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AIRBUS

Flight Planning and Monitoring

New programme

EASA
European Aviation Safety Agency

ATPL Training

033

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Flight Planning and Monitoring

Version 2

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PREFACE

The "Flight Planning And Monitoring" book is a course intended for candidates to the theoretical exam for CPL and ATPL licenses. It was developed in compliance with the official program and applicable LO (Learning Objectives), defined within the scope of JAR-FCL theoretical knowledge.
This book offers a theoretical coverage of all the components of flight planning (long-term and short-term planning), as well as a section concerning the in-flight monitoring and management. It includes the following main sections.

- Long-term planning, with the following chapters:
  - VFR navigation;
  - IFR navigation;

  These two chapters are aimed at studying:
  - the routes and associated elements (safety altitude, restricted areas, etc.), using enroute charts;
  - the departure, arrival and approach standard procedures, using aerodrome data charts.

- Short-term planning, with:
  - the regulation concerning the fuel load and the fuel calculation, using the performance data published in the flight manuals for the four aircraft mentioned in the ATPL syllabus of the 033 certificate (see note hereinafter for the CPL program);
  - the study of the pre-flight documents: AIP/NOTAM, weather information, and determination of the Point of Equal Time (PET) and point of safe return (PSR);
  - drafting of the ATC flight plan and flight plan filing procedures.

- Flight monitoring and management rules.

Considering the contents of this syllabus, the candidate should first review the "Meteorology", "Performance", "Navigation" modules, and more especially "Mass and Balance", which are not discussed in the book but which are key elements for flight planning.
It is therefore highly recommended to review the basic notions concerning the various operational masses, such as the basic mass, the zero fuel weight, the Traffic load, etc., in order to deal with possible mass and balance questions during the 033 exam.

A number of aeronautical documents are used within the scope of this module; these documents are excerpts from:
- the Jeppesen Student Pilot Route Manual for the VFR and IFR navigation part;
- the flight manuals of the generic aircraft published in the CAP 697 (Civil Aviation Publication) and Airbus A310 for the fuel calculation;
- meteorological messages and charts, especially the TEMSI, SWC EUR type charts that we shall review in Chapter 4 "Pre-Flight Preparation".

It is important to remind the candidates that all of this data is included in the syllabus of the 033 certificate and that thoroughly grasping how to use such information is a key point for a successful certificate, the exam duration of which is relatively long to allow enough time to analyze the data (2 hours for 43 questions in ATPL and 1 hr 30 for 33 questions in CPL).

Preface

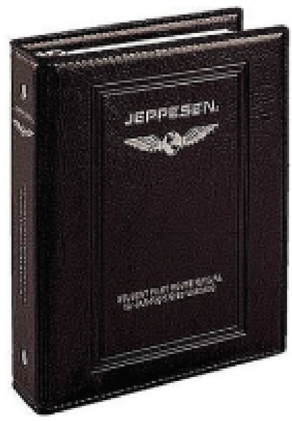
It should be noted that all charts, aerodrome data charts, tables and performance graphs used in this module are strictly reserved for ground training. Their use in operational conditions is strictly prohibited.

Introduction to the Jeppesen Student Pilot Route Manual

In order to prepare his navigation flight plan, the pilot carries out the planning of navigation, called long-term planning, using:

- enroute charts;
- procedure files of the departure aerodrome;
- procedure files of the arrival and alternate aerodromes;
- instrument approach procedure files of the destination and alternate aerodromes (for IFR flights).

All the enroute charts and airport charts of the 033 exam syllabus are excerpts from the Jeppesen Student Pilot Route Manual, which is the reference for the exam annexes.



This manual includes two main sections:

- the "En-route" section includes a set of en-route charts;
- the "Terminal" section includes departure and arrival procedure files of the airport and the instrument approach charts for a number of major airports in Europe (Amsterdam, London, Madrid, Munich, Paris CDG, etc.).

In order to prepare the exam for the "Flight Planning and Monitoring" certificate, the candidates should review their knowledge concerning the charts and airport charts published in this manual, and should also know the various acronyms used and the popular abbreviations and symbols found in the charts and airport charts.
This book, as well as the Enac - Mermoz "e-learning" electronic database, provides the most representative excerpts of charts or airport charts.

Introduction to the CAP 697 and A310 data

The CAP 697 manual (Civil Aviation Publication) describes the performance data extracted from the flight manuals of various generic aircraft. This data, provided in tables and graphs, can be used to determine the fuel for the various flight phases of a specified trip, as well as the regulatory fuel load before each departure.

These three aircraft use the following pseudonyms:

- SEP (Single Engine Piston): single-engine piston aircraft, such as Beechcraft BE 36;
- MEP (Multi Engine Piston): twin-engine piston aircraft, such as Piper Seneca PA 34;
- MRJT (Medium Range Jet Twin): medium range airliner twin-jet engine aircraft; Boeing 737-400.

In addition to the data for the three above-mentioned aircraft, the exam syllabus of the 033 module also includes the Airbus A310 fuel calculation. The data for this aircraft are not included in CAP 697;

therefore, we published in this book, and on the "Mermoz e-learning" site, a number of examples showing the use of performance graphs and tables best representing this aircraft, as well as those of generic aircraft mentioned in CAP 697.
We recommend that the candidates to the 033 certificate regularly practice the exercises in order to be familiar with the format and contents of the graphs and tables for all four aircraft.

Note on the syllabus

A logo allow the book sections to be identified depending on the syllabus concerned:
~~CPL~~ the section does not concern the CPL syllabus;

Bibliography

ICAO Doc 4444 (PANS-RAC): "Procedures for Air Navigation Services – Rules of the air and air traffic services", 15th edition. PANS-RAC "Procedures for Air Navigation Services – Rules of the air and air traffic services".
AIR OPS Official Journal of the European Union: Appendix III to Regulation n 3922/91 – Technical requirements and administrative procedures in the field of civil aviation.
AIR OPS: Requirements in the field of commercial air transportation.

Abbreviations

A	
AC	Altocumulus
ADF	Automatic Direction Finder
ADS	Automatic Dependent Surveillance
AFIS	Aerodrome Flight Information Service
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AIP SUP	Supplement to AIP
AIRAC	Aeronautical Information Regulation and Control
AIS	Aeronautical Information Services
ALS	Approach Light System
AMDT	Amendment (AIP Amendment)
AMSL	Above Mean Sea Level
APU	Auxiliary Power Unit
APV	Approach Procedure with Vertical guidance
AS	Altostratus
ASFC	Above SurFaCe
ASMA	ATC Surveillance Minimum Altitude
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATS	Air Traffic Service
AUP	Airspace Utilisation Plan
B	
BC	Benches
BECMG	Becoming
BKN	Broken
BMJ	Update Bulletin
BR	Mist
C	
CAP	Civil Aviation Publication
CAS	Calibrated Airspeed
CAT	Clear Air Turbulence
CB	Cumulonimbus
CC	Cirrocumulus
Cc	Compass heading
CDFA	Continuous Descent Final Approach
CDR	ConDitional Routes
CG	Center of Gravity
CI	Cirrus
CIT	Near or above large towns
CL	Centerline Lights
Cm	Magnetic heading
COT	At the coast
CPL	Current Flight Plan (active flight plan)
CS	Cirrostratus
CTA	Air control center
CU	Cumulus
Cv	True heading
D	
DER	Departure End of Runway

DH Decision Height
Dm Magnetic variation
DME Distant Measuring Equipment
D_{PET} Equal point time position
DPP Decision Point Procedure
D_{PSR} Point of safe return position
DS Dust storm
DTC Distance Time Consumption (in relation with fuel) or Direct (in relation with the approach type)
DU Dust
DZ Drizzle

E
EASA European Aviation Safety Agency
EGT Exhaust Gas Temperature
ELT Emergency Locator Transmitter
EMBD CB embedded in a layer
ETOPS Extended Twin-jet engines OPerationS
EU-OPS European OPerationS

F
f Lift/drag ratio
FAF Final Approach Fix
FEW few (1 to 2 Oktas)
FG Fog
FIS Flight Information Services
FMS Flight Management System
FL Flight Level
FPL Filed Flight Plan
FREQ Frequent CB or TCU
FU Smoke
FZ Freezing

G
GBAS Ground-Based Augmentation System
GLS GBAS Landing System
eGNOS European Geostationary Navigation Overlay Systems
GNSS Global Navigation Satellite System
GP Glide Path
GPH Gallon Per Hour
GPWS Ground Proximity Warning System
GR Hail
GS Ground Speed
GS Small hail

H
HEL Helicopter
HF High Frequency (3 000 to 30 000 kHz)
HIALS High Intensity Approach Lights
HIRL High Intensity Runway Edge Lights
HPA HectoPascal
HST High Speed Taxiway Tour-off
HZ Haze

I
IAC Instrument Approach Chart
IAF Initial Approach Fix
IAP Instrument Approach Procedure
IAS Indicated AirSpeed
IC Ice Crystals
IFR IMC Flight Rules
ILS Instrument Landing System
IMC Instrument Meteorological Condition
INS Inertial Navigation System
IR-OPS Implementary Regulation OPS
ISA International Standard Atmosphere
ISOL Isolated CB or TCU

J
JAA Joint Aviation Agency

L
L Locator
LAN Inland
LAT Latitude
LDA Landing Distance Available
LON Longitude
LOC Locally
LORAN LOng RAnge Navigation
LYR Layered

M
M Mach
MAA Maximum Authorised Altitude
MAPt Missed Approach Point
MAR At sea
MCA Minimum Crossing Altitude
MCT Maxi Continuous Thrust
MDA Minimum Descent Altitude
MEA Minimum En-route Altitude
MEL Minimum Equipment List
MEP Multi Engine Piston
METAR METeorological Airport Report
MFA Minimum Flight Altitude
MHA Minimum Holding Altitude
MHz Megahertz
MI Thin
MLS Microwave Landing System
MM Middle Marker
M_{MO} Maximum Operating Mach

MNPS	Minimum Navigation Performance Specifications
MORA	Minimum Off-Route Altitude
MOCA	Minimum Obstacle Clearance Altitude
MR	Speed/Mach Maxi Range
MRJT	Medium Range Jet Transport
MRVA	Minimum Radar Vectoring Altitude
MSA	Minimum Sector Altitude

N

NAT OTS	North Atlantic Organized Track System
NANU	Notice Advisory to Navstar Users
NAP	Non-Precision Approach
ND	Navigation Display
NDB	Non-Directional radio Beacon
NM	Nautical Miles
NOTAM	Notice-To-AirMen
NPA	Non-Precision Approach
NS	Nimbostratus

O

ICAO	International Civil Aviation Organization
OCA	Oceanic Control Area
OCA	Obstacle Clearance Altitude
OCH	Obstacle Clearance Height
OCNL	Occasional CB or TCU
OTS	Organized Track System
OVC	Overcast (8 oktas)

P

PANS	Procedures for Air Navigation Services
PAPI	Precision Approach Path Indicator
PET	Equal time point
PDP	PreDetermined Point Procedure
PL	Ice pellets
PBN	Performance Based Navigation
PO	Dust/sand whirls
PPL	Private Pilot License
PR	Partial
PSR	Point of Safe Return
PTS	Polar Track Structure
PPR	Prior Permission Required

