upon safety and airworthiness, not just for engineers or certifying staff.

Part-145.A.30(e) requires that "the organisation shall establish and control the competence of personnel involved in any maintenance, management and/or quality audits" where "competence must include an understanding of the application of human factors and human performance issues appropriate to that person's function in the organisation".

AMC-145.A.30(e) proposes human factors training as an acceptable means of compliance with the requirement in Part-145.A.30(e) to have an appropriate understanding of the application of human factors, and gives further details as to how this training should be implemented. The JAA MHFWG report expands on this, and whilst not a part of the Part-145 requirement, is nevertheless interpreted by the CAA as JAA guidance material. At the time of writing this CAP, the JAA MHFWG report was published on the JAA website (www.jaa.nl) and has been included in CAP716, complete with the expanded human factors training syllabus, as Appendix A.

6. Who should receive human factors training?

6.1 Personnel to receive human factors training

AMC-145.A.30(e)6 lists the personnel for whom human factors training is applicable:
"This should include, as a minimum:
-Post-holders, managers, supervisors
-Certifying staff, technicians, and mechanics.
-Technical support personnel such as planners, engineers, technical records staff
-Quality control/assurance staff
-Specialised services staff
-Human factors staff/ Human factors trainers
-Store department staff, Purchasing dept. staff
-Ground equipment operators
-Contract staff in the above categories"

To this list should be added[27]:
- Human factors programme managers
- The person doing the TNA
- Competence assessors
- Accident/ incident investigation personnel
- Technical trainers (where relevant)
- Health and Safety staff
- Human resources personnel

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[27] Additional categories of staff recommended by ICAO Doc 9824-AN/450, and CAP 716

Ideally, this list should also extend to the customer with whom the Part-145 organisation interfaces, since the customer ought to be aware of the human factors and safety implications of the demands which they place upon the maintainer. However, the requirement for human factors training is restricted to Part/JAR-145 approved organisations and their staff (and contractors), and does not extend to JAROPS.

Also included are personnel who work for organisations which are not approved under Part-145, but which are working under sub-contract. AMC-145.A.75(b) states that " subcontractor's personnel .... involved with the maintenance organisation's products undergoing maintenance should meet Part-145 requirements for the duration of that maintenance and it remains the organisation's responsibility to ensure such requirements are satisfied". This includes human factors training, but with the caveat 'as appropriate'. For instance, it would probably be applicable to ensure that subcontractors dealing with NDT on critical components are aware of human factors issues in visual inspection, but probably not necessary for subcontractors dealing with IFE to have human factors training. It would be up to the contracting company to determine what human factors training was necessary.

The requirements include a need for regulators to be appropriately trained, and, although not explicit in Part 145, the implication is that this training would therefore include human factors. Indeed, the recently published ICAO document 9824-AN/450 (Human Factors Guidelines for Aircraft Maintenance Manual) states that "In addition to having suitable background, experience and qualifications, the maintenance inspectors from the State aviation regulatory body should have human factors training to a level at least comparable to their counterparts in industry".

6.2 Why train everyone in the organisation?

Evidence from incidents and accidents shows that human error and human factors problems are not limited to 'hands-on' maintenance staff (whether certifying or non-certifying), but may extend to planners, technical records staff, etc. In addition, it is often organisational decisions and policies made by managers that are at the root of some incidents (eg. to ensure adequate resources). Senior management commitment to, and support of, the company human factors programme is essential to the success of such programmes. Staff need to be convinced of this commitment by management. Managers attending the human factors training themselves is one way of showing this.

Whilst managers may think that they understand what the human factors problems are, informal feedback from various human factors conferences indicates that some have previously been unaware of the extent and nature of the problems that exist in industry. Training for managers, including the accountable manager, is considered important to raise awareness of problems both in the industry as a whole, but also within their own company.

As stated in para 5, the training should be "appropriate to that person's function in the organisation". Thus technical records staff, for instance, should be aware of the types of problems which occur, or may occur, due to human error, especially those which have arisen from poor manuals and procedures, but may not need to have an in-depth knowledge of human performance and limitations or error theories. Certifying staff within an aircraft maintenance organisation would need a reasonable understanding of all the syllabus items, whereas support staff (eg. stores/supply) may not.

An organisation should carry out a Training Needs Analysis (TNA) in order to determine what training (and to what level) is appropriate for the various categories of staff.

7. Stages of Implementation

Training will not be successful in the long term unless what it teaches is supported within the organisation on a day-to-day basis. Therefore the human factors training requirement within Part-145 should not be considered in isolation. The training should be a part of the total package of measures within a Part-145 approved organisation to assure safety and airworthiness.

The following stages of implementation should be completed to ensure the success of the human factors training. Where organisations have already embarked on some of the stages below, they should give consideration to revisiting earlier stages in case they have not been covered properly.

