K. SUBJECT 062 — RADIO NAVIGATION

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
060 00 00 00	**NAVIGATION**						
062 00 00 00	**RADIO NAVIGATION**						
062 01 00 00	**BASIC RADIO PROPAGATION THEORY**						
062 01 01 00	**Basic principles**						
062 01 01 01	**Electromagnetic waves**						
LO	State that radio waves travel at the speed of light, being approximately 300 000 km/s or 162 000 NM/s.	x	x	x	x	x	x
LO	Define a ‘cycle’. A complete series of values of a periodical process.	x	x	x	x	x	x
LO	Define ‘Hertz (Hz)’. 1 Hertz is 1 cycle per second.	x	x	x	x	x	x
062 01 01 02	**Frequency, wavelength, amplitude, phase angle**						
LO	Define ‘frequency’. The number of cycles occurring in 1 second in a radio wave expressed in Hertz (Hz).	x	x	x	x	x	x
LO	Define ‘wavelength’. The physical distance travelled by a radio wave during one cycle of transmission.	x	x	x	x	x	x
LO	Define ‘amplitude’. The maximum deflection in an oscillation or wave.	x	x	x	x	x	x
LO	State that the relationship between wavelength and frequency is: — wavelength (λ) = speed of light (c) / frequency (f); — or λ (meters) = 300 000 / kHz.	x	x	x	x	x	x
LO	Define ‘phase’. The fraction of one wavelength expressed in degrees from 000° to 360°.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*			*Helicopter*		*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Define 'phase difference/shift'. The angular difference between the corresponding points of two cycles of equal wavelength, which is measurable in degrees.	x	x	x	x	x	x
062 01 01 03	**Frequency bands, sidebands, single sideband**						
LO	List the bands of the frequency spectrum for electromagnetic waves: — Very Low Frequency (VLF): 3–30 kHz; — Low Frequency (LF): 30–300 kHz; — Medium Frequency (MF): 300–3 000 kHz; — High Frequency (HF): 3–30 MHz; — Very High Frequency (VHF): 30–300 MHz; — Ultra High Frequency (UHF): 300–3 000 MHz; — Super High Frequency (SHF): 3–30 GHz; — Extremely High Frequency (EHF): 30–300 GHz.	x	x	x	x	x	x
LO	State that when a carrier wave is modulated, the resultant radiation consists of the carrier frequency plus additional upper and lower sidebands.	x	x	x	x	x	x
LO	State that HF VOLMET and HF two-way communication use a single sideband.	x	x	x	x	x	x
LO	State that a radio signal may be classified by three symbols in accordance with the ITU Radio Regulation, Volume 1: e.g. A1A. — The first symbol indicates the type of modulation of the main carrier; — The second symbol indicates the nature of the signal modulating the main carrier; — The third symbol indicates the nature of the information to be transmitted.	x	x	x	x	x	x
062 01 01 04	**Pulse characteristics**						
LO	Define the following terms as associated with a pulse string: — pulse length, — pulse power, — continuous power.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
062 01 01 05	**Carrier, modulation**						
LO	Define 'carrier wave'. The radio wave acting as the carrier or transporter.	x	x	x	x	x	x
LO	Define 'keying'. Interrupting the carrier wave to break it into dots and dashes.	x	x	x	x	x	x
LO	Define 'modulation'. The technical term for the process of impressing and transporting information by radio waves.	x	x	x	x	x	x
062 01 01 06	**Kinds of modulation (amplitude, frequency, pulse, phase)**						
LO	Define 'amplitude modulation'. The information that is impressed onto the carrier wave by altering the amplitude of the carrier.	x	x	x	x	x	x
LO	Define 'frequency modulation'. The information that is impressed onto the carrier wave by altering the frequency of the carrier.	x	x	x	x	x	x
LO	Describe 'pulse modulation'. A modulation form used in radar by transmitting short pulses followed by larger interruptions.	x	x	x	x	x	x
LO	Describe 'phase modulation'. A modulation form used in GPS where the phase of the carrier wave is reversed.	x	x	x	x	x	x
062 01 02 00	**Antennas**						
062 01 02 01	**Characteristics**						
LO	Define 'antenna'. A wave-type transducer for the process of converting a line AC into a free electromagnetic wave.	x	x	x	x	x	x
LO	State that the simplest type of antenna is a dipole which is a wire of length equal to one-half of the wavelength.	x	x	x	x	x	x
LO	State that in a wire which is fed with an AC (alternating current), some of the power will radiate into space.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that in a wire parallel to the wire fed with an AC but remote from it, an AC will be induced.	x	x	x	x	x	x
LO	State that an electromagnetic wave always consists of an oscillating electric (E) and an oscillating magnetic (H) field which propagates at the speed of light.	x	x	x	x	x	x
LO	State that the (E) and (H) fields are perpendicular to each other. The oscillations are perpendicular to the propagation direction and are in-phase.	x	x	x	x	x	x
LO	State that the electric field is parallel to the wire and the magnetic field is perpendicular to it.	x	x	x	x	x	x
062 01 02 02	**Polarisation**						
LO	State that the polarisation of an electromagnetic wave describes the orientation of the plane of oscillation of the electrical component of the wave with regard to its direction of propagation.	x	x	x	x	x	x
LO	State that in linear polarisation the plane of oscillation is fixed in space, whereas in circular (eliptical) polarisation the plane is rotating.	x	x	x	x	x	x
LO	Explain the difference between horizontal and vertical polarisation in the dependence of the alignment of the dipole.	x	x	x	x	x	x
062 01 02 03	**Types of antennas**						
LO	List and describe the common different kinds of directional antennas: — loop antenna used in old ADF receivers; — parabolic antenna used in weather radars; — slotted planar array used in more modern weather radars; — helical antenna used in GPS transmitters.	x	x	x	x	x	x
062 01 03 00	**Wave propagation**						
062 01 03 01	**Structure of the ionosphere**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the ionosphere is the ionised component of the Earth's upper atmosphere from 60 to 400 km above the surface, which is vertically structured in three regions or layers.	x	x	x	x	x	x
LO	State that the layers in the ionosphere are named D, E and F layers, and their depth varies with time.	x	x	x	x	x	x
LO	State that electromagnetic waves refracted from the E and F layers of the ionosphere are called sky waves.	x	x	x	x	x	x
062 01 03 02	**Ground waves**						
LO	Define 'ground or surface waves'. The electromagnetic waves travelling along the surface of the Earth.	x	x	x	x	x	x
062 01 03 03	**Space waves**						
LO	Define 'space waves'. The electromagnetic waves travelling through the air directly from the transmitter to the receiver.	x	x	x	x	x	x
062 01 03 04	**Propagation with the frequency bands**						
LO	State that radio waves in VHF, UHF, SHF and EHF propagate as space waves.	x	x	x	x	x	x
LO	State that radio waves in VLF, LF, MF and HF propagate as surface/ground waves and sky waves.	x	x	x	x	x	x
062 01 03 05	**Doppler principle**						
LO	State that Doppler effect is the phenomenon that the frequency of an electromagnetic wave will increase or decrease if there is relative motion between the transmitter and the receiver.	x	x	x	x	x	x
LO	State that the frequency will increase if the transmitter and receiver are converging, and will decrease if they are diverging.	x	x	x	x	x	x
062 01 03 06	**Factors affecting propagation**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Define 'skip distance'. The distance between the transmitter and the point on the surface of the Earth where the first sky return arrives.	x	x	x	x	x	x
LO	State that skip zone/dead space is the distance between the limit of the surface wave and the sky wave.	x	x	x	x	x	x
LO	Describe 'fading'. When a receiver picks up the sky signal and the surface signal, the signals will interfere with each other causing the signals to be cancelled out.	x	x	x	x	x	x
LO	State that radio waves in the VHF band and above are limited in range as they are not reflected by the ionosphere and do not have a surface wave.	x	x	x	x	x	x
LO	Describe the physical phenomena reflection, refraction, diffraction, absorption and interference.	x	x	x	x	x	x
062 02 00 00	**RADIO AIDS**						
062 02 01 00	**Ground D/F**						
062 02 01 01	**Principles**						
LO	Describe the use of a Ground Direction Finder.	x	x	x	x	x	x
LO	Explain why the service provided is subdivided as: — VHF direction finding (VDF) — UHF direction finding (UDF).	x	x	x	x	x	x
LO	Explain the limitation of range because of the path of the VHF signal.	x	x	x	x	x	x
LO	Describe the operation of the VDF in the following general terms: — radio waves emitted by the radio-telephony (R/T) equipment of the aircraft; — special directional antenna; — determination of the direction of the incoming signal; — ATC display.	x	x	x	x	x	x
062 02 01 02	**Presentation and interpretation**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Define the term 'QDM'. The magnetic bearing to the station.	x	x	x	x	x	x
LO	Define the term 'QDR'. The magnetic bearing from the station.	x	x	x	x	x	x
LO	Define the term 'QUJ'. The true bearing to the station.	x	x	x	x	x	x
LO	Define the term 'QTE'. The true bearing from the station.	x	x	x	x	x	x
LO	Explain that by using more than one ground station, the position of an aircraft can be determined and transmitted to the pilot.	x	x	x	x	x	x
062 02 01 03	**Coverage and range**						
LO	Use the formula: 1.23 × √transmitter height in feet + 1.23 × √receiver height in feet, to calculate the range in NM.	x	x	x	x	x	x
062 02 01 04	**Errors and accuracy**						
LO	Explain why synchronous transmissions will cause errors.	x	x	x	x	x	x
LO	Describe the effect of 'multipath signals'.	x	x	x	x	x	x
LO	Explain that VDF information is divided into the following classes according to ICAO Annex 10: — class A: accurate to a range within ± 2°; — class B: accurate to a range within ± 5°; — class C: accurate to a range within ± 10°; — class D: accurate to less than class C.	x	x	x	x	x	x
062 02 02 00	**Non-Directional Beacon (NDB)/ Automatic Direction Finder (ADF)**						
062 02 02 01	**Principles**						
LO	Define the acronym 'NDB'. Non-Directional Beacon.	x	x	x	x	x	x
