Unit T22: Avionic Systems Engineering

Unit code:	R/504/0134
QCF level:	6
Credit value:	15

Aim

The aim of this unit is to provide learners with a detailed knowledge and understanding of a wide range of avionic and radar systems used in aircraft and how they are integrated into more complex flight management systems to provide efficient, reliable and safe control of an aircraft.

Unit abstract

Effective avionic systems are crucial to the operation of all modern aircraft. This unit will develop learner understanding of a wide range of avionic systems. Learners will begin by investigating and analysing representative aircraft systems used for communication, navigation, transponder, collision avoidance, flight monitoring and automatic control. They will also test and evaluate the different types of antenna used for avionic applications. Learners will continue by investigating the principles, operation and application of aircraft radar and ground radar systems. They will critically evaluate these systems and analyse the performance of representative radar antennas.

Aircraft data bus systems allow a wide variety of avionics equipment to communicate with one another and exchange data. Learners will investigate representative data bus systems demonstrating their use in a modern aircraft where a number of complex avionic systems need to be interoperable and yet remain tolerant of faults which can potentially propagate through the system.

Finally, learners will analyse, evaluate and demonstrate systems used to ensure the safe, reliable and cost-effective operation of an aircraft. These include systems used for gathering, processing and displaying information about an aircraft's position, altitude and motion, as well as automatically controlling an aircraft in flight and during landing.

Learning outcomes

On successful completion of this unit a learner will:

1 be able to analyse the avionic systems used in modern aircraft

2 understand the principles, operation and application of aircraft and ground radar systems

3 understand aircraft data bus and integrated avionic systems

4 understand systems for flight monitoring, automatic flight control (AFCS) and flight management (FMS).

Unit content

1 Be able to analyse the avionic systems used in modern aircraft

Communication systems: HF voice; VHF voice; satellite voice; HF data link (HFDL); VHF data link (VHFDL); aircraft communications addressing and reporting system (ACARS); amplitude modulation (AM); frequency modulation (FM) single-sideband (SSB); multiple frequency shift keying (MFSK); phase shift keying (PSK)

Navigation systems: VHF omnidirectional radio range (VOR); tactical air navigation (TACAN); automatic direction finder (ADF); distance measuring equipment (DME); global positioning system (GPS) and global navigation satellite system (GNSS); inertial navigation systems (INS); Kalman filters; errors and corrections

Surveillance systems: traffic alert and collision avoidance system (TCAS); air traffic control transponder systems (Modes A, C and S); automatic dependent surveillance-broadcast (ADS-B)

Antennas: Ultra High Frequency (UHF); Very High Frequency (VHF); High Frequency (HF); omnidirectional; directional; steerable; satellite communications (Satcom); low profile; antenna feeders; coupling units; switching units; matching units

2 Understand the principles, operation and application of aircraft and ground radar systems

Aircraft radar: pulsed radar systems; Continuous-wave (CW) radar systems; primary, secondary and Doppler radar systems

Antennas: horn; flat plate array; reflector types

Ground radar: ground movement; surveillance; precision approach radar; air traffic control radar

Performance parameters: mean and peak power; range; bearing; height; radar equations.

3 Understand aircraft data bus and integrated avionic systems

Aircraft data bus systems: bus architecture; bus protocols; bus timing; bus control; data word format; physical bus connections; bus termination; ARINC 429; ARINC 573; ARINC 629; MIL-STD-1553B/1773B; CSDB; ASCB; FDDI

Integrated avionic systems: flight data recorder (FDR); electronic aircraft monitoring systems (ECAM); built-in test equipment (BITE).

4 **Understand systems for flight monitoring, automatic flight control (AFCS) and flight management (FMS)**

Flight monitoring systems: gyroscopic systems; magnetic systems; air data systems; air data computers; electronic displays; data recording; electronic attitude director indicator (EADI); electronic horizontal situation indicator (EHSI); electronic attitude director indicator (EADI); multi-function displays

Automatic flight control systems (AFCS): integrated flight control systems; flight directors; auto throttle; auto pilot; instrument landing systems (ILS); auto land systems

Flight management systems: aircraft navigation database; required navigation performance (RNP); lateral navigation (LNAV); vertical navigation (VNAV); factors affecting fuel efficiency.

