

Higher National Unit Specification

General information for centres

Unit title: Radio and Radar Principles for Aviation

Unit code: F0M9 35

Unit purpose: This Unit is designed to allow candidates to acquire the knowledge, understanding and analysis skills of the principles, functions, implementation and operation of aviation radio and radar systems. It covers the knowledge about aircraft radio and radar systems required for EASA Part 66 B1 license (part of module 11 in EASA Part 66 requirements) or for EASA Part 66 B2 license (part of module 13 in EASA Part 66 requirements).

On completion of the Unit the candidate should be able to:

- 1 Explain radio fundamentals.
- 2 Analyse transmitters.
- 3 Analyse receivers.
- 4 Analyse single side-band (SSB) and frequency-modulation (FM) communications.
- 5 Explain radar fundamentals.

Credit points and level: 2 HN Credits at SCQF level 8: (16 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Recommended prior knowledge and skills: Access to this Unit will be at the discretion of the centre. It is recommended that candidates have completed Higher National Units: DR0A 33 *Mathematics and Physics for Aviation*, DR06 34 *Electrical Fundamentals for Aviation*, DR07 34 *Electronic Fundamentals for Aviation* and DR05 34 *Avionics*.

Core Skills: There are opportunities to develop the Core Skills of Problem Solving: Critical Thinking at SCQF level 6 and Numeracy: Using Number at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

General information for centres (cont)

Assessment: Candidates can be assessed either by two one hour assessments or by a single two-hour assessment. If two one hour assessments are used, the first assessment covers Outcomes 1, 2 and 3, and the second assessment covers Outcomes 4 and 5. If a single two-hour assessment is used, the assessment covers all five Outcomes. The assessment papers could be composed of an appropriate balance of short answer, restricted response and structured questions. Assessment should be carried out on a sample basis and under supervised, closed-book, controlled conditions.

Accurate records should be made of the assessment instruments used showing how evidence is generated for each Outcome and giving marking schemes and/or checklists, etc. Records of candidates' achievements should be kept. These records will be available for external verification.

Higher National Unit specification: statement of standards

Unit title: Radio and Radar Principles for Aviation

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The sections of the Unit stating the Outcomes, knowledge and/or skills, and Evidence Requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Explain radio fundamentals

Knowledge and/or skills

- ◆ Propagation of radio waves
- ◆ Aerial parameters
- ◆ Transmission lines and aerial matching
- ◆ Simple resonant aerials

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome together with that in Outcome 2 and 3 will be provided by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Where the knowledge is sampled, the sample should comprise three bullet points listed under knowledge and/or skills. In order to ensure that candidates will not be able to foresee the sample, the whole of the content listed must be taught and available for assessment. Moreover, a different sample is required each time the Outcome is assessed, to which candidates must give a satisfactory response. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that he/she can achieve at least 60% of the marks available in the assessment.

A candidate's response can be judged to be satisfactory where the evidence provided is sufficient to meet the requirements for each item by showing that the candidate has correct understanding or skills to:

- ◆ Explain the propagation of radio waves: transverse electromagnetic wave; velocity and wavelength; electromagnetic spectrum; polarisation; ground waves, space waves, and sky waves; effects of ionisation on radio waves.
- ◆ Explain aerial parameters: near and far fields; radiation pattern; polarisation; aerial gain; beam-width and sidelobes.
- ◆ Explain transmission lines and aerial matching: classification of transmission line; characteristic impedance; standing wave ratio and its measurements; resonant and non-resonant lines; aerial input impedance; aerial radiation resistance; aerial matching methods.

Higher National Unit specification: statement of standards (cont)

Unit title: Radio and Radar Principles for Aviation

- ◆ Explain simple resonant aerials: standing waves or resonant aerials; half-wave dipole; polar diagrams; Marconi aerial; loop aerial; ferrite aerial; directional aerial arrays; parasitic elements; Yagi array.