LO	Define the acronym 'ADF'. Automatic Direction Finder.	x	x	x	x	x	x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the NDB is the ground part of the system.	x	x	x	x	x	x
LO	State that the ADF is the airborne part of the system.	x	x	x	x	x	x
LO	State that the NDB operates in the LF and MF frequency bands.	x	x	x	x	x	x
LO	The frequency band assigned to aeronautical NDBs according to ICAO Annex 10 is 190–1 750 kHz.	x	x	x	x	x	x
LO	Define a 'locator beacon'. An LF/MF NDB used as an aid to final approach usually with a range, according to ICAO Annex 10, of 10–25 NM.	x	x	x	x	x	x
LO	Explain the difference between NDBs and locator beacons.	x	x	x	x	x	x
LO	Explain which beacons transmit signals suitable for use by an ADF.	x	x	x	x	x	x
LO	State that certain commercial radio stations transmit within the frequency band of the NDB.	x	x	x	x	x	x
LO	Explain why it is necessary to use a directionally sensitive receiver antenna system in order to obtain the direction of the incoming radio wave.	x	x	x	x	x	x
LO	Describe the use of NDBs for navigation.	x	x	x	x	x	x
LO	Describe the procedure to identify an NDB station.	x	x	x	x	x	x
LO	Interpret the term 'cone of silence' in respect of an NDB.	x	x	x	x	x	x
LO	State that an NDB station emits a NON/A1A or a NON/A2A signal.	x	x	x	x	x	x
LO	State the function of the Beat Frequency Oscillator (BFO).	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that in order to identify a NON/A1A NDB, the BFO circuit of the receiver has to be activated.	x	x	x	x	x	x
LO	State that the NDB emitting NON/A1A gives rise to erratic indications of the bearing while the station is identifying.	x	x	x	x	x	x
LO	Explain that on modern aircraft the BFO is activated automatically.	x	x	x	x	x	x
062 02 02 02	**Presentation and interpretation**						
LO	Name the types of indicators in common use: — electronic navigation display; — Radio Magnetic Indicator (RMI); — fixed card ADF (radio compass); — moving card ADF.	x	x	x	x	x	x
LO	Describe the indications given on RMI, fixed card and moving card ADF displays.	x	x	x	x	x	x
LO	Given a display, interpret the relevant ADF information.	x	x	x	x	x	x
LO	Calculate the true bearing from the compass heading and relative bearing.	x	x	x	x	x	x
LO	Convert the compass bearing into magnetic bearing and true bearing.	x	x	x	x	x	x
LO	Describe how to fly the following in-flight ADF procedures according to ICAO Doc 8168, Volume 1: — homing and tracking, and explain the influence of wind; — interceptions; — procedural turns; — holding patterns.	x	x	x	x	x	x
062 02 02 03	**Coverage and range**						
LO	State that the power limits the range of an NDB.	x	x	x	x	x	x
LO	Explain the relationship between power and range.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the range of an NDB over sea is better than over land due to better ground wave propagation over seawater than over land.	x	x	x	x	x	x
LO	Describe the propagation path of NDB radio waves with respect to the ionosphere and the Earth's surface.	x	x	x	x	x	x
LO	Explain that interference between sky and ground waves at night leads to 'fading'.	x	x	x	x	x	x
LO	Define the accuracy the pilot has to fly the required bearing in order to be considered established during approach according to ICAO Doc 8168 as within ± 5°.	x	x	x	x	x	x
LO	State that there is no warning indication of NDB failure.	x	x	x	x	x	x
062 02 02 04	**Errors and accuracy**						
LO	Define 'quadrantal error'. The distortion of the incoming signal from the NDB station by reradiation from the airframe. This is corrected for during installation of the antenna.	x	x	x	x	x	x
LO	Explain 'coastal refraction'. As a radio wave travelling over land crosses the coast, the wave speeds up over water and the wave front bends.	x	x	x	x	x	x
LO	Define 'night/twilight effect'. The influence of sky waves and ground waves arriving at the ADF receiver with a difference of phase and polarisation which introduce bearing errors.	x	x	x	x	x	x
LO	State that interference from other NDB stations on the same frequency may occur at night due to sky-wave contamination.	x	x	x	x	x	x
062 02 02 05	**Factors affecting range and accuracy**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that there is no coastal refraction error when: — the propagation direction of the wave is 90° to the coastline; — the NDB station is sited on the coastline.	x	x	x	x	x	x
LO	State that coastal refraction error increases with increased incidence.	x	x	x	x	x	x
LO	State that night effect predominates around dusk and dawn.	x	x	x	x	x	x
LO	Define ‘multipath propagation of the radio wave (mountain effect)’.	x	x	x	x	x	x
LO	State that static emission energy from a cumulonimbus cloud may interfere with the radio wave and influence the ADF bearing indication.	x	x	x	x	x	x
062 02 03 00	**VOR and Doppler VOR**						
062 02 03 01	**Principles**						
LO	Explain the operation of VOR using the following general terms: — reference phase; — variable phase; — phase difference.	x	x	x	x	x	x
LO	State that the frequency band allocated to VOR according to ICAO Annex 10 is VHF and the frequencies used are 108.0–117.975 MHz.	x	x	x	x	x	x
LO	State that frequencies within the allocated VOR range which have an odd number in the first decimal place, are used by ILS.	x	x	x	x	x	x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the following types of VOR are in operation: — Conventional VOR (CVOR): a first-generation VOR station emitting signals by means of a rotating antenna; — Doppler VOR (DVOR): a second-generation VOR station emitting signals by means of a combination of fixed antennas utilising the Doppler principle; — en route VOR for use by IFR traffic; — Terminal VOR (TVOR): a station with a shorter range used as part of the approach and departure structure at major airports; — Test VOR (VOT): a VOR station emitting a signal to test VOR indicators in an aircraft.	x	x	x	x	x	x
LO	Describe how ATIS information is transmitted on VOR frequencies.	x	x	x	x	x	x
LO	List the three main components of VOR airborne equipment: — the antenna, — the receiver, — the indicator.	x	x	x	x	x	x
LO	Describe the identification of a VOR in terms of Morse-code letters, continuous tone or dots (VOT), tone pitch, repetition rate and additional plain text.	x	x	x	x	x	x
LO	State that according to ICAO Annex 10, a VOR station has an automatic ground monitoring system.	x	x	x	x	x	x
LO	State that the VOR monitoring system monitors change in measured radial and reduction in signal strength.	x	x	x	x	x	x
LO	State that failure of the VOR station to stay within the required limits can cause the removal of identification and navigation components from the carrier or radiation to cease.	x	x	x	x	x	x
062 02 03 02	**Presentation and interpretation**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Read off the radial on a Radio Magnetic Indicator (RMI).	x	x	x	x	x	x
LO	Read off the angular displacement in relation to a preselected radial on an HSI or CDI.	x	x	x	x	x	x
LO	Explain the use of the TO/FROM indicator in order to determine aircraft position relative to the VOR considering also the heading of the aircraft.	x	x	x	x	x	x
LO	Interpret VOR information as displayed on HSI, CDI and RMI.	x	x	x	x	x	x
LO	Describe the following in-flight VOR procedures as in ICAO Doc 8168, Volume 1: — tracking, and explain the influence of wind when tracking; — interceptions; — procedural turns; — holding patterns.	x	x	x	x	x	x
LO	State that when converting a radial into a true bearing, the variation at the VOR station has to be taken into account.	x	x	x	x	x	x
062 02 03 03	**Coverage and range**						
LO	Describe the range with respect to the transmitting power and radio signal.	x	x	x	x	x	x
LO	Calculate the range using the formula: 1.23 × √transmitter height in feet + 1.23 × √receiver height in feet.	x	x	x	x	x	x
062 02 03 04	**Errors and accuracy**						
LO	Define the accuracy the pilot has to fly the required bearing in order to be considered established on a VOR track when flying approach procedures according to ICAO Doc 8168 as within half-full scale deflection of the required track.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that due to reflections from terrain, radials can be bent and lead to wrong or fluctuating indications, which is called 'scalloping'.	x	x	x	x	x	x
LO	State that DVOR is less sensitive to site error than CVOR.	x	x	x	x	x	x
062 02 04 00	**DME**						
062 02 04 01	**Principles**						
LO	State that DME operates in the UHF band between 960–1215 MHz according to ICAO Annex 10.	x	x	x	x	x	x
LO	State that the system comprises two basic components: — the aircraft component, the interrogator; — the ground component, the transponder.	x	x	x	x	x	x
LO	Describe the principle of distance measurement using DME in terms of: — pulse pairs; — fixed frequency division of 63 MHz; — propagation delay; — 50-microsecond delay time; — irregular transmission sequence; — search mode; — tracking mode; — memory mode.	x	x	x	x	x	x
LO	State that the distance measured by DME is slant range.	x	x	x	x	x	x
LO	Illustrate that a position line using DME is a circle with the station at its centre.	x	x	x	x	x	x
LO	Describe how the pairing of VHF and UHF frequencies (VOR/DME) enables the selection of two items of navigation information from one frequency setting.	x	x	x	x	x	x
LO	Describe, in the case of co-location, the frequency pairing and identification procedure.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain that depending on the configuration, the combination of a DME distance with a VOR radial can determine the position of the aircraft.	x	x	x	x	x	x
LO	Explain that military TACAN stations may be used for DME information.	x	x	x	x	x	x
062 02 04 02	**Presentation and interpretation**						
LO	Explain that when identifying a DME station co-located with a VOR station, the identification signal with the higher-tone frequency is the DME which idents approximately every 40seconds.	x	x	x	x	x	x
LO	Calculate ground distance from given slant range and altitude.	x	x	x	x	x	x
LO	Describe the use of DME to fly a DME arc in accordance with ICAO Doc 8168, Volume 1.	x	x	x	x	x	x
LO	State that a DME system may have a ground speed read-out combined with the DME read-out.	x	x	x	x	x	x
