

Unit 77: Human Factors in Aircraft Engineering

Unit code:	R/600/7239
QCF Level 3:	BTEC Nationals
Credit value:	10
Guided learning hours:	60

● Aim and purpose

This unit gives learners an understanding of the human factors that can affect the performance of an aircraft maintenance technician.

● Unit introduction

Although aviation is the safest means of transportation, the aerospace industry can not take aircraft safety for granted. Within any safety-critical industry such as aerospace, where human beings play a central role, it is of paramount importance that the 'right first time' approach is applied. For any technician involved in the manufacture or maintenance of an aircraft or its components, it is essential that they have an understanding of how human factors can impact on their daily routines.

This unit seeks to cover the many performance-influencing factors that can inhibit a technician, both from an organisational and personal perspective. It includes social, cultural, and individual, team and organisational responsibility issues. Learners will be encouraged to relate to their own personal experiences from all aspects of life whilst working towards this unit. The use of facilitated learner-group discussions will form an important part of the learning process, together with looking at recent aircraft accidents/incidents that have been attributed to human factors.

This unit has been written to serve as an introduction to human factors and closely follows the European Aviation Safety Agency (EASA) Human Factors syllabus requirements. It also provides some of the basic knowledge and understanding for learners working towards EASA Part 66 licensing.

Learners will develop their understanding of the wider implications of human factors and its relationship to individual and organisational behaviours that can lead to mistakes being made within the industry.

● Learning outcomes

On completion of this unit a learner should:

- 1 Know the importance of human factors and how they have contributed to aviation accidents
- 2 Understand how various human limitations and behaviours can affect performance
- 3 Know the differences between an error and a violation, and the importance of basic error management principles
- 4 Understand the effect of the organisation and the working environment on safety and performance.

Unit content

1 Know the importance of human factors and how they have contributed to aviation accidents

Importance: human factors in safety-critical industries eg aerospace, rail, medical; relevant and current legislation eg EASA Part 66, Part 145, CAP 715, CAP 716; accident/incident research eg data classification (machine/human), reduction of controlled flight into terrain (CFIT), advances of cockpit resource management (CRM)

Human factors concepts: error chains; Murphy's law; 'Dirty Dozen' (12 most common causes of error)

Accident/incidents: eg Japan Airlines JA123 (1985), Aloha Airlines Flight 243 (1988), United Flight 232 (1989), British Airways Flight 5390 (1990), Alaska Airlines Flight 261 (2000)

2 Understand how various human limitations and behaviours can affect performance

Human limitations: memory; motivation; stress eg work related, personal, domestic; fatigue and sleep patterns (circadian rhythm); perception; knowledge and experience eg situation awareness; complacency; general health; vision; inhibitors eg alcohol, drugs, medicines; external influences eg diet, lifestyle, fitness, exercise; training; individual communication eg verbal, written, body language, gestures

Behaviour: relevance of work ethics eg integrity, professionalism; importance of procedural compliance eg manuals, task sheets, company policies and procedures

3 Know the differences between an error and a violation and the importance of basic error management principles

Error and violation: definitions and forms eg active and latent error, situational and routine violation; social acceptance of rule breaking eg speeding; how norms and habits can impact behaviour

Error prevention: methods eg the importance of using technical data (manuals and task sheets), training, staff selection; audits (both internal and external)

Error capturing: defence barriers eg inspections including duplicates, tool control, calibration, audits, functional tests, training, the use of technical data (manuals, task sheets, procedures)

Error reporting: awareness of reporting requirements eg organisational/internal, legislative/external (Mandatory Occurrence Report (MOR)); error investigation methods eg Maintenance Error Decision Aid (MEDA)

4 Understand the effect of the organisation and the working environment on safety and performance

Workplace factors: organisational eg communication (such as formal, informal), company structure (such as tall, flat, hierarchical), cost constraints, leadership (such as autocratic, democratic); staffing and resource levels; culture eg safety, blame, just, blame free; type of tasks eg simple, complex, repetitive; social psychology (peer pressure); distractions; time constraints; workload; team working eg effective, non-effective

Environment: general working conditions (ergonomic) factors eg space, lighting, heating, noise, climate, temperature; mistakes eg incorrect readings, incorrect messages, poor workmanship, accidents to self and others during work; importance of risk assessments