Q

QFU	Magnetic orientation of runway
QDR	Magnetic bearing

R

RA	Rain
RAI	Runway Alignment Indicator
RAIM	Receiver Autonomous Integrity Monitoring
RCF	Reduced Contingency Fuel Procedure
Rm	Magnetic track
RNP	Required Navigation Performance
RNP AR APCH	RNP Authorization Required Approach
RPL	Repetitive Flight Plan
RS	Specific range
Rv	True track
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minimum

S

SA	Sand
SALS	Short Approach Light System
SBAS	Satellite-Based Augmentation Signal
SCT	Scattered (3 to 4 oktas)
SEP	Single Engine Piston
SFC	Surface
SFL	Sequenced Flashing Lights
SID	Standard Instrument Departure
SIV	Flight information service
SG	Snow grains
SH	Shower
SN	Snow
SNOWTAM	SNOW Notice to Airmen
SQ	Squall
SS	Sand Storm
ST	Stratus
STAR	Standard Terminal Arrival Routes

T

TAF	Terminal Aerodrome Forecast
TAS	True Air Speed
TACAN	Tactical Air Navigation
TCU	Towering Cumulus
TDZ	Touchdown Zone Lights
TEMPSI	Significant weather chart
TMA	Terminal Manoeuvring Area
TOC	Top Of Climb
TOD	Top Of Descent
T_{PSR}	Estimated time to the PSR point
T_{PET}	Estimated time to the PET point
TS	Thunderstorm

U

UTC	Coordinated Universal Time

V

VA	Volcanic Ash
VAC	Visual Approach Chart
VAL	In valleys
VASI	Visual Approach Slope Indicator
VAT	Velocity At Threshold
VFR	Visual Flight Rules.
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOLMET	Meteorological Information for aircraft in flight
VOR	VHF Omnidirectional Range
VORTAC	VOR and TACAN combination
V_P	Airspeed
V_{SOL}	Ground speed

W

WAAS	Wide Area Augmentation System

Miscellaneous

a	Sound velocity
d	Density
φ	Density

033 FLIGHT PLANNING AND MONITORING

01

VFR NAVIGATION

In order to make out his navigation log, the pilot has to prepare the navigation of his VFR flight, which is the prime activity of the preparation stage.

This is a relatively heavy planning task, consisting of carefully collecting information for the selected route using the radio navigation chart and airport charts.
This work involves:

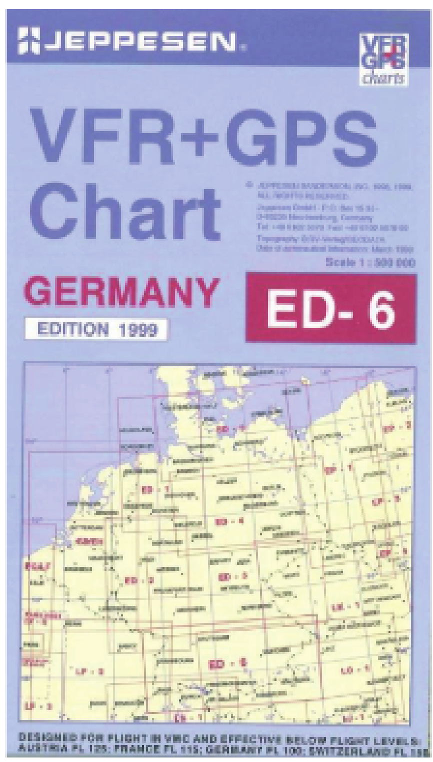
- selecting the most appropriate routes and decoding the symbols displayed on the radio navigation chart and the departure, arrival and visual approach airport charts;
- identifying airspaces and restricted areas;
- selecting the appropriate flight altitude or flight level, according to the direction of the route and to the obstacle clearance margin;
- using the charts to identify the true tracks, true headings, distances and magnetic variations, in order to determine the magnetic tracks and headings, etc.;
- listing the radio communication and radio navigation information;
- and, finally, completing the navigation log with all the above-mentioned elements.

In order to perform this work, candidates should know the various acronyms used, as well as the most popular ICAO abbreviations and symbols used on the navigation charts and airport charts.

01 AIRSPACE, COMMUNICATION, VISUAL AND RADIO-NAVIGATION DATA FROM VFR CHARTS

In order to cover this part of the navigation planning, the 033 certificate syllabus refers to the visual radio navigation chart of the Stuttgart region (Germany), extracted from the Jeppesen *Student Pilot Route Manual*.

This is the "VFR-GPS Chart, Germany ED-6" chart (1/500000 ICAO) indicating the GPS latitude and longitude positions based on the WGS-84 system (World Geodetic System). It contains a lot of the data required for VFR flights.



This chart is a Lambert conformal and conical projection; it is very similar to the 1/500000 radio navigation charts used in France for PPL.

The selection of routes and flight altitudes should take into account the following key points:

- airspace classification;
- identification of restricted areas;
- consideration of the semi-circular rule;
- observance of the minimum safe altitude;
- identification of navigation aids.

Each point will be described hereafter in detail.

1.1- Airspace classification

Interferences are possible between the IFR and VFR flight paths in the airspace. In order to protect IFR flights, or allow the ATC (Air Traffic Control) to provide appropriate air traffic services (separation, traffic information, etc.), qualifying index letters called "airspace classes" are assigned to airspaces: A, B, C, D, E, F or G.
The requirements and services are listed in the table below.

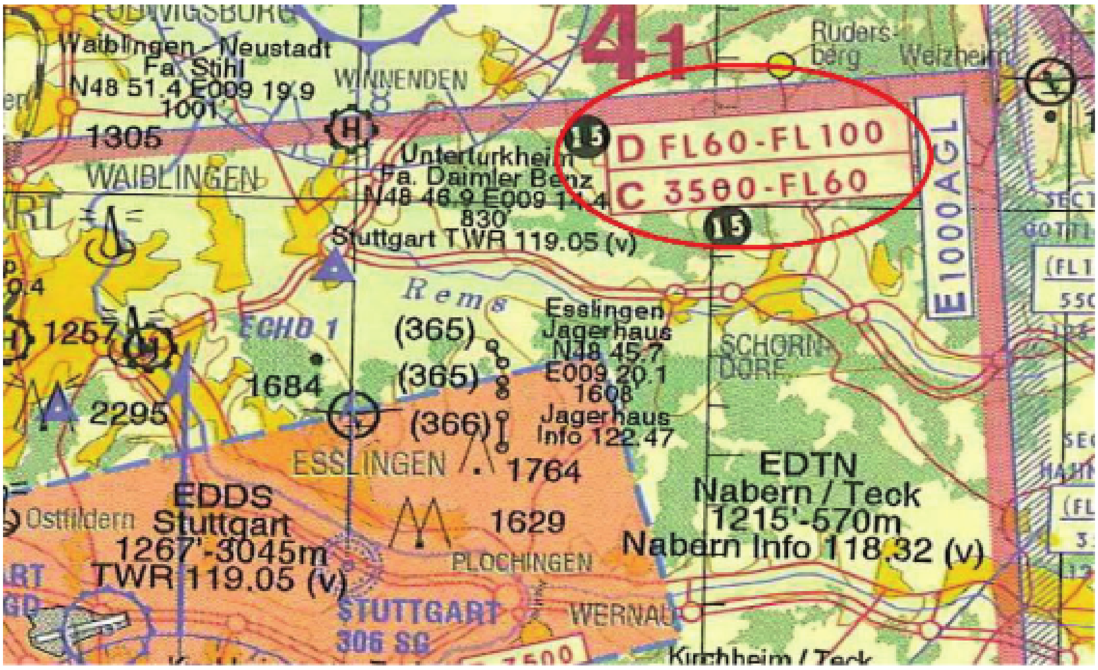
Airspace Class	Authorized flights*	Services		Radio obligation	Clearance obligation
		control	information/alerts		
A	IFR	IFR/IFR separation	YES	YES	YES
B	IFR	IFR/IFR separation IFR/VFR	YES	YES	YES
	VFR	IFR/VFR separation VFR/VFR	YES	YES	YES
C	IFR	IFR/IFR separation IFR/VFR	YES	YES	YES
	VFR	IFR/VFR separation. traffic information VFR/VFR	YES	YES	YES
D	IFR	IFR/IFR separation traffic information IFR/VFR	YES	YES	YES
	VFR	traffic information IFR/VFR VFR/VFR	YES	YES	YES
E	IFR	IFR/IFR separation traffic information IFR/VFR	YES	YES	YES
	VFR	No but Traffic information IFR/VFR	YES	NO	NO
F	IFR	No but separation IFR/VFR	YES	YES	NO
	VFR	No	YES	NO	NO
G	IFR	No	YES	YES	NO
	VFR	No	YES	NO	NO

VFR flights are prohibited in the Class A airspace.

* To simplify, night VFR or special VFR cases are not mentioned here.

The applicable airspaces in Germany are indicated in the banner at the bottom of the VFR-ED6 chart, and also on the radio navigation chart itself.

The charts indicate the airspace classes, usually identified with a magenta outline centered on the airport. Here we can see the case of the Stuttgart airport below, with airspaces C (from 3,500 ft to FL 60) and D (from FL 60 to FL 100) in the same sector.



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1.2- Restricted airspaces

Using the acronyms mentioned on the radio navigation chart, we can identify the presence of areas with a specific status or with activities being on or close to the selected route:

- P area ("Prohibited"): area strictly prohibited to air traffic; e.g. ED(P)-51;
- R area: restricted area, for which access is subject to certain conditions; e.g., ED(R)-132A; access to this area may be prohibited during the military drill hours, for instance;
- D area: dangerous area, for which access does not require any preliminary clearance, but which may be dangerous for air traffic (firing zone, etc.); e.g., ED(D)-123.
- parachuting, gliding zone;
- etc.

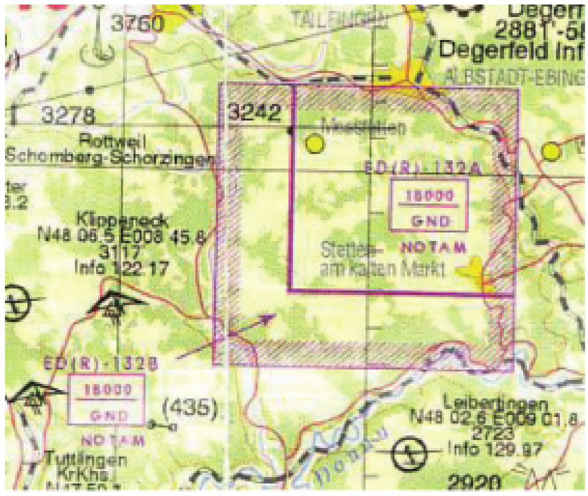
Note. *The identification of P, R and D areas are preceded by the ICAO region and country identification (ED: E for Northern and Eastern Europe ICAO region, and D for Germany ("Deutschland").*

Note. *In the radio navigation charts, the P, R and D areas are identified by dotted lines, as shown in the figure below.*

Check that the planned route is not affected by the activity areas; if such is the case, a change of route or the obtention of a preliminary clearance should be considered before accessing the area.

Some zones are not permanent. Consequently, they are often subject to information mentioned in the NOTAM: it is therefore always necessary to check them before the flight.

Example of identification for the two restricted areas (ED(R)-132A and ED(R)-132B on an excerpt of the radio navigation chart below. Both areas are activated by NOTAM as specified on the illustration.