062 02 04 03	**Coverage and range**						
LO	Explain why a ground station can generally respond to a maximum of 100 aircraft.	x	x	x	x	x	x
LO	Explain which aircraft will be denied a DME range first when more than 100 interrogations are being made.	x	x	x	x	x	x
062 02 04 04	**Errors and accuracy**						
LO	State that the error of the DME ‘N’ according to ICAO Annex 10 should not exceed ± 0.25 NM + 1.25 % of the distance measured. For installations installed after 1 January 1989, the total system error should not exceed 0.2 NM DME ‘P’.	x	x	x	x	x	x
062 02 04 05	**Factors affecting range and accuracy**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the ground speed read-out combined with DME is only correct when tracking directly to or from the DME station.	x	x	x	x	x	x
LO	State that, close to the station, the ground speed read-out combined with DME is less than the actual ground speed.	x	x	x	x	x	x
062 02 05 00	**ILS**						
062 02 05 01	**Principles**						
LO	Name the three main components of an ILS: — the localiser (LLZ); — the glide path (GP); — range information (markers or DME).	x		x			x
LO	State the site locations of the ILS components: — the localiser antenna should be located on the extension of the runway centre line at the stop-end; — The glide-path antenna should be located 300 metres beyond the runway threshold, laterally displaced approximately 120 metres to the side of the runway centre line.	x		x			x
LO	Explain that marker beacons produce radiation patterns to indicate predetermined distances from the threshold along the ILS glide path.	x		x			x
LO	Explain that marker beacons are sometimes replaced by a DME paired with the LLZ frequency.	x		x			x
LO	State that in the ILS frequency assigned band 108.0–111.975 MHz, only frequencies which have an odd number in the first decimal, are ILS frequencies.	x		x			x
LO	State that the LLZ operates in the 108,0–111.975 MHz VHF band, according to ICAO Annex 10.	x		x			x
LO	State that the GP operates in the UHF band.	x		x			x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Describe the use of the 90-Hz and the 150-Hz signals in the LLZ and GP transmitters/ receivers, stating how the signals at the receivers vary with angular deviation.	x		x			x
LO	Draw the radiation pattern with respect to the 90-Hz and 150-Hz signals.	x		x			x
LO	Describe how the UHF glide-path frequency is selected automatically by being paired with the LLZ frequency.	x		x			x
LO	Explain the term 'Difference of Depth of Modulation (DDM)'.	x		x			x
LO	State that the difference in the modulation depth increases with displacement from the centre line.	x		x			x
LO	State that both the LLZ and the GP antenna radiate side lobes (false beams) which could give rise to false centre-line and false glide-path indication.	x		x			x
LO	Explain that the back beam from the LLZ antenna may be used as a published 'non-precision approach'.	x		x			x
LO	State that according to ICAO Annex 10 the nominal glide path is 3°.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Name the frequency, modulation and identification assigned to all marker beacons according to ICAO Annex 10: all marker beacons operate on 75-MHz carrier frequency. The modulation frequencies are: — outer marker: 400 Hz; — middle marker: 1 300 Hz; — inner marker: 3 000 Hz. The audio frequency modulation (for identification) is the continuous modulation of the audio frequency and is keyed as follows: — outer marker: 2 dashes per second continuously; — middle marker: a continuous series of alternate dots and dashes; — inner marker: 6 dots per second continuously.	x		x			x
LO	State that according to ICAO Doc 8168, the final-approach area contains a fix or facility that permits verification of the ILS glide path–altimeter relationship. The outer marker or DME is usually used for this purpose.	x		x			x
062 02 05 02	**Presentation and interpretation**						
LO	Describe the ILS identification regarding frequency and Morse code and/or plain text.	x		x			x
LO	Calculate the rate of descent for a 3°-glide-path angle given the ground speed of the aircraft and using the formula: Rate of Descent (ROD) in ft/min = (ground speed in kt × 10) / 2.	x		x			x
LO	Calculate the rate of descent using the following formula when flying any glide-path angle: ROD ft/min = *Speed Factor (SF)* × glide-path angle × 100.	x		x			x
LO	Interpret the markers by sound, modulation, and frequency.	x		x			x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the outer-marker cockpit indicator is coloured blue, the middle marker amber, and the inner marker white.	x		x			x
LO	State that in accordance with ICAO Annex 10, an ILS installation has an automatic ground monitoring system.	x		x			x
LO	State that the LLZ and GP monitoring system monitors any shift in the LLZ and GP mean course line or reduction in signal strength.	x		x			x
LO	State that a failure of either the LLZ or the GP to stay within the predetermined limits will cause: — removal of identification and navigation components from the carrier; — radiation to cease; — a warning to be displayed at the designated control point.	x		x			x
LO	State that an ILS receiver has an automatic monitoring function.	x		x			x
LO	Describe the circumstances in which warning flags will appear for both the LLZ and the GP: — absence of the carrier frequency; — absence of the 90 and 150-Hz modulation simultaneously; — the percentage modulation of either the 90 or 150-Hz signal reduced to 0.	x		x			x
LO	Interpret the indications on a Course Deviation Indicator (CDI) and a Horizontal Situation Indicator (HSI): — full-scale deflection of the CDI needle corresponds to approximately 2,5° displacement from the ILS centre line; — full-scale deflection on the GP corresponds to approximately 0,7° from the ILS GP centre line.	x		x			x
LO	Interpret the aircraft's position in relation to the extended runway centre line on a back-beam approach.	x		x			x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain the setting of the course pointer of an HSI for front-beam and back-beam approaches.	x		x			x
062 02 05 03	**Coverage and range**						
LO	Sketch the standard coverage area of the LLZ and GP with angular sector limits in degrees and distance limits from the transmitter in accordance with ICAO Annex 10: — LLZ coverage area is 10° on either side of the centre line to a distance of 25 NM from the runway, and 35° on either side of the centre line to a distance of 17 NM from the runway; — GP coverage area is 8° on either side of the centre line to a distance of minimum 10 NM from the runway.	x		x			x
062 02 05 04	**Errors and accuracy**						
LO	Explain that ILS approaches are divided into facility performance categories defined in ICAO Annex 10.	x		x			x
LO	Define the following ILS operation categories: — Category I, — Category II, — Category IIIA, — Category IIIB, — Category IIIC.	x		x			x
LO	Explain that all Category-III ILS operations guidance information is provided from the coverage limits of the facility to, and along, the surface of the runway.	x		x			x
LO	Explain why the accuracy requirements are progressively higher for CAT I, CAT II and CAT III ILS.	x		x			x
LO	State the vertical-accuracy requirements above the threshold for CAT I, II and III for the signals of the ILS ground installation.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain the following in accordance with ICAO Doc 8168: — the accuracy the pilot has to fly the ILS localiser to be considered established on an ILS track is within the half-full scale deflection of the required track; — the aircraft has to be established within the half-scale deflection of the LLZ before starting descent on the GP; — the pilot has to fly the ILS GP to a maximum of half-scale fly-up deflection of the GP in order to stay in protected airspace.	x		x			x
LO	State that if a pilot deviates by more than half-scale deflection on the LLZ or by more than half-course fly-up deflection on the GP, an immediate missed approach should be executed because obstacle clearance may no longer be guaranteed.	x		x			x
LO	Describe ILS beam bends. Deviations from the nominal position of the LLZ and GP respectively. They are ascertained by flight test.	x		x			x
LO	Explain multipath interference. Reflections from large objects within the ILS coverage area.	x		x			x
062 02 05 05	**Factors affecting range and accuracy**						
LO	Define the ‘ILS-critical area’. An area of defined dimensions about the LLZ and GP antennas where vehicles, including aircraft, are excluded during all ILS operations.	x		x			x
LO	Define the ‘ILS-sensitive area’. An area extending beyond the critical area where the parking and/or movement of vehicles, including aircraft, is controlled to prevent the possibility of unacceptable interference to the ILS signal during ILS operations.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Describe the effect of FM broadcast stations that transmit on frequencies just below 108 MHz.	x		x			x
062 02 06 00	**Microwave Landing System (MLS)**						
062 02 06 01	**Principles**						
LO	Explain the principle of operation: — horizontal course guidance during the approach; — vertical guidance during the approach; — horizontal guidance for departure and missed approach; — DME (DME/P) distance; — transmission of special information regarding the system and the approach conditions.	x		x			x
LO	State that MLS operates in the S band on 200 channels.	x		x			x
LO	Explain the reason why MLS can be installed at airports on which, as a result of the effects of surrounding buildings and/or terrain, ILS siting is difficult.	x		x			x
062 02 06 02	**Presentation and interpretation**						
LO	Interpret the display of airborne equipment designed to continuously show the position of the aircraft in relation to a preselected course and glide path along with distance information, during approach and departure.	x		x			x
LO	Explain that segmented approaches can be carried out with a presentation with two cross bars directed by a computer which has been programmed with the approach to be flown.	x		x			x