1. **Genesis**. Ensure the person or people responsible for putting in place the human factors training and programme, are appropriately trained. External training will be necessary since the company human factors training programme will not yet have started. It may also be useful to seek views or even assistance from other similar organisations.

2. A company **Human Factors and Safety Management Programme** needs to be designed and the structure in place (including a process for error management). The introduction of human factors training, particularly Module 10 of the syllabus, should be timed such that the key elements of the company human factors and safety management programme, in particular the error management process, are already in place before training starts.

3. **Measurement of Competence** - Identify current levels of competence and methods for monitoring and managing competence. Part-145.A.30(e) requires that "the organisation shall establish and control the competence of personnel involved in any maintenance, management and/or quality audits" where "competence must include an understanding of the application of human factors and human performance issues appropriate to that person's function in the organisation".

4. Conduct a **Training Needs Analysis** (TNA) - An organisation should carry out a Training Needs Analysis (TNA) in order to determine what training (and to what level) is appropriate for the various categories of staff. Please note there is no 'one size fits all' solution for training. The findings from a TNA are used to tailor the scope of the training provided to ensure the training is suitable for the needs of your particular company.

5. **In house, or contracted out?** - Determine whether the organisation is able, or willing, to run the training in-house. If in-house training is not an option, organisations are advised to carefully consider the options for contracting out, or compromises, such as a joint training programme with other similar companies in the vicinity.

6. Develop Tailored **Training Material** - There is a wealth of material from which human factors trainers may draw when developing their training course, varying from off-the-shelf

packages which may suit their needs, to generic[28] training material which may be customised, to source information from which trainers can develop their own training material. Many of these sources are referenced in Appendix Z.

7. Provide **Initial Training** in Human Factors - This is described in greater detail later in this chapter.

8. Provide **Continuation Training** in Human Factors - This is described in greater detail later in this chapter.

9. **Review and update** training, on a regular basis. This includes the need for the human factors trainer to keep up-to-date with current thinking and best practice on human factors.

7.1 Timing of the introduction of human factors training

The timing of human factors training with respect to the introduction and implementation of the key elements of the company human factors and error management programme, is important. The key people involved in the introduction of such a programme should have received fairly comprehensive human factors training beforehand. The introduction of such a programme should ideally be timed to coincide with human factors training for the staff, particularly module 10. One could even argue that basic human factors concepts ought to be taught beforehand, so that the staff understand the rationale behind such initiatives as Maintenance Error Management, or more formalised shift handover procedures, and don't reject them out of hand. On the other hand, one could argue that if training takes place too soon before the introduction of the supporting elements of a company human factors programme, staff will become disillusioned that they cannot implement what they have been taught. This is particularly important in the case of maintenance error reporting and the disciplinary policy.

Different approaches will work for different organisations, but careful thought should be given to the relative timing of all the elements of the company human factors programme, in particular module 10. Training staff on something which doesn't yet exist is likely to be ineffective at best, and may even cause future problems once the elements of a human factors and error management programme have finally been introduced.

8. Measurement of Competence

Organisations should have a mechanism for determining competence of staff, not just with respect to human factors, but for all areas (both technical and non-technical) in which staff are required to be competent.

Demonstration of competence applies to all staff within an Part-145 organisation, not just the hands-on technical staff, or even just the licensed engineers. Management competence and human factors competence should be closely linked. A manager may be highly competent in day-to-day

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[28] The Proceedings of the 15th HFIAM symposium, 2001, contain a set of slides and notes which may be customised and used, at no charge.

management and making money for the company, but not particularly supportive of human factors principles and policies, despite the fact that he understands what they are all about.

There are many different mechanisms available that may be used as evidence of competence. These include:

- Examination - a good mechanism for assessing knowledge, but not necessarily competence of applying knowledge in a work context;
- Interview;
- Qualifications - a good source of evidence, if the training course or other method used to gain the qualification are directly relevant and practical for application in the workplace;
- Completion of training courses is a good way of providing information, but not sufficient to prove individual competence in applying the knowledge gained from the course;
- On-the-job assessment - a good way of determining competence, however its effectiveness relies heavily on the competence of the supervisor or manager conducting the assessment as it relies on their subjective judgement;
- Tailored assessments – staff are ask what they would take into account when doing particular tasks, e.g. a planner explains that he would give consideration to the effect fatigue may have and schedules critical tasks to be completed during the day shift or at the start of the night shift rather than in the early hours of the morning. This explanation shows the planner understands how some human factors issues are applicable to his job.

Assessing competence in the practical application of human factors is difficult, therefore it may be appropriate in your organisation to apply a selection of the above methods. Please note, that the pervading culture within the company may be contrary to good human factors principles (eg. the culture might be that errors are not tolerated, and are regarded as signs of incompetence). If this is the case, it is likely that judgements of competence will be biased towards that company culture. It is important, therefore, that staff are trained in how to assess competence, and that independent checks are carried out of the competence assessment process.