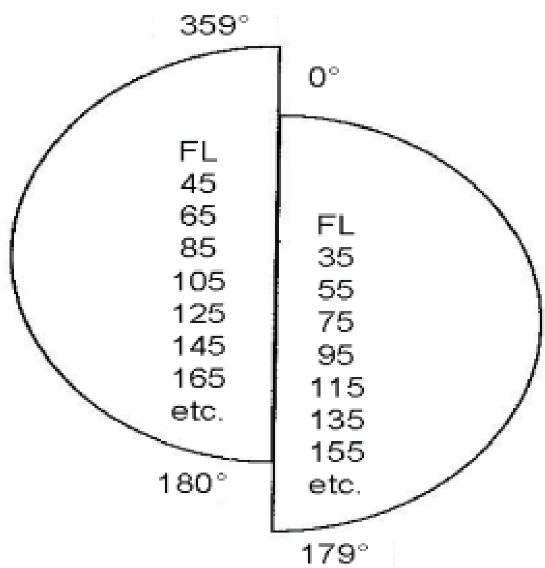


1.3 - Semi-circular rule in VFR

After determining the safe altitude, it must never be forgotten that for VFR flights operated above 3,000 ft ASFC ("Above surface"), the semi-circular rule should be used in order to determine the cruising altitude or level.

This rule requires selection of the cruising altitude or level according to the magnetic route (not the magnetic heading) followed by the aircraft.
When the magnetic route is between **000° and 179°**: the flight level should be an **odd altitude + 5** level or an **odd multiple of 500** altitude: FL 35, 55, 75, 95, 115, … 275, or 3,500 ft, 5,500 ft, 7,500 ft, 9,500 ft, 11,500 ft… 27,500 ft.

When the magnetic route is between **180° and 359°**: the flight level should be an **even altitude + 5** level or an **even multiple of 500** altitude: FL 45, 65, 85, 105, 125… 285, or 4,500 ft, 6,500 ft, 8,500 ft, 10,500 ft, 12,500 ft… 28,500 ft.



1.4- Radiocommunication and radio navigation

All the frequencies and radiocommunication and radio navigation call signs that may be used during the travel should be reported in the navigation log.

1.4.1 – Radiocommunication

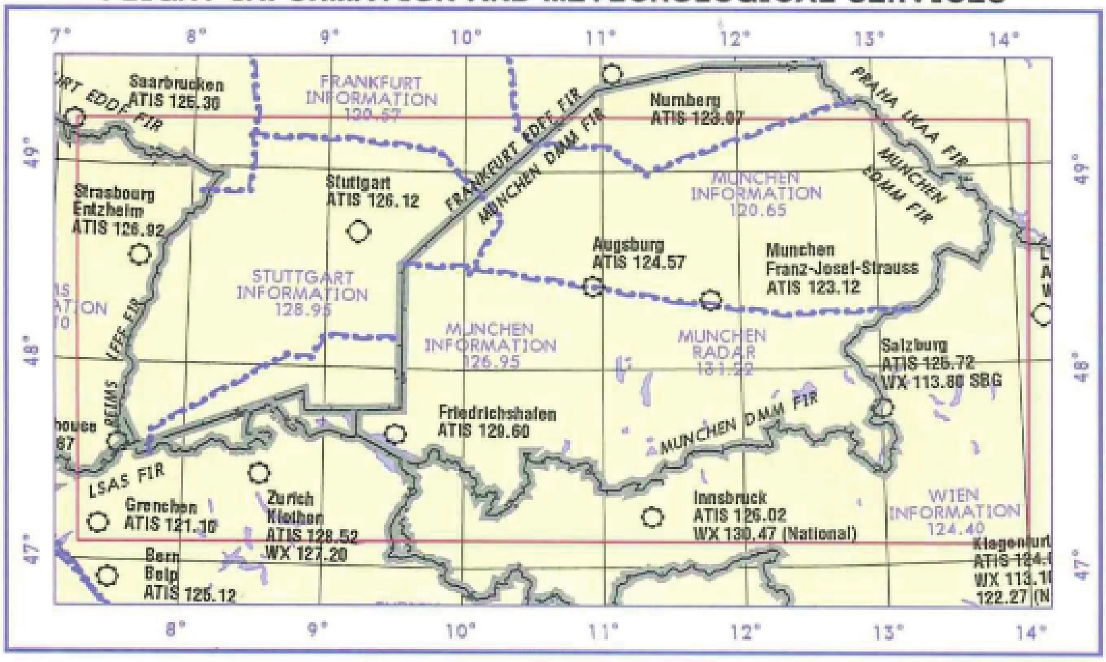
For each segment of the route, it is essential to record the radiocommunication frequencies required for the flight. They allow a permanent bidirectional link to be set up with the control tower.

- Departure and arrival airports. The frequencies of the ATC, such as the approach control center, the ground and flight control towers, AFIS, etc. are specified in the VAC chart header.

- En route. The flight information services (FIS) and meteorological services deliver all the useful information for flights, such as the weather conditions along the route, status of the radio facilities, activity areas, etc.

On the VFR-ED6 chart, their frequencies are specified in the "Flight Information and Meteorological Services" field, in the left-hand bottom corner of the chart.

FLIGHT INFORMATION AND METEOROLOGICAL SERVICES



Example

What is the ATIS and FIS frequency for Stuttgart?

Answer

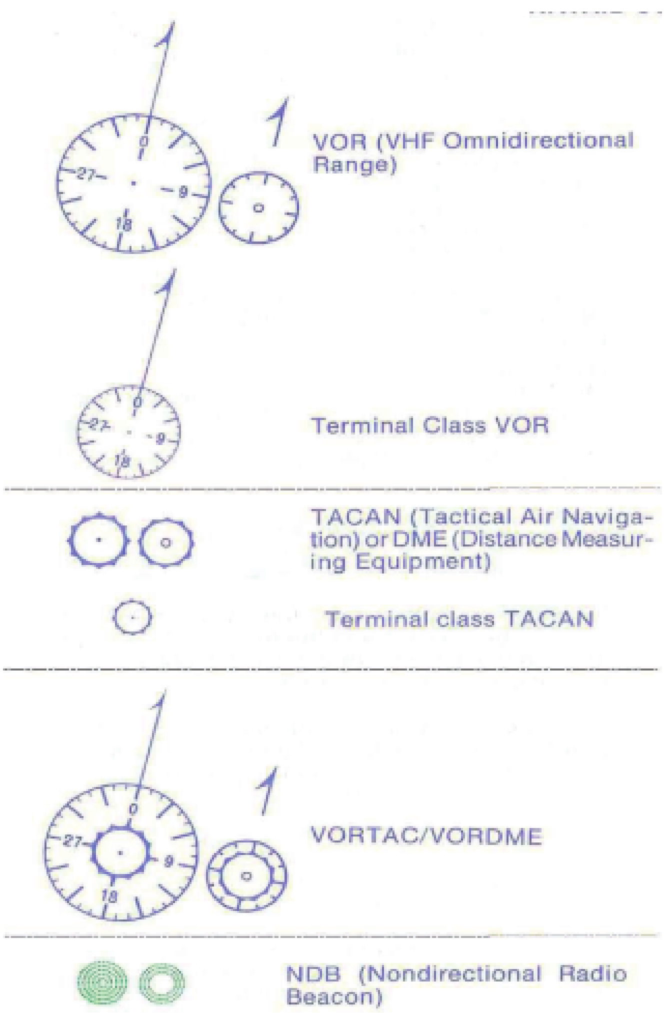
The Stuttgart ATIS or FIS frequencies are not directly specified on the ED-6 chart, but in the "Flight Information and Meteorological Services" box.

The Stuttgart ATIS and FIS frequencies displayed in the box above are **126,12 MHz and 128,95 MHz**, respectively.

1.4.2 - Radio navigation

Depending on the radio navigation equipment installed onboard, it is recommended to record the frequencies and call signs of the radio navigation facilities that may be used during the trip.

Using the following ICAO symbols, these aids are easy to identify on the ED-6 chart.



The description of all the radio navigation facilities will be recalled in Chapter 033 02 "IFR Navigation".

Example

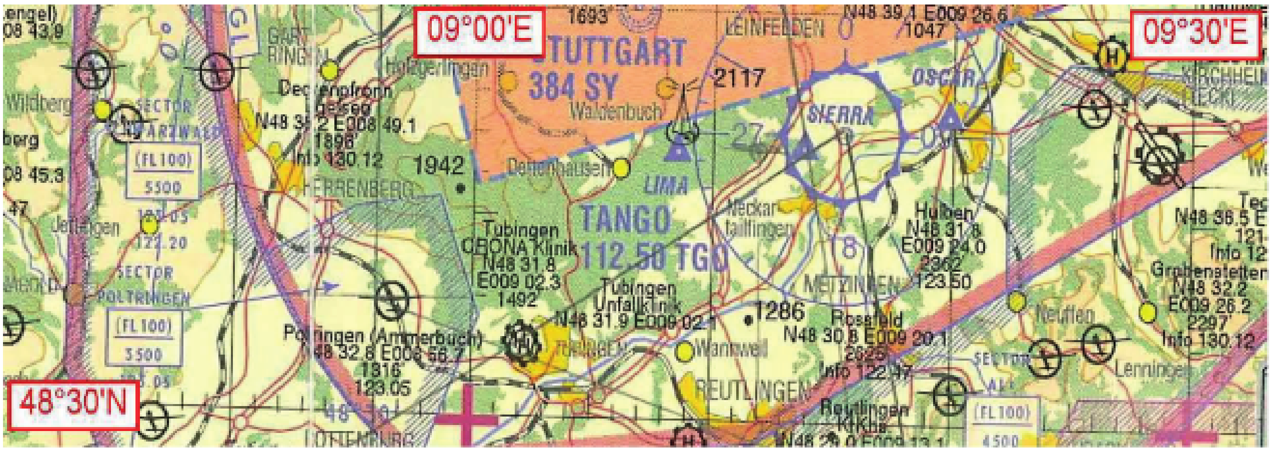
An aircraft, in VFR flight, approaches the TANGO position (48° 37′ N – 009° 16′ E) at FL 055, while following the 090° magnetic route at a 20 NM distance from the TANGO point.

What is the radio navigation aid and the frequency associated with TANGO?
A) VOR-TACAN 112.50 kHz
B) DME 112.50 MHz
C) VOR 112.50 with no DME
D) VOR-TACAN 112.50 MHz

Answer

First, identify the TANGO position (48° 37′ N – 009° 16′ E) on the chart extract, page 21.

Reading the symbol mentioned on the chart indicates that this is a VOR-TACAN or VOR-DME with a 112.50 MHz frequency and TGO call sign.



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02 PLANNED COURSES, DISTANCES AND CRUISING LEVELS WITH VFR CHARTS

2.1 - Altitude selection

In order to validate the selected route, flight altitudes should be determined using the following criteria.

