Unit 85: Aircraft Instruments and Indicating Systems

Unit code: K/600/7280

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit will familiarise learners with some of the key instruments and indicating systems installed on modern aircraft. These include primary flying instruments, primary engine instruments and airframe system indicators.

Unit introduction

Although electromechanical instruments are being replaced by electronic displays on transport and military aircraft, it is important that learners appreciate the fundamentals and origins of instrumentation and indicating systems. To broaden the scope of this knowledge, it is necessary that learners have an understanding of some fundamental instrumentation principles, including gyroscopes, air data instruments and synchro systems. Learners should also know how instrument systems are installed and tested.

This unit encourages learners to investigate the purpose of key instrument systems and how they contribute to the overall effectiveness of aircraft operation. Learners start by investigating the earth's atmosphere and the construction and operation of air data instruments. This is followed by a study of the gyroscopic instruments that provide attitude and directional information. The unit concludes with an investigation into engine and airframe instruments.

On completion of this unit learners will have a broad understanding of the operation of these key instrument systems, together with how basic scientific principles are applied. This will include understanding the principles of monitoring to identify faults in these 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 Know the operation of air data instrument systems

2 Know the operation of gyroscopic instruments

3 Know the operation of engine indicating systems

4 Know the operation of airframe system indicators.

Unit content

1 Know the operation of air data instrument systems

Principles: physical properties of the earth's atmosphere eg pressure, density and temperature variations with altitude; measurement of aircraft altitude, forward speed and vertical speed; construction and operation of air data instruments eg altimeters, vertical speed indicators (VSI), air speed indicators (ASI), Mach meters, angle of attack indicator, stall and warning system, turn co-ordinator, capsules, pointers, displays

Systems: Pitot-static systems eg altimeters, vertical speed indicators (VSI), air speed indicators (ASI), Mach meters, Pitot tubes, angle of attack indication, static ports, piping, connectors, drain traps, sense and leak checks, associated maintenance procedures and related safety precautions

2 Know the operation of gyroscopic instruments

Principles: gyroscope properties eg rigidity, precession; gyroscope eg space, earth tied; wander eg real, apparent, transport

Instruments: construction of basic instruments eg rotors, gimbals, bearings, torque motors, levelling switches, damping mechanisms; attitude reference eg artificial horizon, attitude direction indicator (ADI), handling of gyroscopic instruments; directional reference instruments eg directional gyro, horizontal situation indicator (HSI), turn and slip indicators, gyrocompass, handling of gyroscopic instruments

3 Know the operation of engine indicating systems

Parameters: primary engine indicators and transducers eg turbine or cylinder temperature, inter-stage turbine temperature, exhaust gas temperature, manifold temperature, engine turbine discharge pressure/ jet pipe pressure systems, rotational speed, fuel flow, torque, thrust, oil pressure and oil temperature, vibration measurement and indication

Operation: simple fault diagnosis on engine indicating systems eg turbine or cylinder temperature, inter-stage turbine temperature, exhaust gas temperature, manifold temperature, engine turbine discharge pressure/jet pipe pressure systems, rotational speed, fuel flow, torque, thrust, oil pressure and oil temperature, vibration measurement and indication

4 Know the operation of airframe system indicators

Principles: fluid temperature transducers and indicators eg resistance temperature devices, Wheatstone bridge, thermocouples, thermostatic switches; fluid pressure transducers and indicators eg capsules, strain gauges, Bourdon tubes, transducers; remote position indicating systems eg potentiometers, DC synchro indicating systems, AC synchro indicating 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 how the earth's atmosphere is used to measure altitude, airspeed and vertical speed [IE4]	**M1** analyse the results of a pitot-static sense and leak check to ascertain the system's operational status	**D1** evaluate the performance of a pitot-static system in respect of the physical properties of the earth's atmosphere
P2 describe the construction and operating principles of three air data instruments	**M2** explain the procedures required to assess the operational status of engine indicating systems	**D2** evaluate the likely cause of given faults on engine indicating systems.
P3 describe a Pitot-static system sense and leak check	**M3** compare the effectiveness of two airframe systems that utilise remote position control indication.	
P4 describe the principles of gyroscopic instruments [IE4]		
P5 describe the construction and operating principles of attitude and direction instruments [IE4]		
P6 identify the parameters used for primary aircraft engine indicating systems [IE4]		
P7 describe the operation of four engine indicating systems [IE4]		
P8 describe the principles of temperature and pressure indicating systems [IE4]		
P9 describe the principles of remote position indicating systems [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

Although this unit assumes that learners have no prior knowledge of aircraft instruments and indicating systems, they must have an understanding of scientific principles equivalent to *Unit 5: Mechanical Principles and Applications* or *Unit 67: Principles and Applications of Aerospace Mechanical Science*. Before delivering this unit, tutors will therefore need to ensure that learners have the relevant prerequisite knowledge.