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 describe the importance of the study of human factors within the aerospace industry	M1 compare the consequences of human factors between the aerospace industry and other safety critical industries such as rail and medical	D1 evaluate the importance of procedural compliance in counteracting human factors within the aerospace industry
P2 describe the human factor concepts that contributed to two recent large-scale air accidents/incidents	M2 explain how changes in the workplace and its environment can affect safety and performance.	D2 evaluate how error management principles can reduce aviation accidents/incidents.
P3 describe the different types of human limitations that can affect human performance		
P4 explain how human behaviour can affect human performance		
P5 describe the differences between error and violation		
P6 describe and explain the importance of error prevention, capturing and reporting		
P7 describe the workplace factors that can affect human performance		
P8 identify conditions in the working environment that could lead to mistakes being made [IE4].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

In all safety-critical industries such as aerospace, it is important that everyone develops an understanding of human factor principles of human factors into everyone as early as possible. Case studies (based on real accidents/incidents) should be considered an essential part of the delivery of the unit to focus learners on the relationship between maintenance error and human factors. Whilst using case studies, learners should be presented with relevant accident/incident investigation material to use. They should be encouraged as much as possible to relate to their own experiences of human factors in their employment/work experience in the industry or other similar fields.

The learning outcomes form a natural order for delivery. A large amount of information relating to all areas of the unit content can be found within CAP 716 and via research on the internet. Centres can also utilise recent television programmes which highlight human factor issues surround aircraft accidents.

Learning outcome 1 provides context for the importance of human factors in the aerospace industry. The investigation of accidents will highlight the human factors involved and learners should be encouraged to look at the relevance of their findings to other safety-critical industries.

Learning outcome 2 is about identifying the human limitations such as fatigue and stress that can affect a technician's performance when undertaking everyday tasks.

Learning outcome 3 must be emphasised as the most important aspect of human factors. Firstly, the differences between errors and violations will need to be highlighted, namely intent, and how norms and habits can have a part to play in the actions and behaviours of technicians. Secondly the importance of error management (or control) through defence barriers such as training, duplicate inspections, calibration etc and other defence barriers will need to be covered. The final part of this learning outcome focuses on error reporting, the legislative requirements of both internal and external reporting and how they can impact on any possible future errors.

Delivery of learning outcome 4 will need to consider organisational impacts and the workplace factors that can affect an individual's behaviour, including the working environment that aerospace technicians are working in.

The unit has been designed to give learners a thorough introduction to human factors appropriate to the industry. Wherever possible (and particularly during case-study exercises) learners should be encouraged to work in small groups, discussing and sharing their experiences with each other and the group as a whole.

Note that the use of 'eg' in the content is to give an indication and illustration of breadth and depth of the topic of human factors. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• Explain role of human factors in safety-critical industries• Explain role of error chains; Murphy's law; 'Dirty Dozen'• Describe factors that have attributed to real air accidents. <p><i>Individual/small group activity:</i></p> <ul style="list-style-type: none">• Case study of examples of air accidents.
<p>Preparation for and carrying out Assignment 1: Human Factors in Aviation (P1, P2, M1).</p>
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• Describe limitations that can affect the work of a technician• Discuss role of memory, stress, knowledge and experience, complacency• Discuss relevance of work ethics and compliance. <p><i>Individual/small group activity:</i></p> <ul style="list-style-type: none">• Case study of examples of incidents in the workplace.
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• Explain and define and forms of error and violation• Describe methods of reducing and preventing error• Explain error reporting processes and procedures. <p><i>Individual/small group activity:</i></p> <ul style="list-style-type: none">• Case study of examples of local/national employer and methods used to reduce risk of error.
<p>Preparation for and carrying out Assignment 2: Human Limitations and Error (P3, P4, P5, P6, D1, D2).</p>
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• Explain organisational factors that can affect safety• Explain effects of staffing, resource levels and workloads• Explain importance of work culture within an organisation. <p><i>Individual/small group activity:</i></p> <ul style="list-style-type: none">• Case study of examples of incidents in the workplace.
<p>Preparation for and carrying out Assignment 3: Organisational Factors and the Working Environment (P7, P8, M2).</p>

Assessment

Evidence of learning outcomes may be collected from case studies, tests, exercises and assignments that enable learners to explore the application of human factors to minimise the risks of human error in maintenance activities.

To achieve a pass grade, learners must demonstrate an understanding of the importance of human factor considerations applied to the aerospace industry and especially within maintenance activities.

The unit could be assessed through the use of three assignments. The first assignment could cover P1, P2 and M1, covering the content of learning outcome 1. Learners are expected to describe in their own words the importance of the study of human factors in the aerospace industry (P1) and its relevance to at least two recent large-scale aircraft accidents/incidents (P2). Where possible learners should be encouraged to research accidents from other safety-critical industries, such as rail, to compare accident analysis data and meet merit criteria M1.