An organisation may decide that it is going to limit its assessments to competence in the "understanding of the application of human factors" as specified in Part-145.A.30(e), ie. if people know what they should be doing, they are considered competent in human factors, even if they don't actually do it. However, the UK interpretation of this particular requirement extends to the *actual* application, as opposed to just the *understanding* of the correct application, of human factors and safety principles. No matter how good your training might be, unless it results in appropriate behaviour, its aims have not been achieved. However, it should also be recognised that human factors training is not *always* the solution to lack of competence in the application of human factors. There may be instances where individuals would like to apply what they know to be good human factors practices, but are unable to do so due to limitations in the company processes. In such cases, appropriate solutions should be sought.

Using the argument in the paragraph above, whilst the manager(s) concerned may have competence in an understanding of the application of human factors, the fact that they fail to support the application of such principles within the company means that the intent of the Part-145.A.30(e) requirement has not been met. The extension of understanding of human factors, to its effective application, should be the ultimate aim for all staff, particularly senior managers, if safety is to be improved.

For further information concerning mechanisms for determining competence, readers are referred to the paper "Proving the Competence of the Aircraft Maintenance Engineer", presented at the International Air Safety Seminar, November 2003. In addition, readers are referred to CAP 737, which contains methods of assessing the competence of personnel in CRM skills, there being many useful parallels.

More work is needed on the subject of competence assessment, both in its wider context and also in the more specific context of human factors. In the meantime, this limited guidance has been included in CAP 716 on competence assessment. Note: until the guidance on competence assessment is more mature, organisations are strongly advised against using 'lack of competence in human factors' in the context of any decisions concerning an individual's position within an organisation (with the possible exceptions of the roles of human factors trainer, and human factors programme manager). Competence should be assessed initially with a view to determining how best to bring individuals up to an appropriate level of competence, by training.

The ICAO document "Human Factors in Aviation Maintenance" (Doc 9824-AN/450) acknowledges that there is a need for better understanding of how best to assess competence in human factors, adding "such an understanding will help prevent premature moves to assessment and testing in circumstances where they could prove counterproductive to long-term learning needs".

9. Course versus other methods of training

A 'course' is not obligatory, but it is felt that it is by far the best way to teach practical maintenance human factors, whether initial or recurrent. Part of the value of the training is to compare views and experiences between course attendees, and between trainer and attendees. The importance of a skilled and knowledgeable trainer cannot be overestimated. Much of the emphasis of the human factors training should be upon reinforcing or changing attitudes, rather than imparting knowledge, and a good trainer/ facilitator is key to this.

9.1 Computer Based Training

Some Computer Based Training (CBT) or internet based human factors training packages are available. Whilst these may be appropriate for some of the more knowledge based elements of GM-145.A.30(e) syllabus (or, indeed, Part-66 module 9), they are not appropriate *in isolation* to meet the intent of AMC-145.A.30(e), especially the syllabus elements dealing with error, communication, safety culture and teamwork. CBT is best used in conjunction with a training course to reinforce syllabus elements, or to cover the more knowledge based syllabus elements (eg. human performance and limitations), allowing more time on the course to address the more complex organisational and safety culture elements. Two way interaction is important to human factors training, especially where attitude change or reinforcement is necessary, and this can only be accomplished by the presence of a good trainer-facilitator in a classroom situation.

9.2 Videos

Videos may also be used for training purposes but, as with CBT, they will be of limited effectiveness unless incorporated as part of a training course with a good trainer. Appendix Z includes details of come videos which might be suitable for inclusion within a maintenance human factors training course.

9.3 Facilitated training

CBT or video in isolation are unlikely to be suitable for continuation training because (i) video or CBT tends to be fairly generic in nature whereas continuation training is intended to address issues and problems specific to each particular organisation, and (ii) CBT and video do not allow for two way communication which is an important element of continuation training. As with initial training, a combination of CBT/video and 'live' facilitation may be appropriate for continuation training, but it should be remembered that the emphasis should be upon company specific issues. If it is discovered that staff still have a poor understanding of some generic human factors issues, then it may be necessary to address this, whereupon use of video and/or CBT may be appropriate. These tools may also be appropriate for continuous reinforcement of human factors 'messages', eg. by running through examples of accidents or incidents and what can be learned from them. What must be avoided is for companies to require all staff to run through a possibly inappropriate CBT course, or sit through a video, just to get the 'tick-in-the-box' for recurrent human factors training.

The best option, for both large and small organisations, for both initial and continuation training, is still considered to be a facilitated course, ideally combining various training methods and media, such as 'chalk and talk', team exercises, video, multi-media, etc., such that all learning styles are catered for.