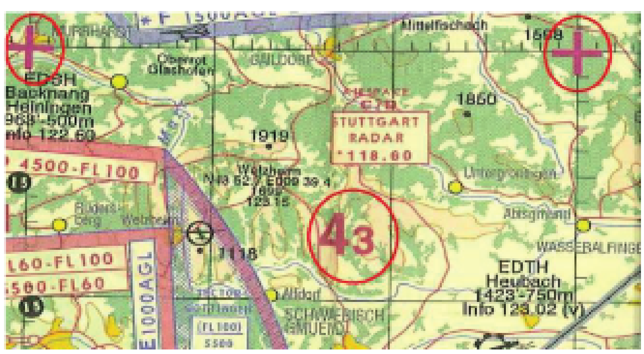
2.1.1 - Minimum heights

The regulation defines the minimum flying heights that should be observed in all circumstances, except for take-off and landing.

- No VFR flight is authorized above high density areas, towns or other urban areas or gatherings of people outdoors below 300 m (1,000 ft) above the highest obstacle located in a 600 m radius around the aircraft.
- Other than in the above-mentioned locations, a VFR flight should not be performed at a height less than 150 m (500 ft) above ground or water level.

Other rules for flying over-populated areas are added to the above general regulation. The minimum flying heights differ depending on the urban area size; they are usually indicated in the radio navigation chart inset.

2.1.2 - Minimum safe altitude



Despite this being a visual flight and all obstacles must be visually avoided, it is necessary to determine a safe altitude for each route segment so that obstacles are avoided with a safety margin.

In order to determine these altitudes, the "minimum grid altitudes" indicated on the

radio navigation chart can be taken. They give a 1,000 ft clearance margin away from the terrain and the highest obstacle within a ½ degree latitude and longitude quadrangle. On the chart, this quadrangle is defined by magenta crosses +.
Grid safety altitude is specified on the chart by a magenta color: e.g., **4** ₃ = 4,300 ft.

Note. The airspace covered by the 1/500000 chart extends from the ground to the highest of the two following levels:

- *5,000 ft above sea level; or*
- *2,000 ft above ground.*

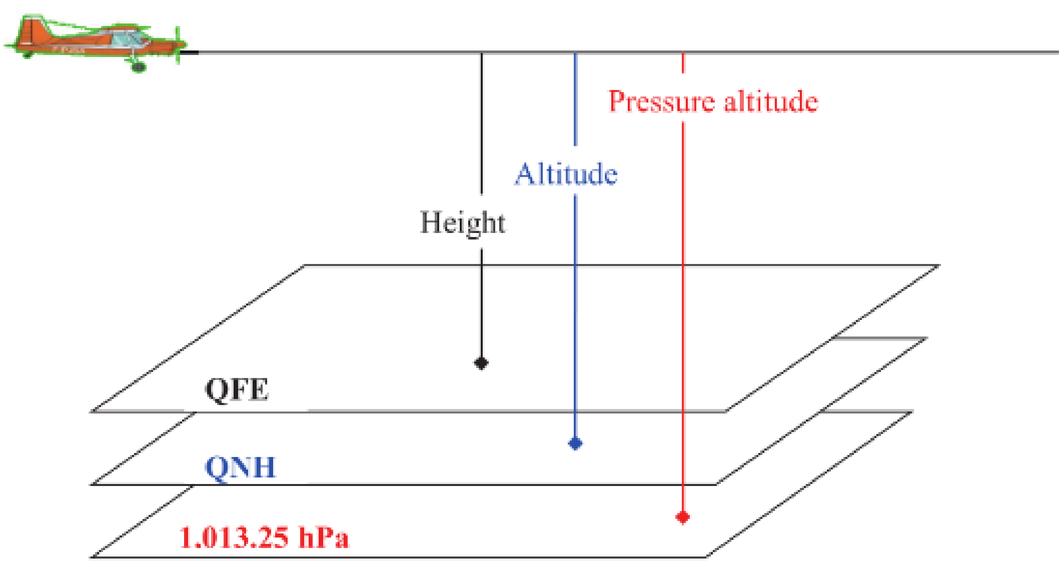
The grid altitudes indicated on this chart apply only for obstacles not exceeding 5,000 ft QNH or 2,000 ft ground.
If the minimum grid altitude is not shown, the following principle can be applied to determine the flight safety altitude:

- note the height of the highest obstacle of the segment on a 5 NM corridor on either side of the route;
- apply a safety margin, usually between 1,000 and 2,000 ft, depending on the operating area;
- consider altimeter corrections: this is the pressure and temperature correction detailed in the next section.

2.1.3 - Altimeter corrections

As a reminder, the following altimeter settings are applied:

- QFE altimeter setting: this setting indicates the aircraft height with regard to the airport;
- QNH altimeter setting: this setting indicates the aircraft altitude above the average sea level, near the airport on which the QNH was determined;
- 1,013.25 hPa standard altimeter setting (QNE): this setting indicates the aircraft pressure altitude, i.e. the altitude with regard to the isobaric surface corresponding to the 1,013.25 hPa pressure.



An altimeter is a barometer calibrated in compliance with standard atmosphere laws: 1,013.25 hPa and a 15 °C temperature at sea level, decreasing by 2 °C (1.98 °C) every 1,000 ft up to 36,090 ft, and then remains constant at – 56.3 °C in our regions.

Therefore, if the atmosphere of the day is different from this standard atmosphere (as is the case most of the time), this pressure and temperature difference must be taken into account.

This difference has no significant consequences for aircraft separation on the vertical plane, as they all undergo the same effects. But in order to comply with obstacle clearance margins this phenomenon should be considered when determining the actual aircraft altitude.

a) Pressure correction

For navigation, the standard altimeter setting is selected above the transition altitude. The difference between 1,013.25 hPa and the airport QNH generates a barometric error approximately equal to 30 ft/hPa.

Example

An aircraft flies at a 10,000 ft pressure altitude. What are the aircraft altitude above the average sea level and air aircraft height with an airport located at 600 ft, when the QNH is:

A) 1,023 hPa ? B) 999 hPa ?

Answer

• **Case A**: QNH = 1,023 hPa.
The aircraft altitude above the average sea level is:
Z = 10,000 + (1,023 – 1,013.25) x 30 = 10,300 ft.
The aircraft height with regard to the airport is:
H = 10,300 – 600 = 9,700 ft.

• **Case B**: QNH = 999 hPa.
The aircraft altitude above the average sea level is:
Z = 10,000 + (999 – 1,013.25) x 30 = 9,580 ft.
The aircraft height with regard to the airport is:
H = 9,580 – 600 = 8,980 ft.

b) Temperature correction

Temperature is the most influential factor on the vertical separation of isobaric surfaces.
Pressure altimeters are calibrated to ISA conditions. Hence, any deviation from ISA will result in error proportional to ISA deviation and to the height of the aircraft relating to the aerodrome pressure datum. When the temperature varies above or below standard conditions, the altimeter error increases; it may be highly significant for flight safety (obstacle clearance) when the air is cold.
In order to take account of temperature correction, the following simplified formula is applied when computing the true altitude of the aircraft according to the difference between the static air temperature (SAT) displayed at the flight level and the standard temperature at this level.
Note. SAT is sometimes called OAT (outside Air Temperature)

$$Z_T = Z_I \times \left(1 + \frac{4 \times \Delta ISA}{1\ 000}\right)$$

Z_T: aircraft true altitude
Z_I: indicated altitude

ΔISA: difference between the actual temperature and the standard temperature

The approximate rule of thumb correction is 4 % height increase for every 10°C below standard temperature as measured at the altimeter setting source.
Hence, when temperature is ***LESS*** *than ISA, an aircraft will be* ***LOWER*** *than the altimeter reading. For example, if the OAT is - 40 °C then for a 2000 ft indicated altitude the true altitude is 1520 ft thus resulting in a lower than anticipated terrain separation and a potential obstacle-clearance hazard.*

Example

An aircraft flies at a 7,500 ft pressure altitude, what is its true altitude if the outside air temperature is – 10 °C (QNH = 1,013.25 hPa)?

A) 7,000 ft	B) 7,200 ft
B) 7,500 ft	C) 7,700 ft

Answer

At 7,500 ft, the standard temperature is: 15 – 2 x 7.5 = 0 °C.
ΔISA = outside air temperature – standard temperature = – 10 °C
Z_T = 7,500 [1 + 4 x (– 10) / 1,000] = **7,200 ft**.

Example

A 6,011 ft mountain above sea level is located on the 356° true track of an aircraft. The magnetic variation is 10° W and the magnetic heading is 355°. What is the lowest VFR flight level in order to keep a 2,000 ft clearance above the mountain with a 990 hPa QNH?
1 hPa = 30 ft will be used for computing.

A) FL 075	B) FL 090
C) FL 095	D) FL 085

Answer

With 1 hPa = 30 ft, the mountain altitude in relation to a QNH = 1,013 hPa is:
6,011 + (1,013 – 990) x 30 = 6,701 ft
The altitude at which the aircraft should fly with 2,000 ft clearance is:
6,701 + 2,000 = 8,701 ft. Therefore, the minimum flight level must be FL 87.
However, as the flight is above 3,000 ft ground, the semi-circular rule should be taken into account.
Magnetic track (TR(M)) = true track (TR(T)) – magnetic variation (VAR)
= 356° – (– 10) = 006° (as a reminder, W ⇨ "–»"; E ⇨ "+")
In accordance with the semi-circular rule, the VFR flight level, for a 006° TR(M), should be an "odd + 5°" level.
The first odd level available above FL 87 is **FL 95**.

2.2 - Computing the distance and time to climb to a specified level or altitude

Using the aircraft performance data published in the flight manual, the rate of climb and/or the climb gradient depending on conditions of the day can be calculated. These two parameters allow the pilots to estimate the climb flying time and the ground distance to reach a specified level or altitude, by applying the various formulas below.

2.2.1 - Computing the time of climb

Knowing the height gain (H) and the rate of climb (ROC), the time of climb is obtained with the formula:

$$\text{Time of climb} = \frac{H}{\mathbf{ROC}}$$

Time of climb: in min
H: height gain in ft
ROC = rate of climb in ft/min

2.2.2 - Computing the distance to climb

The distance to climb can be computed with the various formulas below.

- Knowing the air gradient determined with the flight manual.

$$D_{AIR} = 100 \times \frac{H}{\gamma_{AIR}}$$

D_{AIR}: air distance in ft
H: height gain in ft
γ_{AIR}: climb air gradient (%)

$$D_{GND} = D_{AIR} \times \frac{GS}{TAS}$$

D_{GND}: travelled ground distance
D_{AIR}: travelled air distance
TAS: true airspeed in kt
GS: ground speed in kt = TAS ± wind

- The ground distance may also be obtained in accordance with the climb flying time and rate of climb (ROC).
D_{GND} = time of climb (in h) x GS, i.e.:

$$D_{GND} = \frac{H}{ROC \times 60} \times GS$$

D_{GND}: in NM
H: height gain in ft
ROC: rate of climb in ft/min
GS: ground speed in kt

2.3 - Computing the distance and time to descend from a specified level or altitude

On a parallel with climb, the descent time and distance can be computed according to the rate of descent and/or the descent gradient, with the various formulas below.

2.3.1 - Computing the descent time

Knowing the descent height (H') and the rate of descent (ROD), the descent time is obtained with the formula:

$$\text{Descent time} = \frac{H'}{ROD}$$

Descent time: in min
H': descent height in ft
ROD = rate of descent in ft/min

2.3.2 - Computing the descent distance

The descent distance can be calculated with the various formulas below.

