Unit 87: Avionic Systems

Unit code: Y/600/7307
QCF Level 3: BTEC Nationals
Credit value: 10
Guided learning hours: 60

Aim and purpose

This unit will develop learners' understanding of aircraft communications, navigation, automatic flight control, flight management and monitoring systems.

Unit introduction

The avionic systems installed on modern aircraft have grown significantly over the last few decades in terms of complexity and their level of integration with other aircraft systems. A thorough understanding of avionic systems and their underpinning principles is needed by aircraft technicians involved in the installation and maintenance of these systems.

This unit will familiarise learners with a range of avionic systems and will develop an understanding of fundamental avionic principles, particularly the application of digital techniques in avionic systems. Learners will also know how avionic systems are monitored and tested.

Learners will investigate the operational aspects of key avionic systems and will understand how they interface with other aircraft systems. Learners will start by investigating how logic functions and numbering systems are used as the basis of digital components. This leads to how digital components form the end applications such as electronic displays and computer memory. This is followed by a look at radio frequency (RF) principles and how these are applied to communication and navigation systems.

The theme of navigation develops through area navigation and on to flight management systems. The unit will also cover the operation of automatic flight control systems (AFCS). The final section of the unit looks at methods of troubleshooting avionic systems.

This unit has been designed to provide some of the knowledge required for learners wishing to progress on to the European Aviation Safety Agency (EASA) Part 66 licensing requirements. It will also benefit those seeking employment within the armed forces or the aircraft manufacturing industry.

Learning outcomes

On completion of this unit a learner should:

1 Be able to relate digital electronic fundamentals to their end applications

2 Know the purpose of typical aircraft electronic systems

3 Understand the operation of an automatic flight control system

4 Understand the principles of monitoring and testing avionic systems

Unit content

1 Be able to relate digital electronic fundamentals to their end applications

Logic functions: common logic circuit functions eg digital signals, combinational logic, sequential logic

Numbering systems: principles of numbering systems eg binary, binary codes, octal, hexadecimal, denary

Hardware: components eg integrated circuits, printed circuit boards, computer memory, microprocessors; electronic displays eg cathode ray tubes, liquid crystal displays, light emitting diodes

2 Know the purpose of typical aircraft electronic systems

Radio frequency (RF) principles: nature of radio wave transmissions eg electromagnetic spectrum, modulation, amplifiers, transmitters, receivers; frequency bands eg high (HF), very high (VHF), ultra high (UHF)

Communication systems: manual and automatic systems eg flight deck communications, data communications, interphone system, aircraft communications addressing and reporting system (ACARS), satellite communications (SATCOM, cockpit voice recorder (CVR), selective calling (SELCAL))

Navigation systems: radio/radar navigation systems eg automatic direction finder (ADF), VHF omnirange (VOR), instrument landing system (ILS), microwave landing system (MLS), distance measuring equipment (DME), VLF/Omega; self-contained/long-range systems eg inertial navigation system (INS), inertial reference system (IRS), global navigation satellite systems (GNSS), long range navigation (LORAN), Doppler navigation

Flight management systems: area navigation eg navigation data base, position initialisation, route planning, navigation system management, lateral navigation (LNAV); performance management eg operational database, performance initialisation, flight planner and management, programme pin identification, auto-throttle, vertical navigation (VNAV)

3 Understand the operation of an automatic flight control system

Automatic flight control system (AFCS) components: mode control panel; computer amplifier; servos (roll, yaw, pitch); attitude references; flight director; flight mode annunciator; audible and visual warnings

Basic operation: pitch modes eg altitude hold; vertical speed select, indicated air speed (IAS) select, mach hold; roll modes eg heading select, LOC/VOR select; auto approach and landing

4 Understand the principles of monitoring and testing aircraft avionic systems

Purpose of monitoring: cost reduction eg reduce unnecessary removals, reduce no fault found; predictive maintenance; simplify troubleshooting

Test methods: individual line replaceable unit (LRU) testing eg current operation monitoring, built-in test (BIT), built-in test equipment (BITE), go/no test, fault codes; comprehensive system testing eg fault history, centralised maintenance systems

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 where digital electronics including logic functions, numbering systems and hardware are used in avionic systems	**M1** compare the operation of three aircraft navigation systems and their application	**D1** evaluate how a flight management system is initialised with performance and navigation data
P2 describe the principles of radio frequency transmissions	**M2** explain in detail how an automatic flight control system is used during approach and landing	**D2** evaluate the interaction of avionic components on the overall performance of an automatic flight control system.
P3 describe the use of three aircraft communication systems	**M3** explain how flight management systems can reduce operating costs with area navigation and flight performance management.	
P4 describe the features of two radio/radar navigation systems and two self-contained/long-range systems		
P5 describe the basic features of flight management system area navigation and performance management		
P6 define the use of AFCS components		
P7 describe the basic operation of one pitch and one roll mode of an automatic flight control system		
P8 state the purpose of monitoring and describe a test method for a given avionic system [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