10. Training Needs Analysis (TNA)

A TNA should be carried out before any major decisions are made concerning human factors training. A TNA is a crucial stage in putting together a human factors training programme, and should not be omitted unless all staff are to receive full training on all syllabus topics. Even then, a TNA would be a valuable tool in helping to design the training and tailor it for the needs of the company and its staff.

10.1 Who should conduct the TNA?
The person doing the TNA should have a reasonable level of competence in human factors, and be aware of the needs of the company and the different roles of its staff. The TNA may either be carried out by one person within the Part-145 organisation, or jointly between one person from the organisation and a specialist who is familiar with TNA principles and the practical application of human factors.

10.2 What does a TNA involve?
The following section provides a summary of the key stages of a TNA. An example TNA is included in Appendix U.

1)   Stage 1 - Categorise all the various jobs within the company according to the different needs for human factors training - an example is given in Table 1 below.

Table 1

Technical Certifying staff (ie.	Permanent staff

those doing hands-on maintenance or overhaul)	Contract staff
Technical non-Certifying staff (ie. those doing hands-on maintenance or overhaul)	Permanent staff
	Contract staff
Management and technical support staff	Post holders/ senior managers
	Managers/ QA
	Supervisors
	Planners/ production control
	Tech records/ tech services/ design
	Purchasing/ supply chain
	Stores
Other staff	Trainers
	Human factors trainers
	Human resources/ personnel
	Loaders/ drivers/ etc

2)   Stage 2 - For each category of staff, identify what level of human factors competence is required for each of the various syllabus elements. This may vary from none (eg. loaders may not need to know anything about error models) to high (eg. supervisors need to know a lot about task/shift handovers).

TNA should consider the nature of the work, as well as the different staff roles, and other issues such as whether staff work shifts. Many different aspects should be taken into account when considering who needs what training, to what level of detail and with what emphasis. For instance, if your staff do not work shifts, shiftwork need not be covered in detail. On the other hand, if you do work shifts, it is particularly important that your planners are aware of the effects of fatigue on human performance, in order to comply with AMC-145.A.47(a).

Safety critical tasks should be a prime consideration when doing a TNA, especially for staff working nights, or on the line in all weathers. The TNA should also take into account the intrinsic vulnerability of the aircraft you are maintaining, and the circumstances under which they may be operating (eg. a TNA for maintainers of helicopters operating in the North Sea might differ from a TNA for passenger shuttle operations using new, easy to maintain modern aircraft, and would definitely differ from a TNA for a company whose business is component overhaul).

3)   Stage 3 - Once the TNA has been reviewed and agreed as appropriate, determine what level of competence in human factors the individual staff members have, compared with that required. E.g. managers may have already attended courses that cover teamwork and assertiveness, and most staff will have undertaken health and safety training, therefore the syllabus element dealing with 'hazardous situations' may have already been covered.

Determining existing levels of competence in human factors may be difficult. Licensed engineers may have successfully passed an examination in Part-66 Module 9, for instance, but only possess some theoretical knowledge concerning human factors, as opposed to competence in its practical

application. The organisation should not give any credit for such training unless they have an acceptable method for determining competence in the subject.

4)   Stage 4 - Determine what level and duration of training to provide to staff, based on the TNA and staff competence assessments. Companies may find it easier to provide the one comprehensive course to all staff as initial training. Others may tailor their training according to suit the different categories of staff.

Ultimately, the duration of both initial and continuation training should be determined by the TNA. Whilst in practice key factors affecting the duration of training tend to be the cost and whether staff can be released, companies should endeavour to make staff available for whatever time is necessary, determined by the TNA, if training is to be effective in meeting its aims and objectives.

It should be remembered that a TNA is not static - it may need to be altered according to the changing nature of the company's business over time, and will be different for initial and continuation training. It may also change based on feedback from the company's occurrence reporting/ Maintenance Error Management System (MEMS) - for instance, if a series of problems are experienced during night shifts, then planners and staff working shifts may need to be given additional training on circadian rhythms and how to minimise fatigue. In particular, human factors continuation training should reflect particular problem areas that the company has experienced recently.

Realistically, it is not expected that organisations will have to run numerous variations of a human factors course for different groups of staff. In some cases, it may be easier to put all staff on the same course, and in others one core course plus two or three tailored modules may suffice. A TNA should be used as a tool to help design training, not an additional 'requirement' to complicate the issue. However, a TNA is a crucial stage in putting together a human factors training programme, and should not be omitted unless all staff are to receive full training on all syllabus topics. Even then, a TNA would be a valuable tool in helping to design the training and tailor it for the needs of the company and its staff.