LO	Illustrate that segmented and curved approaches can only be executed with DME-P installed.	x		x			x
LO	Explain why aircraft are equipped with a Multimode Receiver (MMR) in order to be able to receive ILS, MLS and GPS.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain why MLS without DME-P gives an ILS lookalike straight-line approach.	x		x			x
062 02 06 03	**Coverage and range**						
LO	Describe the coverage area for the approach direction as being within a sector of ± 40° of the centre line out to a range of 20 NM from the threshold (according to ICAO Annex 10).	x		x			x
062 02 06 04	**Error and accuracy**						
LO	State the 95 % lateral and vertical accuracy within 20 NM (37 km) of the MLS approach reference datum and 60 ft above the MLS datum point (according to ICAO Annex 10).	x		x			x
062 03 00 00	**RADAR**						
062 03 01 00	**Pulse techniques and associated terms**						
LO	Name the different applications of radar with respect to ATC, MET observations and airborne weather radar.	x	x	x	x	x	x
LO	Describe the pulse technique and echo principle on which primary radar systems are based.	x	x	x	x	x	x
LO	Explain the relationship between the maximum theoretical range and the Pulse Repetition Frequency (PRF).	x	x	x	x	x	x
LO	Calculate the maximum theoretical unambiguous range if the PRF is given using the formula: $\text{Range in km} = \frac{300\,000}{\text{PRF} \times 2}$	x	x	x	x	x	x
LO	Calculate the PRF if the maximum theoretical unambiguous range of the radar is given using the formula: $\text{PRF} = \frac{300\,000}{\text{range (km)} \times 2}$	x	x	x	x	x	x
LO	Explain that pulse length defines the minimum theoretical range of a radar.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain the need to harmonise the rotation speed of the antenna, the pulse length and the pulse repetition frequency for range.	x	x	x	x	x	x
LO	Describe, in general terms, the effects of the following factors with respect to the quality of the target depiction on the radar display: — atmospheric conditions: superrefraction and subrefraction; — attenuation with distance; — condition and size of the reflecting surface.	x	x	x	x	x	x
062 03 02 00	**Ground radar**						
062 03 02 01	**Principles**						
LO	Explain that primary radar provides bearing and distance of targets.	x		x	x		x
LO	Explain that primary ground radar is used to detect aircraft that are not equipped with a secondary radar transponder.	x		x	x		x
LO	Explain why Moving Target Indicator (MTI) is used.	x		x	x		x
062 03 02 02	**Presentation and interpretation**						
LO	State that modern ATC systems use computer-generated display.	x		x	x		x
LO	Explain that the radar display enables the ATS controller to provide information, surveillance or guidance service.	x		x	x		x
062 03 03 00	**Airborne weather radar**						
062 03 03 01	**Principles**						
LO	List the two main tasks of the weather radar in respect of weather and navigation.	x		x	x		x
LO	State the wavelength (approx. 3 cm) and frequency of most AWRs (approx. 9 GHz).	x		x	x		x
LO	Explain how the antenna is attitude-stabilised in relation to the horizontal plane using the aircraft's attitude reference system.	x		x	x		x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain that older AWRs have two different radiation patterns which can be produced by a single antenna, one for mapping (cosecant-squared) and the other for weather (pencil/cone-shaped).	x		x	x		x
LO	Describe the cone-shaped pencil beam of about 3° to 5° beam width used for weather depiction.	x		x	x		x
LO	Explain that in modern AWRs a single radiation pattern is used for both mapping and weather with the scanning angle being changed between them.	x		x	x		x
062 03 03 02	**Presentation and interpretation**						
LO	Explain the functions of the following different modes on the radar control panel: — off/on switch; — function switch, with WX, WX+T and MAP modes; — gain-control setting (auto/manual); — tilt/autotilt switch.	x		x	x		x
LO	Name, for areas of differing reflection intensity, the colour gradations (green, yellow, red and magenta) indicating the increasing intensity of precipitation.	x		x	x		x
LO	Illustrate the use of azimuth-marker lines and range lines in respect of the relative bearing and the distance to a thunderstorm or to a landmark on the screen.	x		x	x		x
062 03 03 03	**Coverage and range**						
LO	Explain how the radar is used for weather detection and for mapping (range, tilt and gain, if available).	x		x	x		x
062 03 03 04	**Errors, accuracy, limitations**						
LO	Explain why AWR should be used with extreme caution when on the ground.	x		x	x		x
062 03 03 05	**Factors affecting range and accuracy**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain the danger of the area behind heavy rain (shadow area) where no radar waves will penetrate.	x		x	x		x
LO	Explain why the tilt setting should be higher when the aircraft descends to a lower altitude.	x		x	x		x
LO	Explain why the tilt setting should be lower when the aircraft climbs to a higher altitude.	x		x	x		x
LO	Explain why a thunderstorm may not be detected when the tilt is set too high.	x		x	x		x
062 03 03 06	**Application for navigation**						
LO	Describe the navigation function of the radar in the mapping mode.	x		x	x		x
LO	Describe the use of the weather radar to avoid a thunderstorm (Cb).	x		x	x		x
LO	Explain how turbulence (not CAT) can be detected by a modern weather radar.	x		x	x		x
LO	Explain how windshear can be detected by a modern weather radar.	x		x	x		x
062 03 04 00	**Secondary surveillance radar and transponder**						
062 03 04 01	**Principles**						
LO	Explain that the Air Traffic Control (ATC) system is based on the replies provided by the airborne transponders in response to interrogations from the ATC secondary radar.	x	x	x	x	x	x
LO	Explain that the ground ATC secondary radar uses techniques which provide the ATC with information that cannot be acquired by the primary radar.	x	x	x	x	x	x
LO	Explain that an airborne transponder provides coded-reply signals in response to interrogation signals from the ground secondary radar and from aircraft equipped with TCAS.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain the advantages of SSR over a primary radar.	x	x	x	x	x	x
062 03 04 02	**Modes and codes**						
LO	Explain that the interrogator transmits its interrogations in the form of a series of pulses.	x	x	x	x	x	x
LO	Name and explain the interrogation modes: — Mode A and C; — Intermode: • Mode A/C/S all call, • Mode A/C only all call; — Mode S: • Mode S only all call, • broadcast (no reply elicited), • selective.	x	x	x	x	x	x
LO	State that the interrogation frequency is 1 030 MHz and the reply frequency is 1 090 MHz.	x	x	x	x	x	x
LO	Explain that the decoding of the time between the interrogation pulses determines the operating mode of the transponder: — Mode A: transmission of aircraft transponder code; — Mode C: transmission of aircraft pressure altitude; — Mode S: aircraft selection and transmission of flight data for the ground surveillance.	x	x	x	x	x	x
LO	State that the ground interrogation signal is transmitted in the form of pairs of pulses P1 and P3 for Mode A and C, and that a control pulse P2 is transmitted following the first interrogation pulse P1.	x	x	x	x	x	x
LO	Explain that the interval between P1 and P3 determines the mode of interrogation, Mode A or C.	x	x	x	x	x	x
LO	State that the radiated amplitude of P2 from the side lobes and from the main lobe is different.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	State that Mode-A designation is a sequence of four digits which can be manually selected from 4 096 available codes.	x	x	x	x	x	x
LO	State that in Mode-C reply the pressure altitude is reported in 100-ft increments.	x	x	x	x	x	x
LO	State that in addition to the information pulses provided, a Special Position Identification (SPI) pulse can be transmitted but only as a result of a manual selection (IDENT).	x	x	x	x	x	x
LO	Explain the need for compatibility of Mode S with Mode A and C.	x	x	x	x	x	x
LO	Explain that Mode-S transponders receive interrogations from other Mode-S transponders and SSR ground stations.	x	x	x	x	x	x
LO	State that Mode-S surveillance protocols implicitly use the principle of selective addressing.	x	x	x	x	x	x
LO	Explain that every aircraft will have been allocated an ICAO Aircraft Address which is hard-coded into the airframe (Mode-S address).	x	x	x	x	x	x
LO	Explain that the ICAO Aircraft Address consists of 24 bits (therefore more than 16 000 000 possible codes) allocated by the registering authority of the State in which the aircraft is registered.	x	x	x	x	x	x
LO	Explain that this (24-bit) address is included in all Mode-S transmissions, so that every interrogation can be directed to a specific aircraft, preventing multiple replies.	x	x	x	x	x	x
LO	State that the ground interrogation signal is transmitted in the form of P1, P3 and P4 pulses for Mode S.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Interpret the following Mode-S terms: — selective addressing; — mode 'all call'; — selective call.	x	x	x	x	x	x
LO	State that Mode-S interrogation contains either: — aircraft address; — all call address; — broadcast address.	x	x	x	x	x	x
LO	Mode A/C/S all-call consists of 3 pulses: P1, P3 and the long P4. A control pulse P2 is transmitted following P1 to suppress responses from aircraft in the side lobes of the interrogation antenna.	x	x	x	x	x	x
LO	Mode A/C only all-call consists of 3 pulses: P1, P3 and the short P4.	x	x	x	x	x	x
LO	State that there are 25 possible Mode-S reply forms.	x	x	x	x	x	x
LO	State that the reply message consists of a preamble and a data block.	x	x	x	x	x	x
LO	State that the Aircraft Address shall be transmitted in any reply except in Mode-S only all-call reply.	x	x	x	x	x	x
LO	Explain that Mode S can provide enhanced vertical tracking, using a 25-feet altitude increment.	x	x	x	x	x	x
LO	Explain how SSR can be used for ADS B.	x	x	x	x	x	x
062 03 04 03	**Presentation and interpretation**						
LO	Explain how an aircraft can be identified by a unique code.	x	x	x	x	x	x