Learning outcomes and assessment criteria

Learning outcomes On successful completion of this unit a learner will:	**Assessment criteria for pass** The learner can:
LO1 Be able to analyse the avionic systems used in modern aircraft	1.1 Critically evaluate High Frequency (HF), Very High Frequency (VHF) and satellite-based communication systems 1.2 Critically evaluate aircraft navigation and position fixing systems 1.3 Critically evaluate collision avoidance and air traffic control transponder systems 1.4 Critically evaluate the performance of antennas suitable for use on aircraft, space vehicles and ground stations
LO2 Understand the principles, operation and application, of aircraft radar and ground radar systems	2.1 Identify the key factors necessary for the satisfactory operation of aircraft and ground radar systems 2.2 Critically evaluate weather radar, ground radar and aircraft tracking systems 2.3 Critically evaluate the performance of horn, flat plate array and reflector radar antennas
LO3 Understand aircraft data bus and integrated avionic systems	3.1 Develop a rationale for the integration and interoperation of aircraft avionic systems 3.2 Critically evaluate current aircraft data bus systems that comply with ARINC standards, using investigation results 3.3 Critically evaluate the performance of integrated avionic systems in relation to fault tolerance, using investigation results
LO4 Understand systems for flight monitoring, automatic flight control (AFCS) and flight management (FMS)	4.1 Critically evaluate the performance of flight monitoring systems including sensors and associated data acquisition, processing and display systems, using investigation results 4.2 Critically evaluate automatic flight control systems (AFCS) including autopilot and automatic landing systems, using investigation results 4.3 Develop a rationale for an integrated flight management system (FMS).

Guidance

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

The learning outcomes associated with this unit are closely linked with:

Level 4	Level 5	Level 6
Unit 85: Automatic Flight Control Systems	*Unit 35: Further Analytical Methods for Engineers*	*Unit T6: Data Communication and Sensor Networks*
	Unit 59: Advanced Mathematics for Engineering	*Unit T7: Modelling and Simulation for Engineers*
	Unit 82: Aircraft Systems Principles and Applications	*Unit T8: Digital Signal Processing*
	Unit 91: Integrated Flight Instrument Systems	*Unit T10: Embedded Systems in Engineering*
		Unit T12: Digital Communications in Engineering

The content of this unit has been designed and mapped against the Engineering Council's current learning outcomes for IEng accreditation. The completion of the learning outcomes for this unit will contribute knowledge, understanding and skills towards the evidence requirements for IEng registration.

See *Annexe B* for a mapping of the Edexcel BTEC Level 6 Diploma units to IEng programmes.

Essential requirements

Representative examples of:

- aircraft communication, navigation, surveillance and radar systems, including displays, controllers and antennas. This should include an allocation of time on representative aircraft and/or simulators.
- avionic test equipment including Radio Frequency (RF) test gear (power meter, modulation meter, digital frequency meter, Standing Wave Radio (SWR) bridge, etc.)
- bus analyser compatible with the bus systems in use (eg ARINC 429, ARINC 573, ARINC 629, ARINC 708, MIL-STD-1553B/1773B, FDDI)
- antenna test equipment (RF anechoic chamber or outside test range). Learners will also need access to appropriate software (eg Matlab or Scilab) for simulation purposes
- ARINC documentation and standards (see 'Other publications').

Delivery

The emphasis for this unit should be on avionic systems rather than the individual components that make up those systems. The unit should ideally involve mixed delivery methods based on the use of whole-class lectures, practical investigations, work-based learning assignments, tutorials and one-to-one consultation with subject specialists.

It is desirable that this unit is taught using case studies that put the avionic systems into context and also motivate learners. The assignment(s) should then be based on critical evaluation of these systems, requiring learners to demonstrate their understanding of the principles, operation, applications and limitations of the systems. This will require access to working systems and relevant documentation (see 'Other publications').

Learners will require access to typical avionic systems either on 'live' aircraft and/or simulators or by making use of working systems within a laboratory or workshop environment. Learners should be encouraged to explore new innovations in avionics rather than those that rely on outdated technology.