11. Training Material

11.1 Syllabus

The human factors syllabus in GM- 145.A.30(e) is a compromise that was developed by the JAA MHFWG, in order to introduce practical elements of human factors whilst not diverging markedly from the existing Part-66 Module 9 human factors syllabus. This compromise was agreed in recognition that many organisations had already been training personnel in human factors for JAR66, and the introduction of a significantly different syllabus for 145, also entitled "human factors" would have caused confusion and unnecessary duplication of training effort. In addition, in order to enable the possibility of future cross-credits between 145 and 66, the syllabi needed to be fairly similar. Note: the UK is not offering such cross-credits.

The main distinction between Part-145 and Part-66 human factors, apart from the content, is in terms of how the syllabus elements are taught, and the relative emphasis upon knowledge, skills, attitude and behaviour. As stated earlier, the Part-66 (module 9) requirement concentrates upon theoretical knowledge of the Module 9 human performance and limitations elements, whereas GM-

145.A.30(e) concentrates upon the practical application of human factors in a work context, with the emphasis upon skills, attitudes and behaviour, as opposed to simply knowledge.

The expanded GM- 145.A.30(e) syllabus is in Appendix A, attachment 7, Table 1. This contains pointers as to where the emphasis on each syllabus item should lie (ie. knowledge, skills, attitude) and examples of source material which instructors may wish to use when teaching the various syllabus elements.

11.2 Module 10 of the syllabus

Module 10 of the human factors training syllabus in GM-145.A.30(e) is company specific, and is intended to inform staff what elements of a HF programme/ SMS programme exist within the company (and what doesn't exist) and in what form. This module is what ties the MHF training together with the processes within the company that will (hopefully) enable the principles taught during the course, to be applied within the organisation.

Module 10 should describe (where present):
- Relevant aspects of the company safety and quality policy
- The company hazard reporting/ occurrence reporting/ MEMS system
- The company occurrence/error investigation system / MEMS system
- The company disciplinary policy, and its interface with the MEMS system
- The company process for identifying and reporting errors and ambiguities with maintenance data
- The company policy on working hours and fatigue, and a reminder of an individual's personal responsibility to obtain adequate rest during time off.
- Company shift/task handover procedures
- Company feedback mechanisms (eg. a magazine or website)
- Details of the company health check system (eg. for night shift workers)/ eyesight testing programme/ hearing testing programme

Ideally, Module 10 of the syllabus should take the form of a presentation by a senior manager within the company, in order to demonstrate senior management support of these policies (although if such support is not present, a presentation by a manager who is obviously not committed can be self defeating). Module 10 may be covered entirely separately from the main initial MHF training (although preferably after the main MHF training has taken place, so that staff better understand why such policies and processes are necessary).

Module 10 should be given to both permanent and temporary staff very soon after joining the company, ideally as part of induction training.

Human factors training in isolation is unlikely to be effective. The training should be just one part of an overall human factors and error management programme. Module 10 is probably the most important element of the human factors syllabus in that it shows staff how the organisation has put in place the mechanisms to support them in applying the human factors practices and principles learned in modules 1 to 9.

12. Initial and continuation training

AMC-145.A.30(e) refers to both initial and continuation training. Initial training and continuation training may be quite different. Note:The AMC- has been written assuming everyone has already undergone initial training, and it is only necessary to ensure that new personnel receive such training (or that they have received it elsewhere to a standard which meets the needs of the company).

12.1 Initial training

The initial training may be generic, but not to such an extent that it is unrelated to the task of aircraft maintenance (or component overhaul, or NDT, etc). However, the more closely it is related to the work of the organisation, the more effective it is likely to be with resulting benefit to the organisation.

Whilst a syllabus is provided in GM-145.A.30(e), organisations may adapt this to best fit their particular needs. The JAA Maintenance Human Factors Working Group Report (Appendix A) expands upon the syllabus and gives examples of subject matter that trainers might wish to call upon, but should only be taken as guidance, there being many other sources of information available in addition to this report. The TNA should provide a clear guide as to what level of training is appropriate, for each group of staff, for each topic.

The recommended form of initial training is a formal training course, following a syllabus, although recognising that the length and content of the course should be tailored to the size and type of organisation, the nature of its business and individuals' jobs.

12.2 Duration of initial training

The recommended form of initial training is a formal training course, following a syllabus, although recognising that the length and content of the course should be tailored to the size and type of organisation, the nature of its business and individuals' jobs. The duration should be determined by the TNA. If an organisation elects not to carry out a TNA, it is advised that the course duration should reflect best practice.

Experience[29] indicates that 3 days is an optimistic estimate to cover the whole syllabus to an adequate depth. Courses in existence range from 2 to 5 days. Less time may be needed for staff who do not need to address all the syllabus items in detail, or where issues have already been covered in other training courses. Longer may be needed for certain groups of staff, eg. human factors programme managers, MEMS investigators, and human factors trainers. (One well-known training programme developed as part of an EC sponsored project, for instance, trains trainers over two staggered 1 week courses, with coursework and practical experience between the two weeks). Additional training in facilitation skills is likely to be needed for human factors trainers.