LO	Illustrate how the following information is presented on the radar screen: — pressure altitude; — flight level; — flight number or aircraft registration; — ground speed.	x	x	x	x	x	x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Name and interpret the codes 7700, 7600 and 7500.	x	x	x	x	x	x
LO	Interpret the selector modes: OFF, Standby, ON (mode A), ALT (mode A and C), and TEST.	x	x	x	x	x	x
LO	Explain the function of the emission of a Special Position Identification (SPI) pulse after pushing the IDENT button in the aircraft.	x	x	x	x	x	x
	ELEMENTARY SURVEILLANCE						
LO	Explain that the elementary surveillance provides the ATC controller with the aircraft's position, altitude and identification.	x	x	x	x	x	x
LO	State that the elementary surveillance needs Mode-S transponders with Surveillance Identifier (SI) code capacity and the automatic reporting of aircraft identification, known as ICAO Level 2s.	x	x	x	x	x	x
LO	State that the SI code must correspond to the aircraft identification specified in item 7 of the ICAO flight plan or to the registration marking.	x	x	x	x	x	x
LO	State that only the ICAO identification format is compatible with the ATS ground system.	x	x	x	x	x	x
LO	State that Mode-S-equipped aircraft with a maximum mass in excess of 5 700 kg or a maximum cruising true airspeed capability in excess of 250 kt must operate with transponder antenna diversity.	x	x	x	x	x	x
LO	Describe the different types of communication protocols (A, B, C and D).	x	x	x	x	x	x
LO	Explain that elementary surveillance is based on Ground-Initiated Comm-B protocols.	x	x	x	x	x	x
	ENHANCED SURVEILLANCE						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that enhanced surveillance consists of the extraction of additional aircraft parameters known as Downlink Aircraft Parameters (DAP) consisting of: — magnetic heading; — indicated airspeed; — Mach number; — vertical rate; — roll angle; — track angle rate; — true track angle; — ground speed; — selected altitude.	x	x	x	x	x	x
LO	Explain that the controller's information is improved by providing actual aircraft-derived data such as magnetic heading, indicated airspeed, vertical rate and selected altitude.	x	x	x	x	x	x
LO	Explain that the automatic extraction of an aircraft's parameters, and their presentation to the controller, will reduce their R/T workload and will free them to concentrate on ensuring the safe and efficient passage of air traffic.	x	x	x	x	x	x
LO	Explain that the reduction in radio-telephony between the air traffic controllers and the pilots will reduce pilot workload and remove a potential source of error.	x	x	x	x	x	x
062 03 04 04	**Errors and accuracy**						
LO	Explain the following disadvantages of SSR (Mode A/C): — code garbling of aircraft less than 1.7 NM apart measured in the vertical plane perpendicular to and from the antenna; — 'fruiting' which results from the reception of replies caused by interrogations from other radar stations.	x	x	x	x	x	x
062 04 00 00	***INTENTONALLY LEFT BLANK***						
062 05 00 00	**AREA NAVIGATION SYSTEMS, RNAV/FMS**						
062 05 01 00	**General philosophy and definitions**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
062 05 01 01	**Basic RNAV (B-RNAV), Precision RNAV (P-RNAV), RNP-PNAV**						
LO	Define 'Area Navigation' (RNAV) (ICAO Annex 11). A method of navigation permitting aircraft operations on any desired track within the coverage of station-referenced navigation signals, or within the limits of a self-contained navigation system.	x		x			x
LO	State that Basic RNAV (B-RNAV) systems require RNP 5.	x		x			x
LO	State that Precision RNAV (P-RNAV) systems require RNP 1.	x		x			x
062 05 01 02	**Principles of 2D RNAV, 3D RNAV and 4D RNAV**						
LO	State that a 2D-RNAV system is able to navigate in the horizontal plane only.	x		x			x
LO	State that a 3D-RNAV system is able to navigate in the horizontal plane and in addition has a guidance capability in the vertical plane.	x		x			x
LO	State that a 4D-RNAV system is able to navigate in the horizontal plane, has a guidance capability in the vertical plane and in addition has a timing function.	x		x			x
062 05 01 03	**Required Navigation Performance (RNP) in accordance with ICAO Doc 9613**						
LO	State that RNP is a concept that applies to navigation performance within an airspace.	x		x			x
LO	The RNP type is based on the navigation performance accuracy to be achieved within anairspace.	x		x			x
LO	State that RNP X requires a navigation performance accuracy of ± X NM both lateral and longitudinal 95 % of the flying time (RNP 1 requires a navigation performance of ± 1 NM both lateral and longitudinal 95 % of the flying time).	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that RNAV equipment is one requirement in order to receive approval to operate in an RNP environment.	x		x			x
LO	State that RNAV equipment operates by automatically determining the aircraft's position.	x		x			x
LO	State the advantages of using RNAV techniques over more conventional forms of navigation: — establishment of more direct routes permitting a reduction in flight distance; — establishment of dual or parallel routes to accommodate a greater flow of en route traffic; — establishment of bypass routes for aircraft overflying high-density terminal areas; — establishment of alternatives or contingency routes either on a planned or ad hoc basis; — establishment of optimum locations for holding patterns; — reduction in the number of ground navigation facilities.	x		x			x
LO	State that RNP may be specified for a route, a number of routes, an area, volume of airspace, or any airspace of defined dimensions.	x		x			x
LO	State that airborne navigation equipment uses inputs from navigational systems such as VOR/DME, DME/DME, GNSS, INS and IRS.	x		x			x
LO	State that aircraft equipped to operate to RNP 1 and better, should be able to compute an estimate of its position error, depending on the sensors being used and time elapsed.	x		x			x
LO	Indicate navigation-equipment failure.	x		x			x
062 05 02 00	**Simple 2D RNAV** *Info: First generation of radio-navigation systems allowing the flight crew to select a phantom waypoint on the RNAV panel and select a desired track to fly inbound to the waypoint.*						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
062 05 02 01	**Flight-deck equipment**						
LO	The control unit allows the flight crew to: — tune the VOR/DME station used to define the phantom waypoint; — define the phantom waypoint as a radial and distance (DME) from the selected VOR/DME station; — select the desired magnetic track to follow inbound to the phantom waypoint; — select between an en route mode, an approach mode of operation and the basic VOR/DME mode of operation.	x		x			x
LO	Track guidance is shown on the HSI/CDI.	x		x			x
062 05 02 02	**Navigation computer, VOR/DME navigation**						
LO	The navigation computer of the simple 2D-RNAV system computes the navigational problems by simple sine and cosine mathematics, solving the triangular problems.	x		x			x
062 05 02 03	**Navigation computer input/output**						
LO	State that the following input data to the navigation computer is: — the actual VOR radial and DME distance from the selected VOR station; — the radial and distance to phantom waypoint; — the desired magnetic track inbound to the phantom waypoint.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State the following output data from the navigation computer: — desired magnetic track to the phantom waypoint shown on the CDI at the course pointer; — distance from the present position to the phantom waypoint; — deviations from the desired track as follows: • in en route mode, full-scale deflection on the CDI is 5 NM; • in approach mode, full-scale deflection on the CDI is 1 ¼ NM; • in VOR/DME mode, full-scale deflection on the CDI is 10°.	x		x			x
LO	State that the system is limited to operate within the range of the selected VOR/DME station.	x		x			x
062 05 03 00	**4D RNAV** *Info: The next generation of area navigation equipment allowed the flight crew to navigate on any desired track within the coverage of VOR/DME stations.*						
062 05 03 01	**Flight-deck equipment**						
LO	State that in order to give the flight crew control over the required lateral guidance functions, RNAV equipment should at least be able to perform the following functions: — display present position in latitude/ longitude or as distance/bearing to the selected waypoint; — select or enter the required flight plan through the Control and Display Unit (CDU); — review and modify navigation data for any part of a flight plan at any stage of flight and store sufficient data to carry out the active flight plan; — review, assemble, modify or verify a flight plan in flight, without affecting the guidance output; — execute a modified flight plan only after positive action by the flight crew; — where provided, assemble and verify an	x		x			x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	alternative flight plan without affecting the active flight plan; — assemble a flight plan, either by identifier or by selection of individual waypoints from the database, or by creation of waypoints from the database, or by creation of waypoints defined by latitude/longitude, bearing/ distance parameters or other parameters; — assemble flight plans by joining routes or route segments; — allow verification or adjustment of displayed position; — provide automatic sequencing through waypoints with turn anticipation; manual sequencing should also be provided to allow flight over, and return to, waypoints; — display cross-track error on the CDU; — provide time to waypoints on the CDU; — execute a direct clearance to any waypoint; — fly parallel tracks at the selected offset distance; offset mode should be clearly indicated; — purge previous radio updates; — carry out RNAV holding procedures (when defined); — make available to the flight crew estimates of positional uncertainty, either as a quality factor or by reference to sensor differences from the computed position; — conform to WGS-84 geodetic reference system; — indicate navigation-equipment failure.						