The second assignment could cover the grading criteria that relate to learning outcomes 2 and 3, namely P3, P4, P5, P6, D1 and D2. Learners are expected to describe the different performance limitations (P3) listed in the unit content, building on the 'dirty dozen' looked at in learning outcome 1. The relationship of behaviour (P4) is key to understanding human factors, especially rule breaking and its effects on error (eg failure to follow procedures). Simple class exercises could be used to show the importance of following instructions and not relying on memory or perception of the required tasks.

Learners will also need to describe the main differences between an error and a violation (P5). This should include the intent to do something wrong (not working to manuals/procedures etc) and how one-off situational violations can turn into routine violations, undertaken every time the same task is required.

It is important that learners are shown that behaviours outside of the workplace, for example speeding and its social acceptance, mean that sometimes people will carry on with law/rule breaking behaviour inside the workplace. Learners should understand that not following the rules can lead to actual (active) or latent error, something done wrong now that won't appear or go wrong until many years in the future, such as the United 232 (Sioux City) accident. The assignment will also need to ask learners to show a level of understanding of basic error management principles (P6). This should include looking at the importance of defence barriers such as duplicate inspections and the legal requirements of error reporting.

To achieve a distinction grade learners must fully understand and evaluate the importance of procedural compliance in counteracting human factors (D1). Learners will also need to demonstrate comprehension of how the reporting of errors and violations and their subsequent investigation using tools such as MEDA can reduce the occurrence of accidents/incidents (D2). This should include details of how learning from other individuals' and organisations' mistakes and the sharing of 'best practice' information around maintenance activities is an integral part of human factors requirements.

The final assignment could cover the criteria associated with learning outcome 4 and build on the knowledge from the other learning outcomes regarding human performance including error and violation. Learners will need to describe what difference an organisation's structure, management style and especially culture (both actual or perceived) can have on individuals or groups (P6). Learners will also need to describe the environmental and ergonomic factors (P7) such as lighting and temperature that could possibly lead to error or violations. A written task to show the relationship of the workplace and its environment to behaviour and how it can affect performance (M2) will be required for the final merit criteria.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1	Human Factors in Aviation	Learners research recent aviation history to establish the role that human factors contributed to an air incident/accident.	A written report and/or presentation.
P3, P4, P5, P6, D1, D2	Human Limitations and Error	Learners investigate the main performance limitations that can apply to maintenance.	A written report.
P7, P8, M2	Organisational Factors and the Working Environment	Learners study an air maintenance/ manufacturing organisation to establish what role its structure, management style and culture have on employees.	A written report.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
		Aircraft Workshop Principles and Practice
		Aircraft Maintenance Practices

The principles within this unit relate to all the practical units within the BTEC Nationals in Aerospace Engineering. The unit also provides some of the knowledge and understanding associated with EASA Part 66, Module 9 Human Factors.

Essential resources

To meet the needs of this unit it is essential that the centre has, or has access to, facilities for carrying out research into the topic. As well as a wide range of subject literature and research material, centres will need to ensure learners have access to the internet.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI – University of Warwick) – www.warwick.ac.uk/wie/cei/
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbook

Patankar M and Taylor J – *A Practical Guide to Applied Human Factors in Aviation Maintenance* (Ashgate, 2004)
ISBN 0754619400

Websites (legislative)

Civil Aviation Authority (CAA)	www.caa.co.uk
Federal Aviation Administration (FAA)	www.hf.faa.gov/webtraining/index.htm
Health and Safety Executive (HSE)	www.hsegov.uk/humanfactors/index.htm

Websites (general interest)

Aviation Safety Network	www.aviation-safety.net
Maintenance and ramp safety society	www.marss.org

Other materials

Available via the CAA website:

- CAP 715: An Introduction to Aircraft Maintenance Engineering Human Factors
- CAP 716: Aviation Maintenance Human Factors
- CAP 718: Human Factors in aircraft maintenance and inspection
- CAP 719: Fundamental Human Factors Concepts.

The appendices of all the above documents provide references for further information and research material.

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	analysing and evaluating information when identify conditions in the working environment that could lead to mistakes being made.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Reflective learners	Setting goals with success criteria for their development and work.

● Functional Skills – Level 2

Skill	When learners are ...
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating how various human limitations and behaviours can affect performance
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the different types of human limitations that can affect performance explaining how human behaviour can affect their performance describing the differences between error and violation describing and explaining the importance of error prevention, capturing and reporting.