- Knowing the descent air gradient determined with the flight manual.

$$D_{AIR} = 100 \times \frac{H'}{\gamma'_{AIR}}$$

D_{AIR}: air distance in ft
H': descent height in ft
γ_{AIR}: descent air gradient (%)

$$D_{GND} = D_{AIR} \times \frac{GS}{TAS}$$

D_{GND}: travelled ground distance
D_{AIR}: travelled air distance
TAS: true airspeed in kt
GS: ground speed in kt

- The descent ground distance may also be obtained in accordance with the descent flying time and rate of descent (ROD).

D_{GND} = descent time (in h) x GS, i.e.:

$$D_{GND} = \frac{H'}{ROD \times 60} \times GS$$

D_{GND}: in NM
H': descent height in ft
ROD: rate of descent in ft/min
GS: ground speed in kt

2.4 - Determining route and distance

Plotting the flight on the chart starts with the departure airport and ends with the arrival airport. Airports with mandatory or recommended reporting points mean that the track plotting should cross these points.

The purpose of radio navigation chart plotting is to determine the reporting points, but also and especially, to accurately collect the tracks and distances in order to determine the flying time for various segments of the travel.
At this stage, this is windless planning; navigation parameters will be updated with the wind effect during the short-term flight planning.

2.4.1 - Reporting points

In general easily identifiable large visual landmarks, such as highways, railways, towns, lakes, rivers, etc., are selected as reporting points.
Radio transmitters like VOR (VHF Omnidirectional Range) or NDB (Non Directional Beacon) can be selected as landmarks or be used in order to materialize a landmark with its crossing.
Crossing these points always represents a significant workload in flight; therefore, they should be distanced well apart from each other.

2.4.2 - Measuring tracks

In order to measure a route in a specified segment, the navigation plotter is used. Simply place the center of the navigation plotter to the track intersection with a meridian. The angle displayed on the navigation plotter is the true track (TR(T)) with the meridian as the origin.
The track angles are counted from 0° to 360° clockwise, from the North.
The magnetic track (TR(M)) is derived from the true track with the following formula:

$$TR(M) = TR(T) - VAR$$

VAR is the value of the magnetic variation indicated by blue and dotted isogonic lines on the ED-6 chart.

2.4.3 - Measuring distances

NM (Nautical Mile) is the unit used for measuring distances. Different methods are available to measure a distance between 2 points:
A navigation ruler graduated in NM corresponding to the chart scale may be used. The distance between two points is read directly on the ruler.
Or, any graduated ruler may be used to measure the distance between two points, then:

- either use the chart scale to calculate the Earth distance with the following formula: scale = distance read on the chart / Earth distance, expressed in the same units; in the case of the ED-6 chart, with a 1/500000 scale, 1 cm ⇨ 5 km = 2.7 NM;
- or report the measurement on the nearest meridian graduated in minutes and degrees to read the corresponding number of NM, taking into account that 1 minute = 1 NM.

Knowing the distance between the two points of the segment and the average true airspeed (TAS), the windless flight time can be calculated using the following formula:

$$\text{flight time} = \frac{\text{ground distance}}{\text{TAS}}$$

Example

From the EDSZ Rottweil Zepfenhan airport (48° 12′ N – 008° 44′ E) to the EDTM Mengen (48° 03′ N – 009° 22′ E) airport, determine the magnetic track (TR(M)) to follow and the distance (d), as well as the highest obstacle in a 5 NM corridor on either side of this track.

A) TR(M) = 108°; d = 40 NM ; 2,920 ft.
B) TR(M) = 288°; d = 27 NM ; 3,331 ft.
C) TR(M) = 108°; d = 27 NM ; 3,760 ft.
D) TR(M) = 288°; d = 27 NM ; 2,605 ft.

Answer

See the chart extract below.

Using the above specifications, identify both airports on the chart, then plot the associated track.

• The true track(TR(T)) to follow from Rottweil to Mengen is approximately 108°.

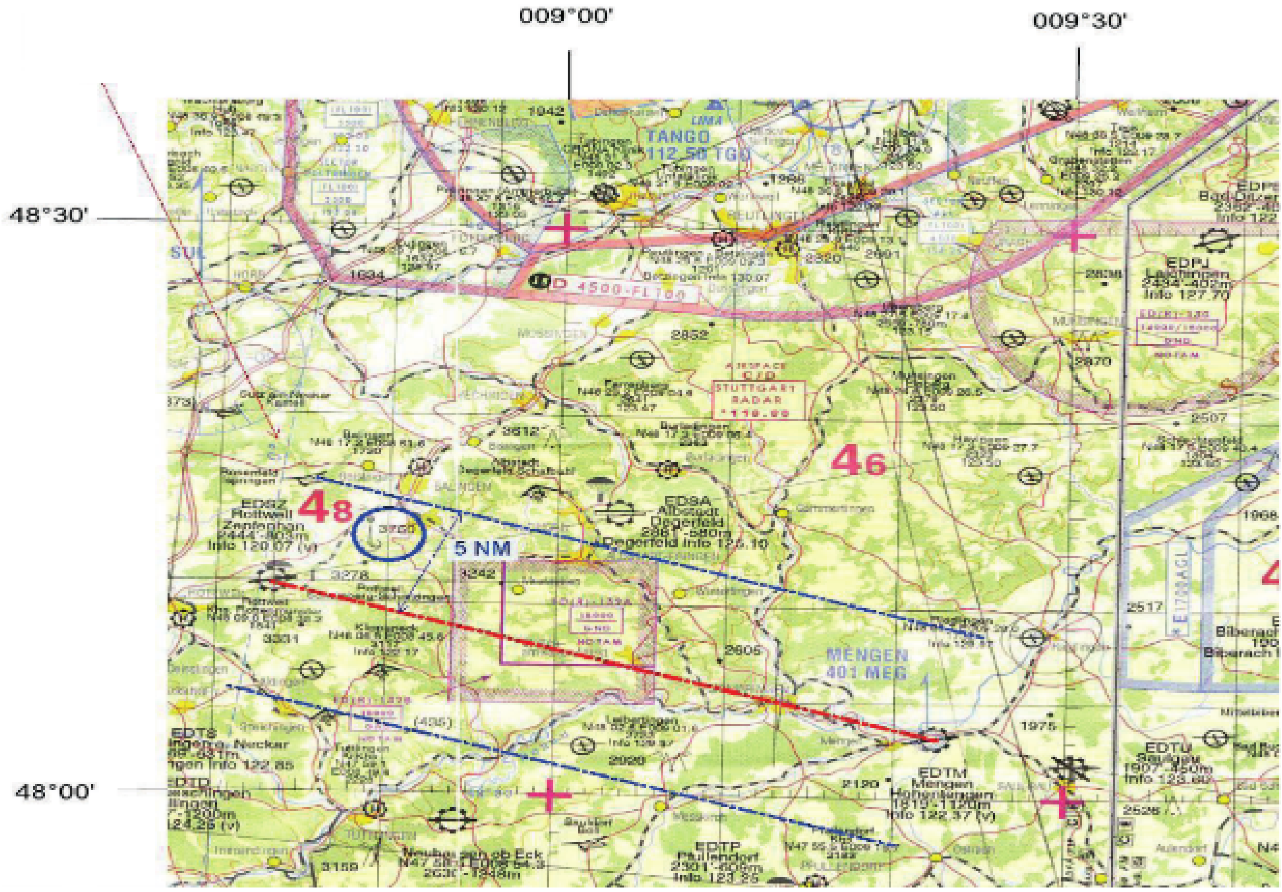
TR(M) = TR(T) – VAR.

Identify the isogonic lines on the chart to read the magnetic variation. As for the track being considered, the magnetic variation is between 0° (dotted blue line starting from the top of the chart at 008° 55′ E) and 1°E (012° 15′ E); VAR = 0° will be selected (as this would require a larger chart extract, the 1°E magnetic variation line is not displayed on the chart below).

Hence, TR(M) = 108°.

• The distance in relation to the chart scale (1/500000°) is approximately equal to 27 NM (beware the chart illustrated below is not to scale).

• Using the plotting of the 5 NM corridor on either side of the track, it is possible to identify the highest obstacle, which is an antenna located East North-East of Rottweil airport. Its altitude in relation to the sea level is 3,760 ft.



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2.5 – Determination position of a significant VFR point for insertion into GNSS flight plan

The Global Navigation Satellite System (GNSS) receivers have found their way into a vast majority of general aviation cockpits during the past decade (refer to 062 certificate for description of the system)

A typical VFR database loaded in a GNSS receiver contains airports, intersections, airspaces and ground-based navigation aids (VORs, NDBs…) and their associated frequencies. Additionally, these databases could contain "visual reference points" such as terrain, forests, lakes, etc… which are crucial in pilotage or "land navigation" for VFR navigation.

If the GNSS device's database does not contain important waypoints e.g. "visual reference points" specified above, the pilot can add those waypoints into the device manually, as their position can be found in AIP. As specified in the previous paragraph, always choose the waypoints so that they correspond with a major landmark and are easily recognizable.

There is usually a number of ways how to do this which vary between device models; typically:

- Selecting a point with a cursor on a moving map display and coordinates can be easily determined. Simply move the map cursor to the desired position or, in case of touch screen devices, put the finger on the map. The coordinates will be displayed on the screen.

- Creating a custom waypoint by selecting "new user waypoint" (or similar) option on the waypoints page. To do this, the pilot has to input:
  - either, exact coordinates of the new waypoint. After entering the waypoint coordinates it is usually necessary to store it prior to using it as a "User Waypoint"; or,
  - distance and bearing (radial) from an existing significant and specified point in the database (e.g. airport, VOR, another user waypoint…), the device will then give the new waypoint with its coordinates shown. In a similar manner, a new waypoint can be created using two bearings.

  The new waypoint created in this way can then be inserted into a flight plan.

  Example of a creation of a "User Waypoint" using its coordinates:

DESIGNATION	LOCATION	COORDINATES	
ALPHA	Saint Chamond (church)	45° 28' 25" N 004° 31' 31" E	entry

03 AERODROME CHARTS (VAC CHARTS) AND AERODROME DIRECTORY

During navigation planning, the pilot has to refer to the visual approach charts or VAC charts (Visual Approach and landing Chart) of the departure and arrival airports, and also the charts of the possible alternate and diversion airports.