Exercises and discussion during the training can lengthen the course but can be valuable to reinforce learning points and generate discussion and debate. Human factors courses benefit very much from facilitation and two-way exchange of information, rather than instruction and one-way exchange of information.

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[29] Feedback from the CAA/Air Safety Services International (ASSI) human factors course (www.caa.co.uk/srg/intsd) indicates that 3 days is either just right, or not quite long enough.

It may be possible to have a short core course (eg. 2 days) covering key syllabus items relevant to all staff, with additional modules (eg. fatigue and shiftwork) which can be pitched at an appropriate level for particular groups of staff where relevant. The ICAO Human Factors Training Manual suggests a duration of 2 days for human factors training, but it should be remembered that this is in the context of a basic understanding of human factors and human performance and limitations based upon Annex 1 standards, and not specifically expanded to include the practical application of human factors in a work context, and the skills which may be required to be competent in human factors. The more recently published ICAO "Human Factors in Aviation Maintenance Manual" (Doc 9824-AN/450) suggests that between 15 and 30 hours will be needed for a course meeting the objectives described in that document.

12.3 Continuation training

The AMC- states that "The purpose of continuation training is primarily to ensure that all staff remain current in terms of human factors and also to collect feedback on human factors issues". In order to be most cost effective, continuation training should concentrate upon those areas within the company where problems and errors are occurring, and where human factors training is most necessary. These may be identified from the quality system, occurrence reporting/ MEMS system, or other mechanisms (see Chapter 10).

The continuation training itself may be used as an opportunity for two way feedback: (i) for the trainers to hear what problems the staff are encountering with respect to human factors and safety, and to pass these on to the quality department and senior management for appropriate action, and (ii) for the staff to be advised of what problems are current, recent incidents from which they can learn, any new safety initiatives, as well as refresher training on topical human factors areas.

Continuation training is an important means of keeping staff involved in the ongoing human factors and error management programme. Without staff 'buy-in', such programmes are destined to fail. Feedback to staff, based on issues they have raised during previous continuation, is important, and helps with the 'buy-in' process.

Continuation training for human factors trainers, human factors programme managers and those staff who may not be able to attend company continuation training sessions for some reason (such as contract staff), may take the form of attendance at conferences, seminars and workshops on maintenance human factors, where appropriate. However, it should be remembered that such presentations, whilst useful for keeping up-to-date on human factors, are unlikely to address specific company problems, so should be looked upon as additional, rather than alternatives, to in-house company continuation training.

Continuation training may take place throughout the year in the form of a company safety magazine, website or other mechanism for communication. However, this does not guarantee that staff will read the information given to them, nor does it easily allow for two-way feedback, therefore an occasion where staff can get together and discuss the issues, is recommended, in addition to on-going feedback.

Continuation training should not take the form of repetition of syllabus items just for the sake of it - the opportunity should be used to address real, topical issues which are of concern. These issues will often be linked to technical issues, in which case the continuation training opportunity could be used

to address both human factors and technical problems. While there are still human factors problems to be resolved and maintenance errors occurring, continuation training is key to maintaining staff buy-in year on year.

12.4 Duration of continuation training

The duration and frequency of continuation training is whatever is appropriate to address the objectives of (i) ensuring that all staff remain current in human factors, (ii) addressing topical issues where training is required (particularly lessons learned from MEMS) and (iii) collecting feedback on human factors issues from the workforce.

In a large company, the minimum duration would probably be at least 1 day every 2 years, with longer if necessary where human factors related problems are being experienced. This does not mean to say that a 1 day course is necessary every 2 years - information fed back to staff during the year, in the form of a staff magazine, for instance, could count as continuation training, as could feedback from staff via hazard and occurrence reporting systems. However, a specific time set aside for continuation training once a year ensures that time is made available for two-way feedback, should it be needed. If everything is working well and continuous feedback throughout the year is effective, specific annual continuation training may not be necessary, but an organisation would have to be very certain that this was the case before dispensing with the formal biennial continuation training opportunity.

12.5 Human factors training duration for smaller organisations (initial and continuation)

For organisations not engaged directly in maintenance of commercially operated aircraft (or their engines), in particular small companies, the nature and duration of human factors training may be significantly reduced, and that which takes place concentrated mainly upon tasks, work and activities which are likely to have safety implication. For example, a company maintaining aircraft seats would not be expected to put its staff through a 3 day human factors course - a short introduction to human factors, plus module 10 would probably suffice for initial training, and continuation training would cover problems which might have arisen (if any) within the company, with respect to human factors. If it is reasonably certain that no problems exist, human factors continuation training might not be necessary.