Assessment guidelines

This Outcome can be assessed together with Outcome 2 and 3 by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

Outcome 2

Analyse transmitters

Knowledge and/or skills

- ◆ Signal modulations
- ◆ Oscillators and frequency synthesisers
- ◆ Radio frequency (RF) amplifiers
- ◆ The techniques for amplitude modulation (AM) and the configuration of AM transmitters
- ◆ Radio transmitters

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome together with that in Outcome 1 and 3 will be provided by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Where the knowledge is sampled, the sample should comprise three bullet points listed under knowledge and/or skills. In order to ensure that candidates will not be able to foresee the sample, the whole of the content listed must be taught and available for assessment. Moreover, a different sample is required each time the Outcome is assessed, to which candidates must give a satisfactory response. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that he/she can achieve at least 60% of the marks available in the assessment.

A candidate's response can be judged to be satisfactory where the evidence provided is sufficient to meet the requirements for each item by showing that the candidate has correct understanding or skills to:

- ◆ Analyse signal modulations: double-sideband (DSB) amplitude modulation (AM); modulation factor; single-sideband suppressed-carrier amplitude modulation (SSB); frequency modulation (FM); power distribution in an AM waveform; power distribution in an FM waveform; bandwidth required for an FM wave; phase modulation; pulse modulation.

Higher National Unit specification: statement of standards (cont)

Unit title: Radio and Radar Principles for Aviation

- ◆ Explain oscillators and frequency synthesisers: crystal oscillators; oscillator frequency stability; indirect frequency synthesis; direct digital frequency synthesis.
- ◆ Analyse RF amplifiers: bipolar transistor amplifiers; field effect transistor (FET) amplifiers; single-ended power amplifiers and parallel operations; double-ended power amplifiers; balanced aerials, unbalanced aerials and aerial coupling circuits.
- ◆ Analyse the techniques for amplitude modulation (AM) and the configuration of AM transmitters: non-linear amplitude modulators; balanced modulators; low-level modulation and high-level modulation; base/gate modulators; emitter/source modulators; collector/drain modulators.
- ◆ Explain radio transmitters: high frequency (HF) communication transmitters; very high frequency (VHF) and ultra high frequency (UHF) communication transmitters.

Assessment guidelines

This Outcome can be assessed together with Outcome 1 and 3 by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

Outcome 3

Analyse receivers

Knowledge and/or skills

- ◆ Tuned radio frequency receiver and superheterodyne radio receiver
- ◆ Frequency mixing, RF amplifiers, intermediate frequency (IF) amplifiers, and audio frequency (AF) amplifiers
- ◆ Demodulation
- ◆ Gain control and noise limiting

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome together with that in Outcome 1 and 2 will be provided by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Where the knowledge is sampled, the sample should comprise three bullet points listed under knowledge and/or skills. In order to ensure that candidates will not be able to foresee the sample, the whole of the content listed must be taught and available for assessment. Moreover, a different sample is required each time the Outcome is assessed, to which candidates must give a satisfactory response. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that he/she can achieve at least 60% of the marks available in the assessment.

Higher National Unit specification: statement of standards (cont)

Unit title: Radio and Radar Principles for Aviation

A candidate's response can be judged to be satisfactory where the evidence provided is sufficient to meet the requirements for each item by showing that the candidate has correct understanding or skills to:

- ◆ Analyse tuned radio frequency (TRF) receiver and superheterodyne radio receiver: TRF receiver and parameters; receiver aerial coupling; interfering signals to receivers; principles for a superheterodyne receiver; block diagram operation for a superheterodyne receiver; functional stages in a superheterodyne receiver.
- ◆ Analyse frequency mixing, RF amplifier, intermediate frequency (IF) amplifiers and audio frequency (AF) amplifiers: additive mixing; multiplicative mixing; FET mixers; dual gate mixers; diode mixer; transistor RF amplifier; FET RF amplifier; cascode RF amplifier; main characteristics of IF amplifiers; crystal filter selectivity control; selectivity control via switched variable coupling, AF amplifiers.
- ◆ Analyse demodulation: series type demodulators; shunt diode detector; product detector; detection distortion.
- ◆ Analyse gain control and noise limiting: effect of variable bias; automatic gain control (AGC); delayed AGC; delayed amplified AGC; post detector AGC; series and shunt noise limiters; muting; squelching and squelch circuits.