062 05 03 02	**Navigation computer, VOR/DME navigation**						
LO	State that the navigation computer uses signals from the VOR/DME stations to determine position.	x		x			x
LO	Explain that the system automatically tunes the VOR/DME stations by selecting stations which provide the best angular fix determination.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain that the computer uses DME/DME to determine position if possible, and only if two DMEs are not available the system will use VOR/DME to determine the position of the aircraft.	x		x			x
LO	Explain that the computer is navigating on the great circle between waypoints inserted into the system.	x		x			x
LO	State that the system has a navigational database which may contain the following elements: — reference data for airports (4-letter ICAO identifier); — VOR/DME station data (3-letter ICAO identifier); — waypoint data (5-letter ICAO identifier); — STAR data; — SID data; — airport runway data including thresholds and outer makers; — NDB stations (alphabetic ICAO identifier); — company flight-plan routes.	x		x			x
LO	State that the navigational database is valid for a limited time, usually 28 days.	x		x			x
LO	State that the navigational database is read only, but additional space exists so that crew-created navigational data may be saved in the computer memory. Such additional data will also be deleted at the 28-day navigational update of the database.	x		x			x
LO	State that the computer receives a TAS input from the air-data computer and a heading input in order to calculate actual wind velocity.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the computer calculates track error in relation to desired track. This data can easily be interfaced with the automatic flight control, and when done so, it enables the aircraft to automatically follow the flight plan loaded into the RNAV computer.	x		x			x
LO	State that the computer is able to perform great-circle navigation when receiving VOR/DME stations. If out of range, the system reverts to DR (Dead Reckoning) mode, where it updates the position by means of last computed wind and TAS and heading information. Operation in DR mode is time-limited.	x		x			x
LO	State that the system has 'direct to' capability to any waypoint.	x		x			x
LO	State that the system is capable of parallel offset tracking.	x		x			x
LO	State that any waypoint can be inserted into the computer in one of the following ways: — alphanumeric ICAO identifier; — latitude and longitude; — radial and distance from a VOR station.	x		x			x
062 05 03 03	**Navigation computer input/output**						
LO	State that the following are input data into a 4D-RNAV system: — DME distances from DME stations; — radial from a VOR station; — TAS and altitude from the air-data computer; — heading from the aircraft's heading system.	x		x			x
LO	State that the following are output data from a 4D-RNAV system: — distance to any waypoint; — estimated time overhead; — ground speed and TAS; — true wind; — track error.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
062 05 04 00	**Flight Management System (FMS) and general terms**						
062 05 04 01	**Navigation and flight management**						
LO	Explain that the development of computers which combine reliable liquid crystal displays offer the means of accessing more data and displaying them to the flight crew.	x		x			x
LO	Explain that a flight management system has the ability to monitor and direct both navigation and performance of the flight.	x		x			x
LO	Explain the two functions common to all FMS systems: — automatic navigation Lateral Navigation (LNAV); — flight path management Vertical Navigation (VNAV).	x		x			x
LO	Name the main components of the FMS system as being: — Flight Management Computer (FMC); — Control and Display Unit (CDU); — symbol generator; — Electronic Flight Instrument System (EFIS) consisting of the NAV display, including mode selector and attitude display; — Auto-throttle (A/T) and Flight Control Computer (FCC).	x		x			x
062 05 04 02	**Flight management computer**						
LO	State that the centre of the flight management system is the FMC with its stored navigation and performance data.	x		x			x
062 05 04 03	**Navigation database**						

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the navigation database of the FMC may contain the following data: — reference data for airports (4-letter ICAO identifier); — VOR/DME station data (3-letter ICAO identifier); — waypoint data (5-letter ICAO identifier); — STAR data; — SID data; — holding patterns; — airport runway data; — NDB stations (alphabetic ICAO identifier); — company flight-plan routes.	x		x			x
LO	State that the navigation database is updated every 28 days.	x		x			x
LO	State that the navigational database is write-protected, but additional space exists so that crew-created navigational data may be saved in the computer's memory. Such additional data will also be deleted at the 28-day navigational update of the database.	x		x			x
062 05 04 04	**Performance database**						
LO	State that the performance database stores all the data relating to the specific aircraft/engine configuration, and is updated by ground staff when necessary.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the performance database of the FMC contain the following data: — V1, VR and V2 speeds; — aircraft drag; — engine-thrust characteristics; — maximum and optimum operating altitudes; — speeds for maximum and optimum climb; — speeds for long-range cruise, maximum endurance and holding; — maximum Zero-Fuel Mass (ZFM), maximum Take-Off Mass (TOM) and maximum Landing Mass (LM); — fuel-flow parameters; — aircraft flight envelope.	x		x			x
062 05 04 05	**Typical input/output data from the FMC**						
LO	State the following are typical input data to the FMC: — time; — fuel flow; — total fuel; — TAS, altitude, vertical speed, Mach number and outside-air temperature from the Air-Data Computer (ADC); — DME and radial information from the VHF/NAV receivers; — air/ground position; — flap/slat position; — IRS and GPS positions; — Control and Display Unit (CDU) entries.	x		x			x
LO	State that the following are typical output data from the FMC: — command signals to the flight directors and autopilot; — command signals to the auto-throttle; — information to the EFIS displays through the symbol generator; — data to the CDU and various annunciators.	x		x			x
062 05 04 06	**Determination of the FMS position of the aircraft**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that modern FMS may use a range of sensors for calculating the position of the aircraft including VOR, DME, GPS, IRS and ILS.	x		x			x
LO	State that the information from the sensors used may be blended into a single position by using the Kalman-filter method.	x		x			x
LO	State that the Kalman filter is an algorithm for filtering incomplete and noisy measurements of dynamical processes so that errors of measurements from different sensors are minimised, thus leading to the calculated position being more accurate than that produced by any single sensor.	x		x			x
062 05 05 00	**Typical flight-deck equipment fitted on FMS aircraft**						
062 05 05 01	**Control and Display Unit (CDU)**						
LO	State that the communication link between the flight crew and the FMC is the CDU.	x		x			x
LO	Explain the main components of the CDU as follows: — CDU display including the following terms: • page title, • data field, • scratch pad; — line-select keys; — numeric keys; — alpha keys; — function and mode keys used to select specific data pages on the CDU display, to execute orders or to navigate to pages through the data presented; — warning lights, message light and offset light.	x		x			x
062 05 05 02	**EFIS instruments (attitude display, navigation display)**						
LO	State that FMS-equipped aircraft typically has two displays on the instrument panel in front of each pilot.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the following data are typically displayed on the attitude display: — attitude information; — flight director command bars; — radio height and barometric altitude; — course deviation indication; — glide-path information (when an ILS is tuned); — speed information.	x		x			x
062 05 05 03	**Typical modes of the navigation display**						
LO	State the following typical modes of the navigation display: — full VOR/ILS mode showing the whole compass rose; — expanded (arc) VOR/ILS mode showing the forward 90° sector; — map mode; — plan mode.	x		x			x
062 05 05 04	**Typical information on the navigation display**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	List and interpret the following information typically shown on a navigation display in 'Full VOR/ILS' mode: — the map display will be in full VOR mode when a VOR frequency is selected, and full ILS mode when an ILS frequency is selected on the VHF NAV frequency selector; — DME distance to selected DME station; — a full 360° compass rose. At the top of the compass rose, present heading is indicated and shown as digital numbers in a heading box. Next to the heading box it is indicated whether the heading is true or magnetic. True heading is available on aircraft with IRS. A triangle (different symbols are used on different aircraft) on the compass rose indicates present track. Track indication is only available when the FMC navigation computer is able to compute the aircraft's position. A square symbol on the outside of the compass rose indicates the selected heading for the autopilot, and if 'heading select' mode is activated on the autopilot, this is the heading the aircraft will turn to. Within the compass rose, a CDI is shown. On the CDI, the course pointer points to the selected VOR/ILS course SET on the OBS. On the CDI, the course deviation bar will indicate angular deflection from the selected VOR/ILS track. Full-scale deflection side to side in VOR mode is 20°, and 5° in ILS mode. In VOR mode, a TO/FROM indication is shown on the display. The selected ILS/VOR frequency is shown.	x		x			x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	ILS or VOR mode is shown according to the selected frequency. If an ILS frequency is selected, a glide-path deviation scale is shown.						