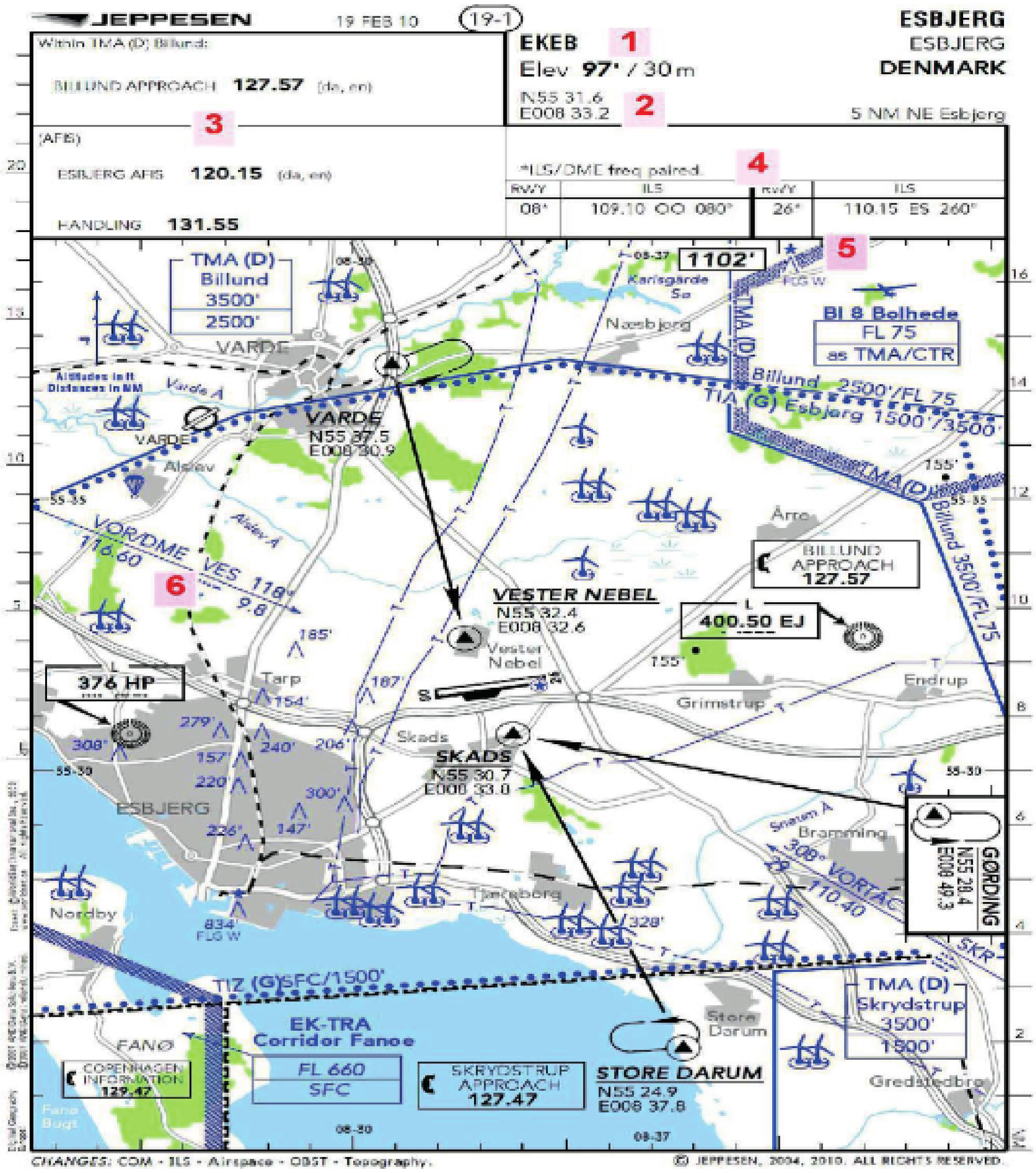
The VAC charts are specific to each airport; therefore it is necessary to refer to these charts when maneuvering near or to an airport is planned.

All the information required for a visual approach is provided on one page or more.
It contains:

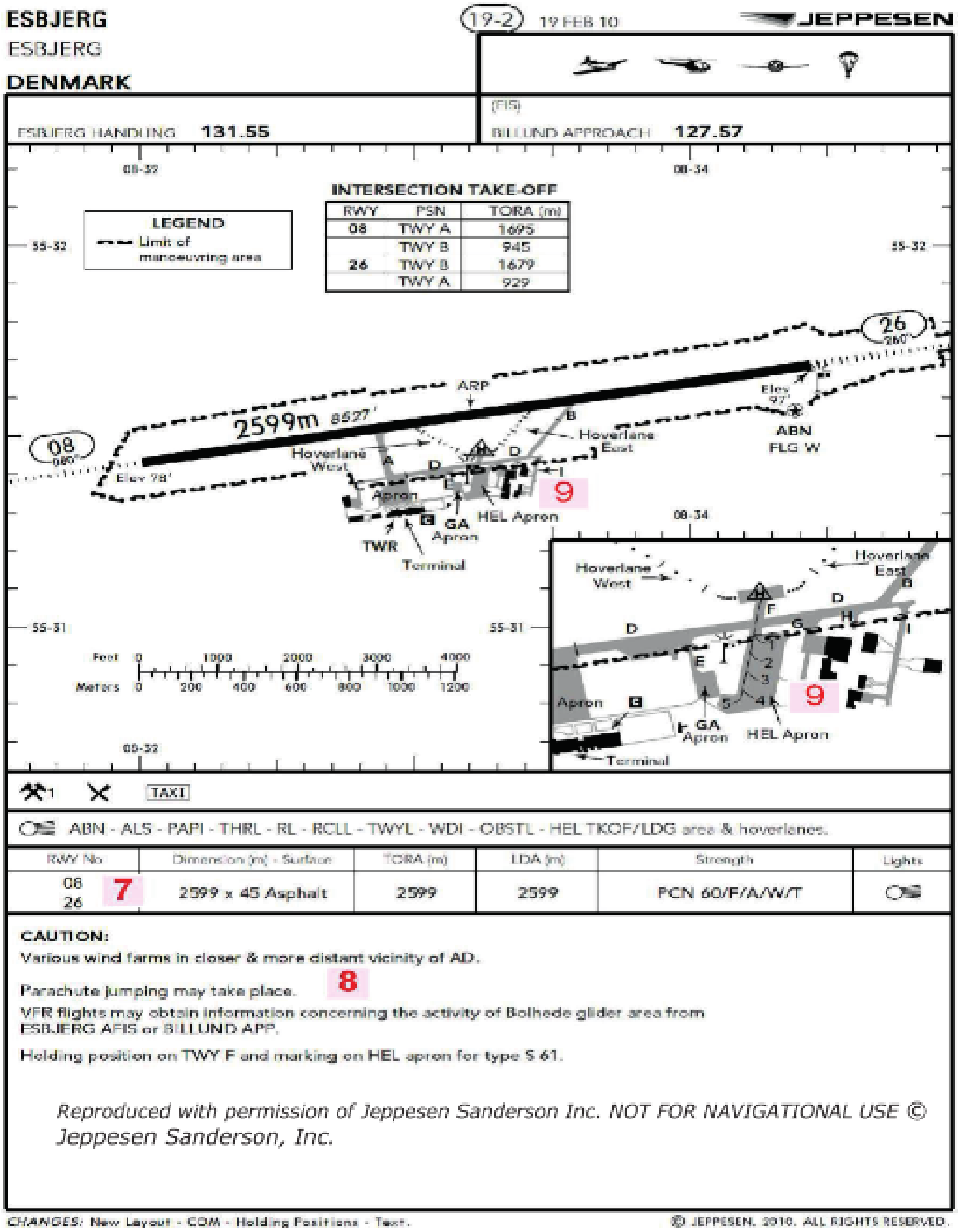
- the airport position (reference latitude and longitude coordinates) and altitude;
- the radiocommunication frequencies of the ATC (approach control center, control tower, AFIS, etc.). Services available depend on the airport importance;
- the working hours;
- the runways and their specifications (runway pavement, TORA, TODA and ASDA runway slope and runway width, etc.);
- etc.

Note. *The airport working hours and other information are available in the general part of the Jeppesen airline manual, "Aerodrome Directory" section.*

Example
TWR 0900LT – SS+30min (at latest 2100LT)
CUSTOMS: Tue-Fri 24hr, Sat Sun Mon & Hol preceding workday before 1600 LT.



1	Airport altitude
2	Position (airport latitude and longitude)
3	Radiocommunication frequencies (approach control and AFIS)
4	ILS/DME frequency
5	The highest obstacle in the Esbjerg control area (boxed value; 1,102 ft)
6	Radio navigation aid on arrival (QDR 118° VOR-DME VES 116,60, distance 9.8 NM)



7	Usable runways and their specifications
8	Other information
9	Heliport

04 COMPLETION OF NAVIGATION PLAN

Using the navigation elements collected during the flight planning, the pilot can draft the navigation log, for use as a reference in fuel computing and flight monitoring.

Various navigation log formats are available. A sample is shown below.

However, candidates for the theoretical exam for the 033 certificate are not required to complete a full navigation log (this is performed during the practical training), but answer isolated questions concerning particular elements of the navigation log.

In the previous sections, we have already seen the determination of:

- cruise safety altitudes;
- distances, the magnetic track and the windless flight time for a specified segment;
- radiocommunication frequencies and the frequencies/call signs of the radio navigation facilities.

In addition, we shall see in this section how to determine Top Of Climb (TOC), Top Of Descent (TOD), magnetic heading and compass heading of the travel, as well as the computation of the correction drift angle, ground speed, in accordance with the latest weather information obtained during short-term planning. The ground speed obtained allows an update of the flight time and the calculation of fuel to be loaded.
Note. The fuel calculation is described in Chapter 033 03 "Fuel Planning"

4.1 - Determination of the TOC and TOD

We shall illustrate the TOC and TOD calculation through two examples.

Example 1: Computing the TOC

Using the following data, compute the distance required to climb up to FL 065:

- average climb ground speed: 105 kt
- rate of climb (ROC): 800 ft/min.

A) 12.7 NM　　B) 14.2 NM
C) 18.8 NM　　D) 20.5 NM

Answer

The climb time to FL 065 with a 800 ft/min ROC is:
Climb time = altitude / ROC = 6,500 / 800 = 8.125 min
Ground distance required for climb = GS x climb time (in hours)
= 105 x (8.125 / 60)
= **14.2 NM**.

Example 2: Computing the TOD

The descent is planned to start at 7,500 ft, in order to reach a 1,000 ft altitude at 6 NM from the VOR-TACAN, with a 156 kt average descent ground speed and a 800 ft/min rate of descent. How far from the VOR-TACAN should the descent start?

A) 11.7 NM　　B) 27.1 NM
C) 30.2 NM　　D) 15.0 NM

Answer

The descent time from 7,500 ft to 1,000 ft = (7,500 – 1,000) / 800 = 8.125 min
Descent distance from 7,500 ft to 1,000 ft = TAS x descent time (in hours)
= 156 x (8.125 / 60)
= 21.1 NM.
The distance from the TOD to the VOR-TACAN is: 21.1 + 6 = **27.1 NM**.

4.2 - Computing the magnetic heading and the compass heading

For each trip segment, the compass heading and/or magnetic heading to follow should be recorded in the navigation log.
The formulas are reviewed during navigation; a brief reminder is provided in the example below.

Example

Determine the aircraft magnetic heading and the compass heading using the following data:

- true heading noted on the chart: 180°;
- magnetic variation read on the chart: 12° W
- compass deviation: 3° E.

A) 168 ; 171 B) 168 ; 165
C) 192 ; 189 D) 189 ; 192

Answer

Magnetic heading (HDG (M)) = true heading (HDG (T)) – magnetic variation.
The magnetic variation is 12° W; by convention, the variation sign is negative Westward.
HDG (M) = 180 – (– 12) = **192°**

Compass heading (HDG(C)) = magnetic heading (HDG(M)) – compass deviation (d).
The compass deviation is 3° E; by convention, the deviation sign is positive Eastward.
HDG(C) = 192 – (3) = **189°**

4.3 - Computing the drift and ground speed

The drift, ground speed, etc. are calculated using the navigation computer:

- computing the drift and ground speed (horizontal situation indicator side);
- computing the airspeed, distance, etc. (slide rule side).