Ultimately, the duration of both initial and continuation training should be determined by the TNA. Whilst in practice key factors affecting the duration of training tend to be the cost and whether staff can be released, companies should endeavour to make staff available for whatever time is necessary, determined by the TNA, if training is to be effective in meeting its aims and objectives.

13. Who should provide the training?

Good instructors are crucial to effective human factors training, especially where the emphasis is upon attitude change. Whilst the skills required to impart knowledge are fairly common across most subjects, whether technical or more esoteric, the skills to influence people's attitudes and behaviours are different, and are key to successful human factors training.

It is essential that the human factors trainer (or facilitator) believes in what they are teaching, and has enough credibility, enthusiasm and knowledge to pass on this belief to his students. A good human

factors trainer should be able to positively influence his trainees' safety behaviour, which, ultimately, should reflect positively upon the organisation's safety culture, and even its commercial profitability.

The JAA MHFWG report (appendix A) recommends certain criteria for instructors providing human factors training to meet the Part-145.A.30(e) requirement, namely that the instructor:

- has attended an acceptable Human Factors training course that covers the 145 training syllabus
- has received additional instruction in training and facilitation techniques
- has worked for at least 3 years for[30] a maintenance organisation[31].

13.1 Training the trainer courses

An "acceptable" course is one that provides the trainer with the depth of knowledge, and supporting material, to enable him/her to teach the factual elements of human factors, but also addresses how the various syllabus elements should be taught, and how they might relate to practical work contexts. A course that concentrates purely on the theoretical aspects of human factors would not be acceptable. It is also recommended that the person within the organisation doing the TNA and/or making key decisions regarding the training (such as whether to do it in-house, or to contract out) attend such a course, so that they are making the decisions on an informed basis.

Whilst training/facilitation skills are important, it is not necessarily vital to attend a course to acquire these techniques. What is more important is to have an appropriate feedback system, and occasional quality audits, to ensure that the instructor's training/facilitation techniques are achieving the desired results. This applies to all forms of instruction, but is particularly vital in the case of human factors facilitation, where two-way interaction is more important. Some guidelines in facilitation techniques are included in Appendix V.

The third recommendation from the JAA MHFWG report arose because it was felt that it was more important to have someone teaching the subject who was aware of the practicalities of the job, and who would be able to call upon his/her own experience (particularly errors) to illustrate points. This experience was felt to be more important than formal qualifications in human factors or training skills (although ideal if an instructor could combine experience and skills in all three areas). Ideally, the instructor should have several years experience in aviation maintenance (or work application area of the engineers and tecnicians they will be teaching). Whilst being a Licensed Aircraft Engineer is not a prerequisite, it is felt that it would be valuable. Companies should consider seeking enthusiastic volunteers from among the workforce, to teach human factors - ideally someone who is respected by his/her colleagues, although not someone who is afraid to admit their own fallibility!

If those training human factors are part-time engineers- part-time trainers, this will probably ensure that they are up-to-date with everyday problems; if those teaching human factors are full-time trainers, it would be beneficial for them to keep up-to-date with maintenance tasks and problems by visiting the workplace frequently, and learning from their 'students' at every opportunity. This also helps maintain credibility, which is vitally important to a human factors trainer.

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[30] CAP 716 interprets "working for a maintenance organis ation" as "within the aviation industry, where a good knowledge of maintenance (or subject area being trained) has been obtained".

[31] The JAA MHFWG report distinguishes between initial and recurrent training; CAP 716 does not make this distinction, considering the criteria applicable to both contexts.

13.2 Training MEMS investigators

Training of MEMS investigators is not covered in this chapter, but it may be worth considering whether similar skills are needed for both human factors training and MEMS incident investigations, and merge the two roles (and their training). Careful thought should be given to the advantages and disadvantages of doing this, however, especially in terms of protecting the confidentiality of the MEMS scheme. It is possible that, if the roles were to be combined, the human factors trainer might inadvertently use details from an incident he has investigated, to illustrate a point in training, and unwittingly compromise the confidentiality of the scheme. In addition, a MEMS investigator needs to be available to investigate an incident at short notice, which may clash with scheduled human factors courses.

13.3 External trainers

Human factors training may be provided by either a trainer employed by the organisation or by trainer(s) outside the organisation, although training is likely to be most effective if it is tailored to the specific needs and problems of one's own organisation and the instructor is someone familiar with the needs and problems of that organisation.

In cases where organisations cannot provide their own in-house training, it is acceptable to contract out as long as the main trainer has a good background in aviation maintenance, and meet the criteria mentioned earlier. It is not enough simply to present a set of slides on the syllabus topics without having adequate knowledge to illustrate points using practical examples, or to answer questions. The quality of the trainer is key to the success of human factors training, remembering that Part-145.A.30(e) human factors training is more about changing attitudes and less about imparting knowledge.