The unit should begin with an introduction to how the physical properties of pressure, density and temperature are utilised by air data instrument systems. This is followed by a review of gyroscopic instruments, primary engine indicators and remote position sensing.

It might be useful to give an overview of how instrument systems have developed over the last 25-30 years as a result of advances in microelectronics and electronic displays. These advances could be illustrated by comparing hardware using actual equipment and DVDs or videos.

Common instrument features link the four learning outcomes, eg layout of the instruments in an aircraft, display format, indicator range, units etc. Examples of how instrument 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 instrument systems covered in this unit make use of advances in technology, eg electronic displays, solid state transducers, air data computers, laser gyros etc. Therefore it may not be possible to cover all of these technologies in depth.

Before starting work on this unit, learners will 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, a repair organisation or a military base. Because of the security associated with the aircraft industry, alternative arrangements could include viewing an aircraft simulator or aircraft museum. It would also be beneficial for learners to get their hands on typical equipment such as control panels or aircraft computers and take them apart to see how they are constructed.

Learning outcome 1 covers the fundamental principles of the earth's atmosphere and how the physical properties of air pressure, temperature and density are used to derive aircraft forward speed, vertical speed and altitude. There is a huge amount of data available on this subject and when learners carry out research they should be given structured tasks which lead them to the specified content. The location of the primary instruments in the cockpit or flight deck should be emphasised.

Learning outcome 2 covers the fundamental principles of gyroscopes and the instruments that utilise these properties for attitude and directional indication. Simple, low-cost gyroscope demonstrations could be used to allow learners to actually feel and see the effects of rigidity and precession. Again, the location of these primary instruments in the cockpit or flight deck should be emphasised.

Learning outcome 3 covers the primary parameters and indicating systems needed to operate the engine safely and economically. The types of engine used to illustrate these parameters should include gas turbine engines, including turboprop applications if possible within the centre's resources. Piston engines can also be included.

Learning outcome 4 covers a range of airframe indicating systems that can be applied to applications such as hydraulic oil pressure, hydraulic oil temperature, bleed air pressure, or bleed air temperature. These applications can start with a review of direct reading instruments, eg Bourdon tubes, leading onto how synchro systems can be used for remote position indication.

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 the properties of the earth's atmosphere and how the physical properties of pressure, density and temperature are utilised by air data instrument systems • explain the construction and operation of a range of air data instruments • explain the operation and use of Pitot-static systems and describe sense and leak checks, associated maintenance procedures and related safety precautions. *Industry visit:* • visit to an airline, aircraft maintenance company or similar to see aircraft instruments and indicating systems on a flight deck/cockpit. Individual learner activities: • research task to investigate how properties of air pressure, temperature and density are used to determine aircraft speed and altitude.
Prepare for and carry out **Assignment 1: Air Data Instrument Systems** (P1, P2, P3, M1, D1).
Whole-class teaching: • explain the principles and behaviours exhibited by a gyroscope, including gyroscope precession and wander • describe the construction of basic gyroscopic instruments • describe the function and operation of attitude and directional reference instruments. *Practical workshop activities:* • use of gyroscopes to demonstrate behaviour and effects of rigidity and precession. *Individual learner activities:* • research task to investigate principles of gyroscopes and their use in aircraft instruments.
Prepare for and carry out **Assignment 2: Gyroscopic Instruments** (P4, P5).
Whole-class teaching: • describe the parameters of primary engine indicators and transducers • explain the function and operation of engine indicating systems and methods for simple fault diagnosis. *Practical workshop activities:* • practical investigation of engine indicating systems. *Individual learner activities:* • research task to investigate primary parameters and indicating systems needed to operate the engine • multiple choice test or quiz on operation of engine indicating systems.
Prepare for and carry out **Assignment 3: Engine Indicating Systems** (P6, P7, M2, D2).
Whole-class teaching: • explain the principles of fluid pressure and temperature • describe the function and operation of fluid pressure and temperature transducers and indicators • describe the function and principles of operation of remote position indicating systems.

Topic and suggested assignments/activities and/assessment
Practical workshop activities: • practical investigation of airframe indicating systems. *Individual learner activities:* • research task to investigate function and operation of fluid pressure and temperature transducers and indicators.
Prepare for and carry out **Assignment 4: System Indicators** (P8, P9, M3).
Feedback on assessment and unit evaluation.