Example

Determine the drift correction angle and the ground speed, using the following elements: true track 017°; wind = 340°/30kt; TAS = 420 kt.

A) – 2°; 396 kt B) + 2°; 396 kt
C) – 2°; 426 kt D) + 2°; 416 kt

Answer

Using the computer, the result should be a **– 2° drift angle correction** (wind from left) and a **396 kt ground speed** (the effective wind component is headwind).

Note. *The wind is indicated in relation to the true North (except the ATIS wind which is indicated in relation to the magnetic North); therefore, the true track should be used for this type of computation.*

4.4 - Drafting the navigation log

See section "Drafting the navigation log" in Chapter 033 02 "IFR navigation" for a detailed description of a navigation log.

033 FLIGHT PLANNING AND MONITORING

02

IFR NAVIGATION

THIS CHAPTER IS NOT FOR CPL

01 AIR TRAFFIC SERVICE (ATS) ROUTES

During the flight preparation stage, studying the en-route charts consists in determining the most direct published routes to the destination airport, considering the following key points:

- the airspace constraints (restricted areas);
- the one-way airways, as well as the airways with "by ATC" mention, which can be used only on instruction from the air traffic control (ATC);
- the minimum safety altitudes;
- compliance with maximum altitudes.

On an IFR flight, the flight is characterized by instrument navigation on the airways, using the on board instruments (FMS or IRS) and the ground-based radio navigation aids.

1.1 - Introduction to the en-route charts

In order to prepare the exam, we shall focus on the following four types of charts. Many questions in the test are derived from these charts.

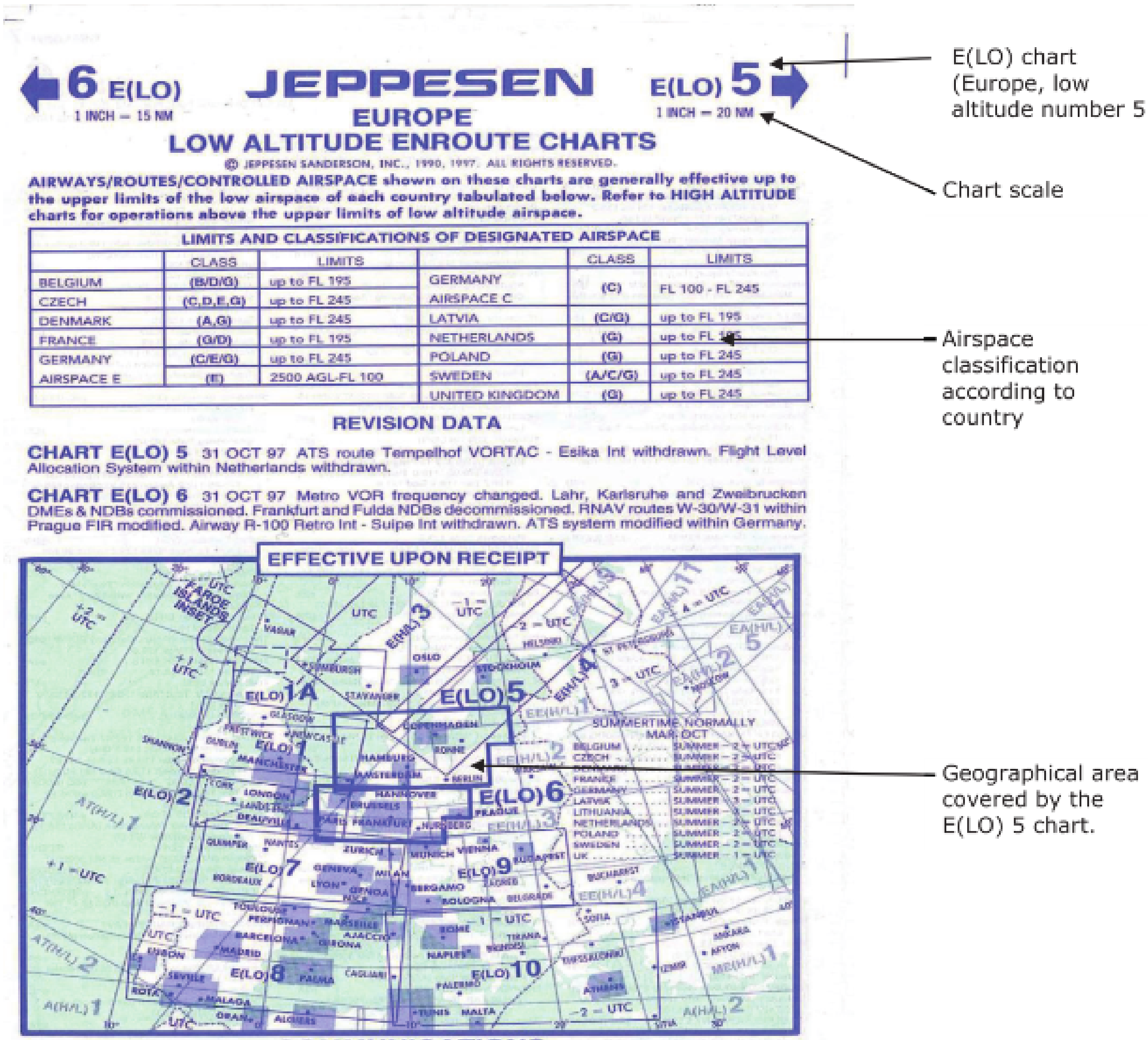
• Europe low altitude en-route chart – E(LO)
Six charts identified as E(LO) 1, E(LO) 2... (E, Europe; LO, Low Altitudes) covering the various regions in Europe, at low altitude.

• Europe high altitude en-route chart – E(HI)
Six charts identified as E(HI) 1, E(HI) 2... (E, Europe; HI, High Altitudes) covering the various regions in Europe, at high altitude.

• Atlantic high altitude en-route chart – AT(HI)
Six top level charts (AT - Atlantic; HI - High Altitudes); the AT(HI) n° 5 chart concerning the Atlantic polar high altitude charts is selected for our study.

• Mid/North Atlantic Plotting chart (MID/NAP)
Chart covering the North Atlantic area

- Europe low altitude en-route charts – E(LO)



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These charts are Lambert conformal projections.

The countries and the associated airspace classification covered by the chart are specified on the chart cover.
These charts are effective from ground to a top limit level, usually located between FL 195 and FL 245, depending on the country.

All the directions on these maps are specified in magnetic degrees, all distances are specified in nautical miles, and all altitudes are specified above sea level (QNH) or are expressed as a flight level (FL).
These charts include symbols and legends, found in the glossary of the Jeppesen manual.

Regardless of the en-route chart, it is important to be familiar with the most popular abbreviations and symbols for a quick use of the information displayed on the chart.

When in doubt, it is always possible to refer to the list of symbols published in the Jeppesen manual preface, but it would be useful to learn them through regular practical exercises.

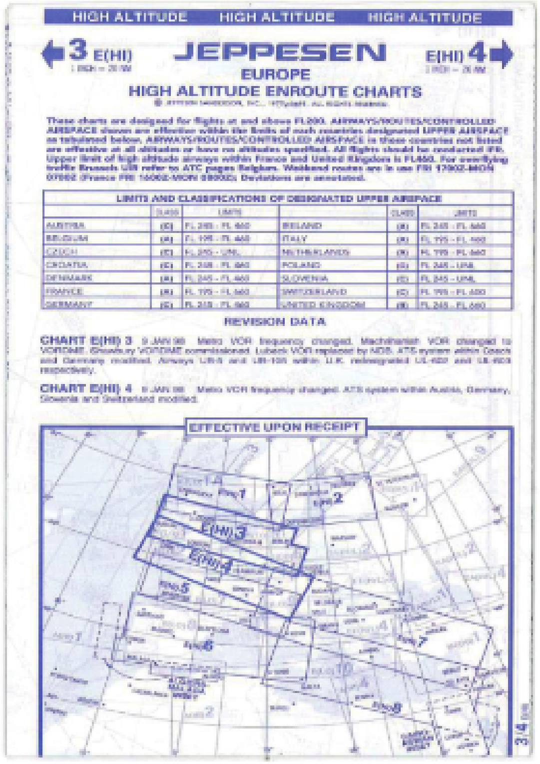
- **Europe high altitude en-route charts – E(HI)**

The layout of these Lambert conformal projection charts is similar to the E(LO) chart already described.

These charts are used for flights in the upper traffic area. The boundary between the lower and upper traffic area changes depending on the country. In Europe, this boundary is between FL 195 and FL 245, depending on the country.

These charts do not display radio navigation and communication aids required at low altitude, such as:

- the ILS frequencies and call signs;
- the locator beacons;
- the terminal communication frequencies.



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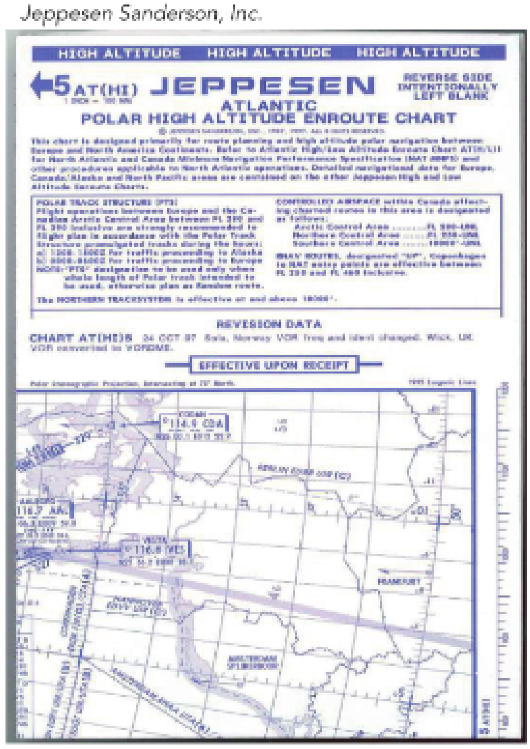
- **Atlantic high altitude en-route charts – AT(HI)**

These charts are used during the flight preparation stage with a transoceanic navigation between Europe and North America.

We shall specifically study the ET(HI) 5 chart – Atlantic polar high altitude en-route chart. This upper traffic area chart is basically used for studying the routes and polar high altitude navigation between Europe and North America.

These charts are polar stereographic projections.



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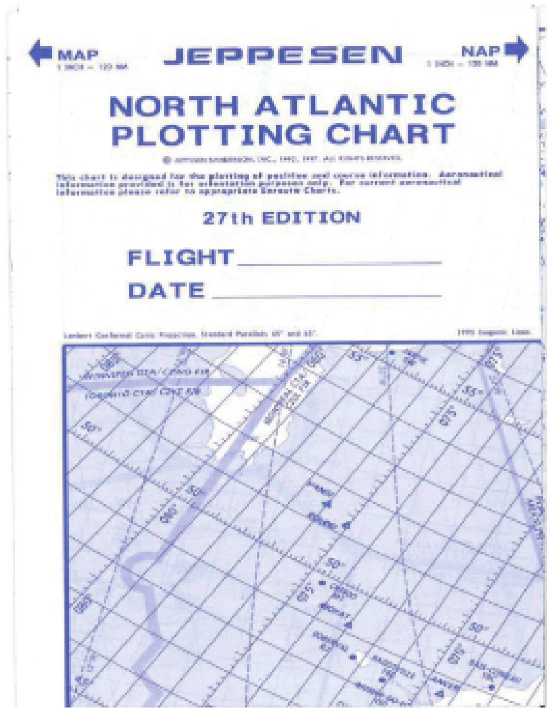
- Mid/North Atlantic Plotting charts (MID/NAP)

These charts are used during the flight preparation stage with transoceanic navigation between Europe and North America. These charts are Lambert conformal projections. They are used for route plotting and position information.