Assessment guidelines

This Outcome can be assessed together with Outcome 1 and 2 by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

Higher National Unit specification: statement of standards (cont)

Unit title: Radio and Radar Principles for Aviation

Outcome 4

Analyse single side-band (SSB) and FM communications

Knowledge and/or skills

- ◆ SSB systems and SSB transmission
- ◆ Modulators and filters in SSB transmitters
- ◆ SSB receivers and automatic frequency control (AFC)
- ◆ Frequency modulation (FM) techniques

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome together with that in Outcome 5 will be provided by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Where the knowledge is sampled, the sample should comprise three bullet points listed under knowledge and/or skills. In order to ensure that candidates will not be able to foresee the sample, the whole of the content listed must be taught and available for assessment. Moreover, a different sample is required each time the Outcome is assessed, to which candidates must give a satisfactory response. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that he/she can achieve at least 60% of the marks available in the assessment.

A candidate's response can be judged to be satisfactory where the evidence provided is sufficient to meet the requirements for each item by showing that the candidate has correct understanding or skills to:

- ◆ Analyse SSB systems and SSB transmission: SSB principles; suppressed carrier, pilot carrier and controlled carrier; block diagram operation of SSB transmitters.
- ◆ Analyse modulators and filters in SSB transmitters: balanced modulators and their circuits; mechanical filters; crystal filters.
- ◆ Analyse SSB receivers and automatic frequency control: operating principles of SSB receivers; triple superhet receivers; product detector; suppressed carrier SSB receiver; AFC in SSB receiver; ratio discriminator.
- ◆ Analyse frequency modulation (FM) techniques: FM frequency spectrum; FM transmitters; FM receivers; FM techniques.

Assessment guidelines

This Outcome can be assessed together with Outcome 5 by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

Higher National Unit specification: statement of standards (cont)

Unit title: Radio and Radar Principles for Aviation

Outcome 5

Explain radar fundamentals

Knowledge and/or skills

- ◆ Basic principles of radar
- ◆ Radar signal frequency, directivity, aerial and radar beam
- ◆ Pulsed operation and range detection
- ◆ Radar signal processing

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome together with that in Outcome 4 will be provided by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Where the knowledge is sampled, the sample should comprise three bullet points listed under knowledge and/or skills. In order to ensure that candidates will not be able to foresee the sample, the whole of the content listed must be taught and available for assessment. Moreover, a different sample is required each time the Outcome is assessed, to which candidates must give a satisfactory response. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that he/she can achieve at least 60% of the marks available in the assessment.

A candidate's response can be judged to be satisfactory where the evidence provided is sufficient to meet the requirements for each item by showing that the candidate has correct understanding or skills to:

- ◆ Explain basic principles of radar: radio detection concepts; block diagram operation for pulse radar; magnetron transmitter; duplexer; receiver and receiver protection device.
- ◆ Explain radar signal frequency, directivity aerial and radar beam: frequency used for radar; distribution of radiated energy; radar aeriels; radar signal beam steering.
- ◆ Explain pulsed operation and range detection: pulsed waveform and transmitted energy; energy of the target signal; range equation; pulse delay ranging; pulse compressions; FM ranging.
- ◆ Explain radar signal processing: Doppler effect; spectrum of pulsed signal; digital filters in radar signal processing.

Assessment guidelines

This Outcome can be assessed together with Outcome 4 by an examination taken as a single assessment lasting one hour or by a single two-hour assessment combining all five Outcomes, and carried out under supervised, closed-book, controlled conditions.

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

Administrative Information

Unit code: F0M9 35

Unit title: Radio and Radar Principles for Aviation

Superclass category: XP

Original date of publication: August 2006

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History of Changes:

Version	Description of change	Date

Source: SQA

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Higher National Unit specification: support notes

Unit title: Radio and Radar Principles for Aviation

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 80 hours.

Guidance on the content and context for this Unit

This Unit is designed to allow candidates to acquire the knowledge and understanding of the principles, functions, operation and maintenance of aviation radio communication systems, radar and radio altimeters, inertial navigation systems and GPS systems.