Assessment

This unit could be assessed using four assignments. A variety of assessment instruments could be used including short-answer questions, observation of practical work and written assignments.

Learners are expected to use their own words when referring to applications and, while much of their research for will be done using the internet, it is important that what they present is not just simply a cut-and-paste exercise.

It is suggested that the first assignment could cover P1, P2 and P3. Evidence for P1 could be generated by giving learners a list of situations/scenarios and asking for details of what would be displayed by each of the three instruments (altimeter, ASI and VSI). Examples could include the aircraft climbing at a constant airspeed and then levelling out; the aircraft flying at constant altitude with increasing airspeed; the aircraft descending with decreasing airspeed and then levelling out.

P2 can be an extension of this theme by asking questions for each of the three instruments, eg what happens to a VSI capsule and pointer when the aircraft is climbing/descending/in level flight? This evidence would need to be backed up by a description of the construction of the instruments. P3 requires learners to understand how air data instruments are connected into a system and how this system is checked for sense and leaks. Criterion P3 leads into M1 and D1. As such, criteria P1, P2, P3, M1 and D1 could all be covered by one assignment comprising of written tasks and the results of practical tasks. Learners can apply their knowledge of pitot-static systems via M1 and then make reasoned judgements on the performance of a pitot-static system for D1.

The second assignment could cover P4 and P5. Evidence to support P4 could be generated through learners predicting what happens to a gyro under certain conditions. It is important that learners describe the principles involved. Evidence to support an understanding of gyroscopic instruments (P5) could be generated by giving learners a list of situations/scenarios and then asking for details of what would be displayed by each of the instruments. This will need to include opportunities to describe the construction and operating principles of both attitude and direction instruments. Examples could include the aircraft turning onto a new heading while climbing at a constant pitch angle.

P6 and P7 could be covered in the third assignment. The tasks set to generate evidence for P6 could involve learners linking given parameters and their respective transducers eg temperature and thermocouples, pressure and capsules etc. For P7, learners could assume the role of a maintenance technician tasked with investigating pilot reports of problems with the four indicating systems. This can be expanded to cover M2 and D2. Starting with simple fault diagnosis (P7) this can then lead to an explanation of procedures (M2). In the context of M2, 'procedures' refers to the essential events, actions, test equipment, documentation and safety considerations required to assess the operational status of engine indicating systems. The assignment finishes with an evaluation of the likely causes of given faults (D2).

The fourth assignment could then cover P8 and P9. Most aspects of these two criteria can be referred back to the previous pass criteria, eg how direct reading oil pressure indicators using Bourdon tubes could be combined with a synchro system to provide remote indication of oil pressure. Tasks should also involve recognition of transducers and synchro systems on aircraft schematics and/or wiring diagrams. P9 requires a description of remote position indicating systems leading into M3 that requires a comparison of two airframe systems.

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, P3, M1, D1	Air Data Instrument Systems	A technician needs to produce a report on the operation of air data instruments.	A written report.
P4, P5	Gyroscopic Instruments	A technician needs to produce a report on the operation of gyroscopic instruments.	A written report.
P6, P7, M2, D2	Engine Indicating Systems	A technician needs to produce a report on the operation of engine indicating systems.	A written report.
P8, P9, M3	System Indicators	A technician needs to produce a report on the operation of system indicators.	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
		Mechanical Principles and Applications
		Electrical and Electronic Principles
		Principles and Applications of Aerospace Mechanical Science

This unit covers some of the knowledge and understanding associated with the SEMTA Level 3 National Occupational Standards in Aeronautical Engineering particularly:

- Unit 63: Installing Aircraft Instrument Panels and Meters
- Unit 73: Installing Aircraft Instrumentation Systems
- Unit 85: Testing Aircraft Instrumentation Systems.

Essential resources

To meet the needs of this unit it is essential that the centre has, or has access to some, if not all of the following:

- an aircraft and/or simulator with functioning instruments
- representative instrumentation components, eg transducers, capsules, temperature sensors, displays and indicators
- simple fault diagnosis equipment used on engine indicating systems
- 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

Pallett E – *Aircraft Instruments and Integrated Systems* (Longman 1992) ISBN 0582086272

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, judging its relevance and value when describing the principles and operation of aircraft instruments and indicating systems.

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 operation of a range of aircraft instruments and indicating systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	describing the operation of a range of aircraft instruments and indicating systems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the operation of a range of aircraft instruments and indicating systems.