Delivery of this unit should begin with an introduction to digital systems and the contribution they make to the effectiveness and capability of avionic systems. It might be useful to give an overview of how avionic systems have developed over the last 25–30 years as a result of advances in microelectronics and electronic displays. Illustrations of these advances could be via comparisons of hardware using actual equipment and/or videos.

Examples of how avionic systems are used should focus on their operation in a commercial or military environment. Use can also be made of any first-hand experience that learners may have gained through work experience and/or the Air Training Corp (ATC). The avionic systems in this unit (communications, navigation, automatic flight control systems and flight management systems) all have significant technical content and it is not intended that each is covered in depth.

Learning outcome 1 covers fundamental principles of digital electronics. Note that this is a subject in its own right and care must be taken to only address the relevant unit content (logic functions, numbering systems and basic hardware). There is a huge amount of data available on this subject and when learners are carrying out research they should be given structured tasks which lead them to the specified content. It is important that learners grasp the concept of how small electronic devices, for example diodes and transistors, can be scaled-up into larger computer functions, such as memory devices.

Before starting work on learning outcomes 2 and 3, learners would benefit from being able to see inside an aircraft flight deck or cockpit. In the context of this unit 'flight deck' is used to define the pilots' stations on a commercial aircraft and 'cockpit' is used for general aviation or military aircraft. This could be achieved by using the centre's own aircraft and/or by carrying out a visit to an airline, repair organisation or military base. Because of the security associated with the aircraft industry, alternative arrangements could include viewing an aircraft simulator or aircraft museum. For learning outcome 2, DVDs and/or videos could be used to help learners appreciate how systems are used. It would also be beneficial for learners to get their hands on equipment such as control panels or aircraft computers and take them apart to see how they are constructed.

Learning outcome 2 is covered by criteria P2, P3, P4 and P5. For the radio frequency criteria (P2), learners are not expected to have detailed knowledge of radio wave propagation. They are only required to produce evidence that relates to the basic principles of how a radio wave is transmitted and received, together with an understanding of frequency bands used for aircraft.

Learning outcome 3 is covered by P6 and P7. When defining the use of the main system components (P6), learners should be guided towards the specific components of the AFCS itself with minimal references to systems that integrate with the AFCS. Where integration of the AFCS with other aircraft systems is covered (P7), it would add interest to the task(s) if it is contextualised and based on a simple flight plan devised by the assessor.

P8 covers learning outcome 4. Delivery of this learning outcome should include some maintenance training DVDs/videos, so that learners can appreciate how avionic systems are tested using built-in test equipment. It would also be beneficial for learners to see printouts from typical aircraft maintenance computers so that normal and abnormal parameters can be discussed. When designing the delivery of learning outcome 4, it is important that learners are only required to retain knowledge and skills for simple procedures relating to the testing, maintenance and faultfinding of systems.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. 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
Whole-class teaching: • introduction to unit content, scheme of work and methods of assessment • explain digital electronic principles, including logic circuit functions and numbering systems • describe the operation and use of a range of digital avionic components and displays. *Individual learner activities:* • investigative task to research digital signals and combinational and sequential logic • investigative task to research use of numbering systems. *Practical workshop activities:* • practical investigation of digital electronic applications in avionic hardware.
Prepare for and carry out **Assignment 1: Avionic Applications of Digital Electronics** (P1).
Industrial visit: • visit to an airline or aircraft repair centre to view commercial flight deck and instruments. *Whole-class teaching:* • explain the nature of radio waves and explain the different frequency bands • describe the purpose and function of manual and automatic communication systems • describe the purpose and function of radio/radar and long-range navigation systems • describe the purpose and function of flight management systems. *Practical workshop activities:* • practical investigation of the construction of aircraft communication, navigation and flight control systems and system components.
Prepare for and carry out **Assignment 2: Aircraft Radio and Communication Systems** (P2, P3).
Prepare for and carry out **Assignment 3: Aircraft Navigation and Flight Management Systems** (P4, P5, M1, M3, D1).
Whole-class teaching: • explain the function and operation of an automatic flight control system and the system components. *Practical workshop activities:* • practical investigation of function and operation of flight control system components. *Individual learner activities:* • investigation of pitch and roll modes for an automatic flight control system.
Prepare for and carry out **Assignment 4: Automatic Flight Control Systems** (P4, P5, M1, M3, D1).
Whole-class teaching: • explain the main reasons for monitoring avionic systems • describe the use of LRU testing and comprehensive system testing • describe and demonstrate simple procedures relating to testing and maintenance of avionic systems.