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	A wind arrow indicating wind direction according to the compass rose, and velocity in numbers next to the arrow.	x		x			x
LO	Given an EFIS navigation display in full VOR/ILS mode, read off the following information: — heading (magnetic/true); — track (magnetic/true); — drift; — wind correction angle; — selected course; — actual radial; — left or right of selected track; — above or below the glide path; — distance to the DME station; — selected heading for the autopilot heading select bug; — determine whether the display is in VOR or ILS rose mode.	x		x			x
LO	Given an EFIS navigation display in expanded VOR/ILS mode, read off the following information: — heading (magnetic/true); — track (magnetic/true); — drift; — wind correction angle; — tailwind/headwind; — wind velocity; — selected course; — actual radial; — left or right of selected track; — above or below the glide path; — distance to the DME station; — selected heading for the autopilot heading select bug; — state whether the display is in VOR or ILS rose mode.	x		x			x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Given an EFIS navigation display in map mode, read off the following information: — heading (magnetic/true); — track (magnetic/true); — drift; — wind correction angle; — tailwind/headwind; — wind velocity; — left or right of the FMS track; — distance to active waypoint; — ETO next waypoint; — selected heading for the autopilot heading select bug; — determine whether a depicted symbol is a VOR/DME station or an airport; — determine whether a specific waypoint is part of the FMS route.	x		x			x
LO	Given an EFIS navigation display in plan mode, read off the following information: — heading (magnetic/true) — track (magnetic/true) — drift; — wind correction angle; — distance to active waypoint; — ETO active waypoint; — state the selected heading for the autopilot heading select bug; — measure and state true track of specific FMS route track.	x		x			x
062 06 00 00	**GLOBAL NAVIGATION SATELLITE SYSTEMS**						
062 06 01 00	**GPS, GLONASS, GALILEO**						
062 06 01 01	**Principles**						
LO	State that there are two main Global Navigation Satellite Systems (GNSS) currently in existence with a third one which is planned to be fully operational by 2011. These are: — USA NAVigation System with Timing And Ranging Global Positioning System (NAVSTAR GPS); — Russian GLObal NAvigation Satellite System (GLONASS); — European GALILEO.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that all three systems (will) consist of a constellation of satellites which can be used by a suitably equipped receiver to determine position.	x	x	x	x	x	x
062 06 01 02	**Operation**						
	NAVSTAR GPS						
LO	State that there are currently two modes of operation: Standard Positioning Service (SPS) for civilian users, and Precise Positioning Service (PPS) for authorised users.	x	x	x	x	x	x
LO	SPS was originally designed to provide civilian users with a less accurate positioning capability than PPS.	x	x	x	x	x	x
LO	Name the three segments as follows: — space segment; — control segment; — user segment.	x	x	x	x	x	x
	Space segment						
LO	State that the space segment consists of a notional constellation of 24 operational satellites.	x	x	x	x	x	x
LO	State that the satellites are orbiting the Earth in orbits inclined 55° to the plane of the equator.	x	x	x	x	x	x
LO	State that the satellites are in a nearly circular orbit of the Earth at an altitude of 20 200 km (10 900 NM).	x	x	x	x	x	x
LO	State that the satellites are distributed in 6 orbital planes with at least 4 satellites in each.	x	x	x	x	x	x
LO	State that a satellite completes an orbit in approximately 12 hours.	x	x	x	x	x	x
LO	State that each satellite broadcasts ranging signals on two UHF frequencies: L1 1575.42 MHz and L2 1227.6 MHz.	x	x	x	x	x	x
LO	State that SPS is a positioning and timing service provided on frequency L1.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that PPS uses both frequencies L1 and L2.	x	x	x	x	x	x
LO	In 2005, the first replacement satellite was launched with a new military M code on the L1 frequency, and a second signal for civilian use L2C on the L2 frequency.	x	x	x	x	x	x
LO	State that the ranging signal contains a Coarse Acquisition (C/A) code and a navigational data message.	x	x	x	x	x	x
LO	State that the navigation message contains: — almanac data; — ephemeris; — satellite clock correction parameters; — UTC parameters; — ionospheric model; — satellite health data.	x	x	x	x	x	x
LO	State that it takes 12,5 minutes for a GPS receiver to receive all the data frames in the navigation message.	x	x	x	x	x	x
LO	State that the almanac contains the orbital data about all the satellites in the GPS constellation.	x	x	x	x	x	x
LO	State that the ephemeris contains data used to correct the orbital data of the satellites due to small disturbances.	x	x	x	x	x	x
LO	State that the clock correction parameters are data for the correction of the satellite time.	x	x	x	x	x	x
LO	State that UTC parameters are factors determining the difference between GPS time and UTC.	x	x	x	x	x	x
LO	State that an ionospheric model is currently used to calculate the time delay of the signal travelling through the ionosphere.	x	x	x	x	x	x
LO	State that the GPS health message is used to exclude unhealthy satellites from the position solution. Satellite health is determined by the validity of the navigation data.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that GPS uses the WGS-84 model.	x	x	x	x	x	x
LO	State that two codes are transmitted on the L1 frequency, namely a C/A code and a Precision (P) code. The P code is not used for SPS.	x	x	x	x	x	x
LO	State that the C/A code is a Pseudo Random Noise (PRN) code sequence, repeating every millisecond. Each C/A code is unique and provides the mechanism to identify each satellite.	x	x	x	x	x	x
LO	State that satellites broadcast the PRN codes with reference to the satellite vehicle time which are subsequently changed by the receiver to UTC.	x	x	x	x	x	x
LO	State that satellites are equipped with atomic clocks, which allow the system to keep very accurate time reference.	x	x	x	x	x	x
	Control segment						
LO	State that the control segment comprises: — a master control station; — ground antenna; — monitoring stations.	x	x	x	x	x	x
LO	State that the master control station is responsible for all aspects of the constellation command and control.	x	x	x	x	x	x
LO	State that the main tasks of the control segment are: — managing SPS performance; — navigation data upload; — monitoring satellites.	x	x	x	x	x	x
	User segment						
LO	State that GPS supplies three-dimensional position fixes and speed data, plus a precise time reference.	x	x	x	x	x	x
LO	State that the GPS receiver used in aviation is a multichannel type.	x	x	x	x	x	x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that a GPS receiver is able to determine the distance to a satellite by determining the difference between the time of transmission by the satellite and the time of reception.	x	x	x	x	x	x
LO	State that the initial distance calculated to the satellites is called pseudo-range because the difference between the GPS receiver and the satellite time references initially creates an erroneous range.	x	x	x	x	x	x
LO	State that each range defines a sphere with its centre at the satellite.	x	x	x	x	x	x
LO	State that three satellites are needed to determine a two-dimensional position.	x	x	x	x	x	x
LO	State that four spheres are needed to calculate a three-dimensional position, hence four satellites are required.	x	x	x	x	x	x
LO	State that the GPS receiver is able to synchronise to the correct time base when receiving four satellites.	x	x	x	x	x	x
LO	State that the receiver is able to calculate aircraft ground speed using the SV Doppler frequency shift and/or the change in receiver position over time.	x	x	x	x	x	x
	NAVSTAR GPS integrity						
LO	Define 'Receiver Autonomous Integrity Monitoring (RAIM)'. A technique whereby a receiver processor determines the integrity of the navigation signals.	x	x	x	x	x	x
LO	State that RAIM is achieved by consistency check among pseudo-range measurements.	x	x	x	x	x	x
LO	State that basic RAIM requires five satellites. A sixth is for isolating a faulty satellite from the navigation solution.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that when a GPS receiver uses barometric altitude as an augmentation to RAIM, the number of satellites needed for the receiver to perform the RAIM function may be reduced by one.	x	x	x	x	x	x
	GLONASS						
LO	List the three components of GLONASS: — space segment, which contains the constellation of satellites; — control segment, which contains the ground-based facilities; — user segment, which contains the user equipment.	x	x	x	x	x	x
LO	State the composition of the constellation in the 'space segment': — 24 satellites in 3 orbital planes with 8 equally displaced by 45° of latitude; — a near-circular orbit at 19 100 km at an inclination of 64.8° to the equator; — each orbit is completed in 11 hours and 15 minutes.	x	x	x	x	x	x
LO	State that the control segment provides: — monitoring of the constellation status; — correction to orbital parameters; — navigation data uploading.	x	x	x	x	x	x
LO	State that the user equipment consists of receivers and processors for the navigation signals for the calculation of the coordinates, velocity and time.	x	x	x	x	x	x
LO	State that the time reference is UTC.	x	x	x	x	x	x
LO	State that the datum used is PZ-90 Earth-centred Earth-fixed.	x	x	x	x	x	
LO	State that each satellite transmits navigation signals on two frequencies of L-band, L1 1.6 GHz and L2 1.2 GHz.	x	x	x	x	x	x
LO	State that L1 is a standard-accuracy signal designed for civilian users worldwide and L2 is a high-accuracy signal modulated by a special code for authorised users only.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the navigation message has a duration of 2 seconds and contains 'immediate' data which relates to the actual satellite transmitting the given navigation signal and 'non-immediate' data which relates to all other satellites within the constellation.	x	x	x	x	x	x