Corresponding to Outcomes:

1 Explain radio fundamentals.

- ◆ Propagation of radio waves
 - Transverse electromagnetic wave
 - Velocity and wavelength
 - Electromagnetic spectrum
 - Polarisation
 - Ground waves
 - Space waves, and sky waves
 - Effects of ionisation on radio waves

- ◆ Aerial parameters
 - Near and far fields
 - Radiation pattern
 - Polarisation of aerials
 - Aerial gain
 - Beam-width and sidelobes

- ◆ Transmission lines and aerial matching
 - Classification of transmission line
 - Characteristic impedance
 - Standing wave ratio and its measurements
 - Resonant and non-resonant lines
 - Aerial input impedance
 - Aerial radiation resistance
 - Aerial matching methods

Higher National Unit specification: support notes (cont)

Unit title: Radio and Radar Principles for Aviation

- ◆ Simple resonant aerials
 - Standing waves or resonant aerials
 - Half-wave dipole
 - Polar diagrams
 - Marconi aerial
 - Loop aerial
 - Ferrite aerial
 - Directional aerial arrays
 - Parasitic elements
 - Yagi array

2 Analyse transmitters.

- ◆ Signal modulations
 - Double-sideband amplitude modulation (AM)
 - Modulation factor
 - Single-sideband suppressed-carrier amplitude modulation (SSB)
 - Frequency modulation (FM)
 - Power distribution in an AM waveform
 - Power distribution in an FM waveform
 - Bandwidth required for an FM wave
 - Phase modulation
 - Pulse modulation
- ◆ Oscillators and frequency synthesisers
 - Crystal oscillators
 - Oscillator frequency stability
 - Indirect frequency synthesis
 - Direct digital frequency synthesis
- ◆ RF amplifiers
 - Bipolar transistor amplifiers
 - Field effect transistor (FET) amplifiers
 - Single-ended power amplifiers and parallel operations
 - Double-ended power amplifiers
 - Balanced aerials, unbalanced aerials and aerial coupling circuits
- ◆ The techniques for amplitude modulation (AM) and the configuration of AM transmitters
 - Non-linear amplitude modulators
 - Balanced modulators
 - Low-level modulation and high-level modulation
 - Base/gate modulators, emitter/source modulators, collector/drain modulators
- ◆ Radio transmitters
 - High frequency (HF) communication transmitters
 - Very high frequency (VHF) and ultra high frequency (UHF) communication transmitters

Higher National Unit specification: support notes (cont)

Unit title: Radio and Radar Principles for Aviation

3 Analyse receivers.

- ◆ Tuned radio frequency (TRF) receiver and superheterodyne radio receiver
 - TRF receiver and parameters
 - Receiver aerial coupling
 - Interfering signals to receivers
 - Principles for a superheterodyne receiver
 - Block diagram operation for a superheterodyne receiver
 - Functional stages in a superheterodyne receiver

- ◆ Frequency mixing, RF amplifier, intermediate frequency (IF) amplifiers and audio frequency (AF) amplifiers
 - Additive mixing
 - Multiplicative mixing; FET mixers
 - Dual gate mixers
 - Diode mixer
 - Transistor RF amplifier
 - FET RF amplifier
 - Cascode RF amplifier
 - Main characteristics of IF amplifiers
 - Crystal filter selectivity control
 - Selectivity control via switched variable coupling, AF amplifiers

- ◆ Demodulation
 - Series type demodulators
 - Shunt diode detector
 - Product detector
 - Detection distortion

- ◆ Gain control and noise limiting
 - Effect of variable bias
 - Automatic gain control (AGC)
 - Delayed AGC
 - Delayed amplified AGC
 - Post detector AGC
 - Series and shunt noise limiters
 - Muting
 - Squelching and squelch circuits

Higher National Unit specification: support notes (cont)

Unit title: Radio and Radar Principles for Aviation

4 Analyse single-side-band (SSB) and frequency-modulation (FM) communications.

- ◆ DSB and SSB systems and SSB transmission
 - SSB principles
 - Suppressed carrier, pilot carrier and controlled carrier
 - Block diagram operation of SSB transmitters

- ◆ Modulators and filters in SSB transmitters
 - Balanced modulators and their circuits
 - Mechanical filters
 - Crystal filters

- ◆ SSB receivers and automatic frequency control
 - Operating principles of SSB receivers
 - Triple superhet receivers
 - Product detector
 - Suppressed carrier SSB receiver
 - AFC in SSB receiver
 - Ratio discriminator