A total of 150 hours of notional learning time is recommended for this unit comprising the following:

1) A lecture program of 2 hours per week (1.5 hours lecture and 0.5 hours discussion/seminar/tutorial) for a total of 20 weeks is suggested as formal learning time (40 hours).
2) Workshop/laboratory-based sessions of 1 hour per week for 20 weeks where learners work in groups carrying out structured investigations and testing of avionic systems with tutor or technician support.
3) Self-study time for learners to work in groups to carry out their investigations, undertake additional research and prepare and present their findings (90 hours).

It is strongly recommended that learners work in small groups (of not more than four learners) and receive individual marks for their work. This will require: (i) supervisors sitting in on some formal meetings, (ii) each page in the report produced by the group must show the name of the learner primarily responsible for the contents and (iii) a system of peer review.

Assessment

Two or three group reports and presentations as described previously in the *Delivery* section.

Resources

Textbooks

Collinson R P G – *Introduction to Avionics* (Springer, 2011)
ISBN 978-9400707078

Federal Aviation Administration – *Advanced Avionics Handbook*
(FAA Handbooks, 2009) ISBN 978-1560277583

Helfrick A – *Principles of Avionics* (Airline Avionics, 2007)
ISBN 978-1885544261

Macnamara T M – *Introduction to Antenna Placement and Installation*
(John Wiley and Sons 2010) ISBN 978-0470019818

Moir I, Seabridge A and Jukes M – *Civil Avionics Systems* (Wiley, Blackwell, 2006) ISBN 978-0470029299

Spitzer C – *Avionics: Development and Implementation (Avionics* Handbook)
(CRC Press, 2006) ISBN 978-0849384417

Spitzer C – *Avionics: Elements, Software and Functions* (Avionics Handbook)
(CRC Press, 2006) ISBN 978-0849384387

Tooley M – *Aircraft Communication and Navigation Systems*
(Butterworth-Heinemann, 2007) ISBN 978-0750681377

Tooley M – *Aircraft Digital Electronic and Computer Systems*
(Butterworth-Heinemann, 2007) ISBN 978-0750681384

Tooley M and Wyatt D – *Aircraft Electrical and Electronic Systems*
(Butterworth-Heinemann, 2009) ISBN 978-0750686952

Other publications

The following is a selection of publications available from ARINC (Aeronautical Radio, Incorporated) at http://www.arinc.com:

- ARINC Specification 429P1-17 Mark 33 Digital Information Transfer System (DITS), Part 1, Functional Description, Electrical Interface, Label Assignments and Word Formats
- ARINC Specification 429P2-16 Mark 33 Digital Information Transfer System (DITS), Part 2 - Discrete Data Standards
- ARINC Specification 429P3-19 Mark 33 Digital Information Transfer System (DITS) - Part 3 - File Data Transfer Techniques
- ARINC Specification 429P3-19 Mark 33 Digital Information Transfer System (DITS) - Part 3 - File Data Transfer Techniques
- ARINC Characteristic 578-4 Airborne ILS Receiver
- ARINC Characteristic 579-2 Airborne VOR Receiver
- ARINC Characteristic 591 Quick Access Recorder for AIDS System (QAR)

- ARINC Characteristic 594-4 Ground Proximity Warning System
- ARINC Report 600-19 Air Transport Avionics Equipment Interfaces
- ARINC Report 629 Part 1-5 - Multi-Transmitter Data Bus, Part 1-Technical Description
- ARINC Report 629 Part 2-2 Multi-Transmitter Data Bus, Part 2-Application Guide
- ARINC Report 631-5 VHF Digital Link (VDL) Mode 2 Implementation Provisions
- ARINC Report 631-6 VHF Digital Link (VDL) Mode 2 Implementation Provisions Standards
- ARINC Report 634 HF Data Link System Design Guidance Material
- ARINC Report 635-4 HF Data Link Protocols
- ARINC Report 636 Onboard Local Area Network (OLAN).

Journals and websites

www.aviationtoday.com/av/	Aviation Today
www.cotsjournalonline.com/technologies/view/Avionics	Journal of Military Electronics and Computing