LO	State that 'immediate data' consists of: — enumeration of the satellite time marks; — difference between onboard time scale of the satellite and GLONASS time; — relative differences between carrier frequency of the satellite and its nominal value; — ephemeris parameters.	x	x	x	x	x	x
LO	State that 'non-immediate' data consists of: — data on the status of all satellites within the space segment; — coarse corrections to onboard time scales of each satellite relative to GLONASS time; — orbital parameters of all satellites within the space segment; — correction to GLONASS time relative to UTC (must remain within 1 microsecond).	x	x	x	x	x	x
LO	State that integrity monitoring includes checking the quality of the characteristics of the navigation signal and the data within the navigation message.	x	x	x	x	x	x
LO	State that integrity monitoring is implemented in two ways: — Continuous automatic operability monitoring of principal systems in each satellite. If a malfunction occurs, an 'unhealthy' flag appears within the 'immediate data' of the navigation message. — Special tracking stations within the ground-based control segment are used to monitor the space-segment performance. If a malfunction occurs, an 'unhealthy' flag appears within the 'immediate data' of the navigation message.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that agreements have been concluded between the appropriate agencies for the interoperability by any approved user of NAVSTAR and GLONASS systems.	x	x	x	x	x	x
	GALILEO						
LO	State that the core of the Galileo constellation will consist of 30 satellites with 9 plus a spare replacement in each of the 3 planes in near-circular orbit at an altitude of 23 222 km inclined at 56° to the plane of the equator.	x	x	x	x	x	x
LO	State that the signals will be transmitted in 3 frequency bands: 1 164–1 215 MHz, 1 260–1 300 MHz and 1 559–1 591 MHz (1 559–1 591 MHz will be shared with GPS on a non-interference basis).	x	x	x	x	x	x
LO	State that each orbit will take 14 hours.	x	x	x	x	x	x
LO	State that each satellite has three sections: timing, signal generation and transmit.	x	x	x	x	x	x
LO	State that in the 'timing section' two clocks have been developed, a Rubidium Frequency Standard clock and a more precise Passive Hydrogen Maser clock.	x	x	x	x	x	x
LO	State that the signal generation contains the navigation signals.	x	x	x	x	x	x
LO	State that the navigation signals consist of a ranging-code identifier and the navigation message.	x	x	x	x	x	x
LO	State that the navigation message basically contains information concerning the satellite orbit (ephemeris) and the clock references.	x	x	x	x	x	x
LO	State that the navigation message is 'up-converted' on four navigation signal carriers and the outputs are combined in a multiplexer before transmission in the transmit section.	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that the navigation antenna has been designed to minimise interference between satellites by having equal power level propagation paths independent of elevation angle.	x	x	x	x	x	x
LO	State that the system is monitored in a similar way for both GPS NAVSTAR and GLONASS, but also by a new method based on spread-spectrum signals.	x	x	x	x	x	x
LO	State that tracking, telemetry and command operations are controlled by sophisticated data encryption and authentication procedures.	x	x	x	x	x	x
LO	GPS, EGNOS and GALILEO are compatible, will not interfere with each other, and the performance of the receiver will be enhanced by the interoperability of the systems.	x	x	x	x	x	x
	GALILEO future developments *Info: Further LOs will be written as details are released.*						
062 06 01 03	**Errors and factors affecting accuracy**						
LO	List the most significant factors affecting accuracy: — ionospheric propagation delay; — dilution of position; — satellite clock error; — satellite orbital variations; — multipath.	x	x	x	x	x	x
LO	State that Ionospheric Propagation Delay (IPD) can almost be eliminated by using two frequencies.	x	x	x	x	x	x
LO	State that in SPS receivers, IPD is currently corrected by using the ionospheric model from the navigation message, but the error is only reduced by 50 %.	x	x	x	x	x	x
LO	State that ionospheric delay is the most significant error.	x	x	x	x	x	x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that dilution of position arises from the geometry and number of satellites in view. It is called Position Dilution of Precision (PDOP).	x	x	x	x	x	x
LO	State that errors in the satellite orbits are due to: — solar wind; — gravitation of the Sun, Moon and planets.	x	x	x	x	x	x
LO	State that multipath is when the signal arrives at the receiver via more than one path (the signal being reflected from surfaces near the receiver).	x	x	x	x	x	x
062 06 02 00	**Ground, satellite and airborne-based augmentation systems**						
062 06 02 01	***Ground-Based Augmentation Systems (GBAS)***						
LO	Explain the principle of a GBAS: to measure on ground the signal errors transmitted by GNSS satellites and relay the measured errors to the user for correction.	x	x	x	x	x	x
LO	State that the ICAO GBAS standard is based on this technique through the use of a data link in the VHF band of ILS–VOR systems (108–118 MHz).	x	x	x	x	x	x
LO	State that for a GBAS station the coverage is about 30 km.	x	x	x	x	x	x
LO	Explain that ICAO Standards provide the possibility to interconnect GBAS stations to form a network broadcasting large-scale differential corrections. Such a system is identified as Ground Regional Augmentation System (GRAS).	x	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	Aeroplane		Helicopter			IR
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain that GBAS ground subsystems provide two services: precision approach service and GBAS positioning service. The precision approach service provides deviation guidance for final-approach Segments, while the GBAS positioning service provides horizontal position information to support RNAV operations in terminal areas.	x	x	x	x	x	x
LO	Explain that one ground station can support all the aircraft subsystems within its coverage providing the aircraft with approach data, corrections and integrity information for GNSS satellites in view via a VHF Data Broadcast (VDB).	x	x	x	x	x	x
LO	State that the minimum GBAS plan coverage is 15 NM from the landing threshold point within 35° apart the final approach path and 10° apart between 15 and 20 NM.	x	x	x	x	x	x
LO	State that GBAS based on GPS is sometimes called Local Area Augmentation System (LAAS).	x	x	x	x	x	x
LO	Describe the characteristics of a Local Area Augmentation System (LAAS) with respect to: — differential corrections applied to a satellite signal by a ground-based reference station; — regional service providers to compute the integrity of the satellite signals over their region; — extra accuracy for extended coverage around airports, railways, seaports and urban areas as required by the user.	x	x	x	x	x	x
062 06 02 02	***Satellite-Based Augmentation Systems (SBAS)***						
LO	Explain the principle of a SBAS: to measure on the ground the signal errors transmitted by GNSS satellites and transmit differential corrections and integrity messages for navigation satellites.	X	x	x	x	x	x
LO	State that the frequency band of the data link is identical to that of the GPS signals.	X	x	x	x	x	x

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain that the use of geostationary satellites enables messages to be broadcast over very wide areas.	X	x	x	x	x	x
LO	Explain that pseudo-range measurements to these geostationary satellites can also be made, as if they were GPS satellites.	X	x	x	x	x	x
LO	State that SBAS consists of three elements: — the ground infrastructure (monitoring and processing stations); — the SBAS satellites; — the SBAS airborne receivers.	X	x	x	x	x	x
LO	Explain that the SBAS station network measures the pseudo-range between the ranging source and an SBAS receiver at the known locations and provides separate corrections for ranging source ephemeris errors, clock errors and ionospheric errors. The user applies corrections for tropospheric delay.	X	x	x	x	x	x
LO	Explain that SBAS can provide approach and landing operations with vertical guidance (APV) and precision approach service.	X	x	x	x	x	x
LO	Explain the difference between 'coverage area' and 'service area'.	X	x	x	x	x	x
LO	State that Satellite-Based Augmentation Systems include: — EGNOS in western Europe and the Mediterranean; — WAAS in the USA; — MSAS in Japan; — GAGAN in India.	X	x	x	x	x	x
LO	Explain that SBAS systems regionally augment GPS and GLONASS by making them suitable for safety-critical applications such as landing aircraft.	X	x	x	x	x	x
062 06 02 03	***European Geostationary Navigation Overlay Service (EGNOS)***						
LO	State that EGNOS consists of three geostationary Inmarsat satellites which broadcast GPS lookalike signals.	X	x	x	x	x	x

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that EGNOS is designed to improve accuracy to 1–2 m horizontally and 3–5 m vertically.	X	x	x	x	x	x
LO	Explain that integrity and safety are improved by alerting users within 6 seconds if a GPS malfunction occurs (up to 3 hours GPS alone).	X	x	x	x	x	x
062 06 02 04	***Airborne-Based Augmentation Systems (ABAS)***						
LO	Explain the principle of ABAS: to use redundant elements within the GPS constellation (e.g.: multiplicity of distance measurements to various satellites) or the combination of GNSS measurements with those of other navigation sensors (such as inertial systems) in order to develop integrity control.	x	x	x	x	x	x
LO	State that the type of ABAS using only GNSS information is named Receiver Autonomous Integrity Monitoring (RAIM).	x	x	x	x	x	x
LO	State that a system using information from additional onboard sensors is named Aircraft Autonomous Integrity Monitoring (AAIM).	x	x	x	x	x	x
LO	Explain that the typical sensors used are barometric altimeter, clock and inertial navigation system.	x	x	x	x	x	x
LO	Explain that unlike GBAS and SBAS, ABAS does not improve positioning accuracy.	x	x	x	x	x	x