Topic and suggested assignments/activities and/assessment
Industrial visit: • visit to aircraft maintenance centre to view use of test equipment and maintenance computers.
Prepare for and carry out **Assignment 5: Avionic Systems Testing and Maintenance** (P8).
Feedback on assessment and unit evaluation.

Assessment

Assessment of this unit could be achieved through five assignments as detailed below. A variety of assessment instruments could be used including (but not limited to) short answer questions, observations and written assignments.

The first assignment could just cover P1 and should be structured so that learners remain focused on the unit content of learning outcome 1. Learners are expected to use their own words when referring to applications and while much of their research will be done using the internet, it is important that what they present is not just a simple cut-and-paste exercise. Evidence to support knowledge of digital applications could be generated by giving learners a list of situations/scenarios and then asking them to detail what methods could be used.

Grading criteria P2 and P3 could be assessed through a second assignment that would cover part of the unit content for learning outcome 2 and lead into P4.

Criterion P4 then links into P5, M1, M3 and D1, which could all be assessed by the third assignment.

Although automatic flight control systems are integrated with many other avionic systems, grading criteria P6 and P7 would fit well into a fourth assignment. This assignment could then be extended to incorporate M2 and D2.

The last assignment would cover grading criteria P8 and should involve a given avionic system scenario. Learners could assume the role of a maintenance technician who has been tasked with investigating pilot reports that have been recorded in the technical log. Evidence for this criterion should show that learners can distinguish between permanent and intermittent faults.

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	Avionic Applications of Digital Electronics	A technician has been asked to produce an information leaflet detailing the applications of digital electronics in avionic systems.	A written task.
P2, P3	Aircraft Radio and Communication Systems	A technician needs to tell a new apprentice about radio frequency principles and the applications of communication systems.	A series of written tasks and/or a presentation evidenced through tutor observation and relevant handouts.
P4, P5, M1, M3, D1	Aircraft Navigation and Flight Management Systems	A technician needs to tell a new apprentice about the features of aircraft navigation and flight management systems.	A series of written tasks and/or a presentation evidenced through tutor observation and relevant handouts.
P6, P7, M2, D2	Automatic Flight Control Systems	A technician needs to tell a new apprentice about the features and operation of an AFCS.	A series of written tasks and/or a presentation evidenced through tutor observation and relevant handouts.
P8	Avionic Systems Testing and Maintenance	A technician has been asked to investigate possible faults reported in an avionic system.	A written task and/or a presentation evidenced through tutor observation and relevant handouts.

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
		Electrical and Electronic Principles
		Aircraft Electrical Systems
		Aircraft Instruments and Indicating Systems

It covers some of the knowledge and understanding associated with the SEMTA Level 3 National Occupational Standards in Aeronautical Engineering (Electrical and Electronic Avionic Systems Installation), particularly:

- Unit 79: Testing Aircraft Communication Systems
- Unit 80: Testing Aircraft Flight Guidance and Control Systems
- Unit 81: Testing Aircraft Navigational Systems.

Essential resources

To meet the needs of this unit it is essential that centres have access to the following:

- an aircraft and/or simulator with functioning avionic equipment
- representative avionic equipment, eg control panels, computers, displays and indicators
- test equipment and measuring instruments
- relevant aircraft technical publications, eg maintenance manuals, system schematics, wiring diagram manuals.

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

Textbooks

Eismin T – *Aircraft Electricity and Electronics* (McGraw-Hill, 1994) ISBN 0071132864

Pallett E and Coombs L – *Aircraft Instruments and Integrated Systems* (Longman Scientific and Technical 1996) ISBN 0582086272

Tooley M and Wyatt D – *Aircraft Digital Electronic and Computer Systems* (Elsevier 2006), ISBN 0750681381

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 determining a test method for a given avionic system.

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	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	describing the applications of digital electronics in avionic systems describing the principles of radio frequency transmissions describing the use of aircraft communication systems describing the features of radio/radar navigation systems self-contained/long range systems describing the features of flight management systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating avionic systems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the applications of digital electronics in avionic systems describing the principles of radio frequency transmissions describing the use of aircraft communication systems describing the features of radio/radar navigation systems self-contained/long range systems describing the features of flight management systems.