Organisations should be wary of inappropriate adaptations of Crew Resource Management (CRM) training being offered as a means to comply with the Part-145.A.30(e) human factors training requirement. Whilst some of the principles may be common to flight operations and maintenance, such courses would need to be specifically tailored to maintenance in order to be applicable. If the course is to be delivered by a CRM instructor (CRMI), it is strongly recommended that this instructor team up with a maintenance engineer so that the latter can assist where practical examples are required to illustrate points.

13.4 Accreditation of human factors trainers

At the time of writing this document, no formal accreditation existed for maintenance human factors instructors, nor do other accreditations (whether CRMI, or Part-147 for individuals, courses or training schools/organisations) apply to Part-145.A.30(e). Organisations are encouraged to train their human factors trainers to an appropriate standard to meet the training needs of the company, or, if contracting out, to seek an instructor and course appropriate to their needs. the best way of doing this is by recommendation, bearing in mind that there is no 'one size fits all' solution, and that what might be appropriate for one company may not be appropriate for another.

13.5 Cost effective training

It may be possible for organisations to meet the letter, but not the intent, of the human factors training requirement by placing their staff on the shortest, cheapest course available. However, organisations are strongly encouraged to investigate the intrinsic quality of the training courses and trainers, and not necessarily to judge by cost, duration or course content. There is evidence to

suggest that good quality human factors training makes commercial sense, as well as safety sense. Several studies have been carried out in the USA on Return on Investment (ROI) of human factors training. The reader is referred to the ROI studies, on http://hfskyway.faa.gov.

If an organisation is looking for the cheapest way of meeting the requirement, it should first consider the following points:

- Not all human factors courses are the same - they will differ in terms of quality and applicability
- Has the company considered the benefits of the training, as well as the costs?
- Is the management deliberately seeking a course that addresses human factors only superficially, because they do not want the behaviour of their workforce changed? In which case, might they be condoning unsafe practices?
- Is the choice of course dictated by what the company thinks will most likely meet the requirement? Have they talked to their CAA surveyor about the options?
- Has the person making the decision done so on an informed basis? - or are they allowing their own preconceptions about human factors to influence their judgement? - consider the benefits of that person attending a human factors course prior to making a decision concerning the company human factors training.
- Does the course adequately address Module 10 of the syllabus?. If not, how will Module 10 be covered?

Organisations are encouraged to seek recommendations from other similar companies which have undergone human factors training, before making a decision. They are also reminded of the long term benefits of training one of their own staff to teach human factors, and to retain and develop this expertise in-house for continuation training purposes. If contracting out, a good quality course meeting the needs of the organisation, based on the company TNA, is what is recommended.

14. Human factors training for contract staff

The guidance in this chapter applies equally to contract staff as well as permanently employed staff, but there were, at the time of writing issue 2 to CAP 716, still some unresolved questions as to the practicalities of how human factors training for contract staff would be effectively achieved and checked. The responsibility is ultimately upon the employing organisation to ensure that "all maintenance...personnel should be assessed for the need to receive initial human factors training, but in any case all maintenance...personnel should receive human factors continuation training" (AMC-145.A.30(e)5).

In addition, the requirement states that "temporary staff [including contractors] may need to be trained shortly after joining the organisation to cope with the duration of employment" (AMC-145.A.30(e)6). This was specifically included in the requirement in order to avert the situation whereby employers and contract staff might be tempted to avoid human factors training by keeping durations of employment under 6 months. This puts more pressure upon contract staff to have received initial human factors training in modules 1-9 before joining an organisation. If a contractor has attended an HF course which is reasonably comprehensive, there is a greater likelihood that the employing organisation will accept this training as meeting AMC-145.A.30(e). This will minimise the need to repeat training. Employing organisations should then ensure that module 10 training, covering the more individual company aspects, is given to contract staff at an early stage, ideally as part of induction training.

Continuation training for contract staff is more difficult, but it is anticipated that employing organisations will be willing to include contract staff, particularly those who are to be authorised to certify for work, when they run such training. This would serve the interest of organisations that use contract staff by ensuring that available staff remain current.

The CAA has implemented and promotes the use of an aircraft maintenance engineers' logbook. This is recommended as suitable mechanism to record human factors training received, along with other training and experience (Part-145 and/or Part-66), although it will still be up to employing organisations to determine whether this training meets their particular needs.

15. Further guidance

The appendices provide much information which may be of use to human factors trainers and those involved in making decisions within each organisation as to how best to meet the Part-145 requirements concerning human factors and error management programmes and human factors training. In particular, the books, videos, websites and other sources of information described in Appendix Z should be of interest, as should the various conferences, seminars, workshops, roadshows and presentations which take place both in the UK and elsewhere, on maintenance human factors.

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