- ◆ Frequency modulation (FM) techniques
 - FM frequency spectrum
 - FM transmitters
 - FM receivers
 - FM techniques

5 Explain radar fundamentals.

- ◆ Basic principles of radar
 - Radio detection concepts
 - Block diagram operation for pulse radar
 - Magnetron transmitter
 - Duplexer
 - Radar aerials
 - Receiver and receiver protection device

- ◆ Radar signal frequency, directivity and the aerial beam
 - Frequency used for radar
 - Distribution of radiated energy
 - Radar signal beam steering

Higher National Unit specification: support notes (cont)

Unit title: Radio and Radar Principles for Aviation

- ◆ Pulsed operation and range detection
 - Pulsed waveform and transmitted energy
 - Energy of the target signal
 - Range equation
 - Pulse delay ranging
 - Pulse compressions
 - FM ranging

- ◆ Radar signal processing
 - Doppler effect
 - Spectrum of pulsed signal
 - Digital filters in radar signal processing

Guidance on the delivery and assessment of this Unit

Candidates are assessed either by two one hour assessments or by a single two-hour assessment. If two one hour assessments are used, the first assessment covers Outcomes 1, 2 and 3, and the second assessment covers Outcomes 4 and 5. If a single two-hour assessment is used, the assessment covers all five Outcomes. The assessment papers could be composed of an appropriate balance of short answer, restricted response and structured questions. Assessment should be carried out on a sample basis and under supervised, closed-book, controlled conditions. The candidate should achieve a minimum of 60% pass rate for the Evidence Requirements.

Opportunities for developing Core Skills

There are opportunities to develop the Core Skills of Problem Solving: Critical Thinking at SCQF level 6 and Numeracy: Using Number at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Candidates can achieve this by demonstrating that they can analyse and evaluate complex issues such as the modulation circuit analysis, the operating principles of radar systems.

The teaching and learning activities would contribute to the Core Skill: Critical Thinking. In Outcomes 2, 3 and 4, candidates would be encouraged to compare and contrast the system configuration and operating efficiency of different radio systems through the analysis of operational principles and circuits of different kinds of signal modulation, amplification, receiving and transmission. This would help candidates to achieve a better understanding of the principles of the aviation radio and radar systems.

The mathematic tools used for analysing power distribution of different waveforms in Outcome 2 and for analysing the signal processing in Outcomes 2, 3 and 4 would enhance the candidate's numeracy skills.

Open learning

If this Unit is delivered by open or distance learning methods, additional planning and resources may be required for candidate support, assessment and quality assurance. The evidence for Outcomes could be held in a portfolio and sent to the assessor.

Higher National Unit specification: support notes (cont)

Candidates with disabilities and/or additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative Outcomes for Units. For information on these, please refer to the SQA document *Guidance on Alternative Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs*, which is available on SQA's website: **www.sqa.org.uk**.

General information for candidates

Unit title: Radio and Radar Principles for Aviation

In this Unit you will acquire the knowledge, understanding, and analysis skills in relation to the principles, functions, implementation and operation of aviation radio and radar systems. It covers the knowledge about aircraft radio and radar systems required for EASA Part 66 B1 license (part of module 11 in EASA Part 66 requirements) or EASA Part 66 B2 license (part of module 13 in EASA Part 66 requirements). There are five Outcomes:

This Unit is designed to allow you to:

- ◆ explain radio fundamentals
- ◆ analyse transmitters
- ◆ analyse receivers
- ◆ analyse single-side-band (SSB) and frequency-modulation (FM) communications
- ◆ explain radar fundamentals

This Unit will be beneficial if you are interested in aircraft engineering or are doing an aircraft engineering course.

You will be assessed either by two one hour assessments or by a single two-hour assessment. If two one hour assessments are used, the first assessment covers Outcomes 1 2 and 3, and the second assessment covers Outcomes 4 and 5. If a single two-hour assessment is used, the assessment covers all five Outcomes. The assessment papers could be composed of an appropriate balance of short answer, restricted response and structured questions. Assessment should be carried out on a sample basis and under supervised, closed-book, controlled conditions. You have to achieve a minimum of 60% pass rate for the Evidence Requirements.