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1.2 – Different types of ATS routes

An ATS (Air Traffic Services) route is a designated route for channeling the flow of traffic as necessary for the provision of air traffic services. In the enroute portion (cruise), the ATS route is usually called airway. There are several types of ATS routes:

- Conventional routes
- aRea NAVigation (RNAV) routes
- Required navigation performance (RNP) routes
- ConDitional Routes (CDR)
- Direct routes

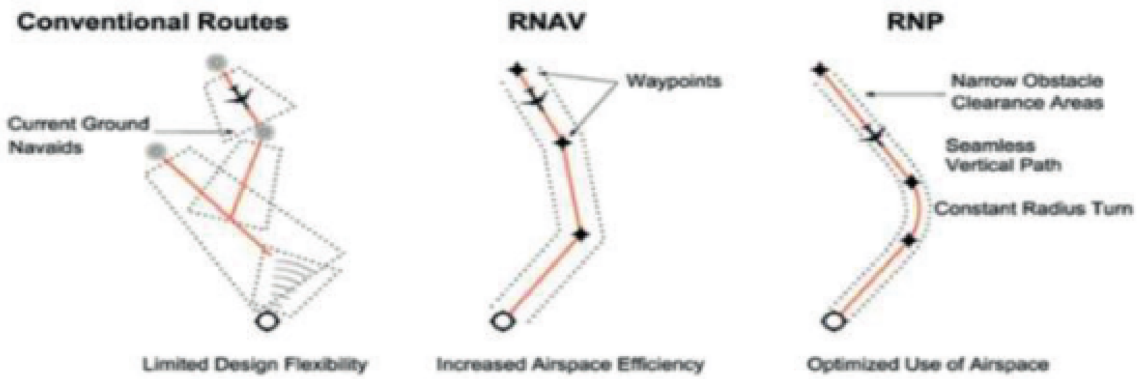
- Conventional routes: these routes are designed with the necessity to follow the infrastructure of navigational aids built on ground (VOR, VOR-DME, VOR-TAC…) with relatively large obstacles protection areas. They are also called "non RNAV routes".

- RNAV routes: these routes are designed to enable an aircraft to use any flight path within a network of waypoints rather than navigating directly between ground radio-navigation stations. The advantages of RNAV are to improve operating efficiency (less distance travelled, less time, less fuel burn) and to increase route capacity (an increased number of routes). These routes can be planned for use by aircraft with RNAV capability. In Europe, we distinguish:
  - B-RNAV or RNAV 5 route extends 5 NM on either side of the intended track within which a RNAV equipped aircraft can be expected to remain for 99.5% of the flight time (typically these routes are designed for the en-route cruise phases).
  - Performance Area Navigation (P-RNAV or RNAV 1) routes where a navigation accuracy better than 1 nautical mile is required (typically designed to be used during terminal phases).

  Many ATS routes around Europe require at least RNAV 5 (B-RNAV)

- **RNP routes**: compared to the RNAV routes, the main difference is that RNP provides even greater navigation precision for these routes and an additional system of monitoring and alerting is incorporated.

The following is a graphic illustration of different navigation concepts for conventional, RNAV and RNP routes.



- **CDR (conditional) routes**: these routes are non-permanent ATS routes which are usable only under specified conditions. They are designed to complement the permanent ATS route network.
  There are 3 categories of Conditional Routes:
  - Category One (CDR 1) - this route is permanently plannable during the times published in the relevant national Aeronautical Information Publication (AIP).
  - Category Two (CDR 2) – this route is only plannable in accordance with the conditions stated in the daily Airspace Utilization Plan (AUP) issued by the Airspace Management Cell.
  - Category Three (CDR 3) - this route is not available for flight planning but may be used tactically at the discretion of ATC.

- **Direct routes**: these routes are based RNAV capability and they are set between waypoints defined in terms of latitude/longitude coordinates, in courses/distances relating to fixes, or offsets from established routes/airways at a specified distance and direction.
  Direct Routes require ATC approval and they will not be accepted in Flight Plans.
  These routes are specified by the letter D on the en-route Jeppesen charts.

ICAO ATS Route Designators

According to ICAO Annex 11, basic designators for ATS routes shall consist of a maximum of five alphanumeric characters in order to be usable by both ground and airborne automation systems. The basic designator consists may be of one letter of the alphabet followed by a number from 1 to 999.

- Regional Route Designators: the following designator routes are part of the regional networks of ATS routes.
  - ✓ **A, B, G, R:** these routes are conventional routes (NOT RNAV). **Example:** A 20.
  - ✓ **L, M, N, P:** these routes are RNAV routes. **Example:** L851.

- Non-Regional Route Designators: the following designator routes do not form part of the regional networks of ATS routes. Usually, they are "secondary" routes as they have a shorter distance compared to the Regional routes.
  - ✓ **H, J, V, W:** these routes are NOT RNAV routes. **Example:** W320.
  - ✓ **Q, T, Y, Z :** these routes are RNAV routes. **Example:** Q21.

- Prefix: where applicable, one supplementary letter shall be added as a **prefix** to the basic designator as follows:
  - ✓ **K: (kopter)** to indicate a low-level route established for use primarily by Helicopters.
  - ✓ **U: (upper)** to indicate that the route or portion thereof is established in the upper airspace. **Example:** UA 12, UP 41.
  - ✓ **S: (supersonic)** to indicate a route established exclusively for use by supersonic aircraft during acceleration/deceleration and while in supersonic flight.

- Suffix: where applicable, a supplementary letter may be added after the basic designator of the ATS route as a **suffix** as follows to indicate the type of service provided or the turn performance required on the route:
  - ✓ **F**: to indicate that on the route or portion thereof advisory service only is provided (class F airspace). **Example:** W 43F
  - ✓ **G**: to indicate that on the route or portion thereof flight information service (FIS) only is provided (class G airspace). **Example:** V 21G
  - ✓ **Y**: for RNP1 routes at and above FL200 to indicate that all turns on the route between 30 and 90 degrees shall be made within the tolerance of a tangential arc between the straight leg segments defined with a radius of 22.5 NM.
  - ✓ **Z**: for RNP1 routes at and below FL190 to indicate that all turns on the route between 30 and 90 degrees shall be made within the tolerance of a tangential arc between the straight leg segments defined with a radius of 15 NM.

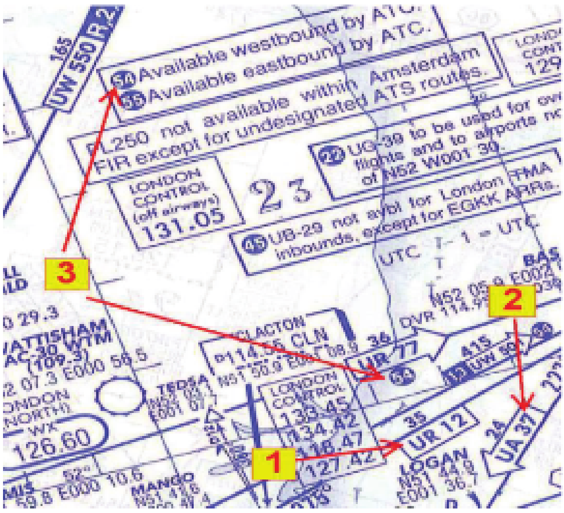
1.3 - Airways designation on Jeppesen en-route charts

The airspace is organized in airways, notified to the flight crews via en-route charts. Airways are corridors followed by the IFR flights; they are usually 10 NM wide and their axes are often defined with radio navigation beacons.

The IFR flight planning should be carried out in accordance with the published routes and flight plans will be more easily accepted when filed following these airways.

1.3.1 - E(LO) and E(HI) type charts

In Europe, on the Jeppesen charts, here are some examples of airway designations and direction that can be found on E(LO) and E(HI) charts.

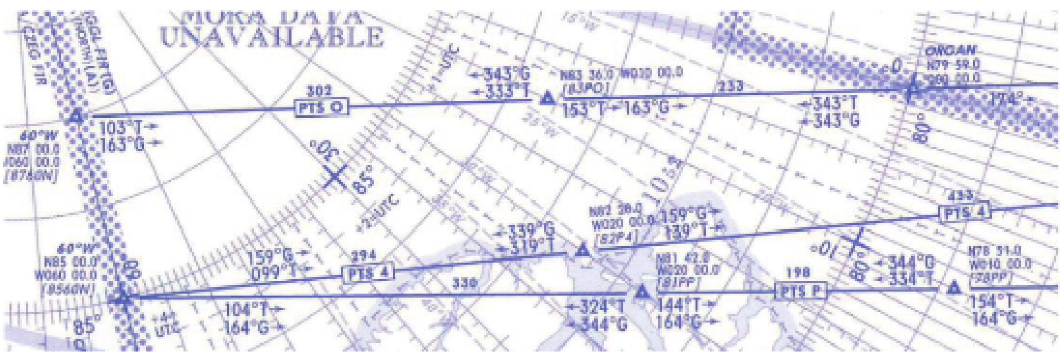


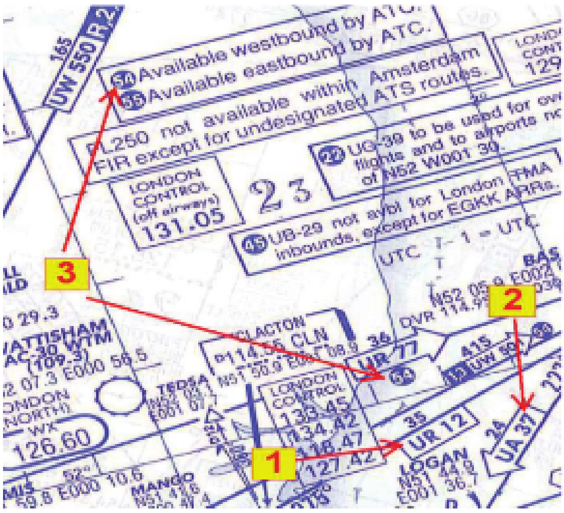
1	UR 12 airway; this is an upper traffic area route.
2	One-way airway (UA 37), whose direction is specified by the direction of the arrow.
3	One-way airway (UA 77). However, this airway can be used in the reverse direction on ATC control instruction (see inset indicating the specification associated with this route).

1.3.2 - Atlantic high altitude en-route chart

Over the North Atlantic, the oceanic tracks are organized in accordance with the NAT OTS system (North Atlantic Organized Track System). The construction of these tracks depends on the wind; so, aircraft operating from the United States to Europe benefit from strong tailwinds and aircraft flying westward will avoid such winds. The organized tracks are published every day.
As concerns eastward flights, the most northern track is named A, the next one B, and so on. As concerns westward flights, the most southern track is named Z, the next one Y, and so on.

On Atlantic polar high altitude charts, type AT(HI) 5, a polar track structure system is created for flights operated between Europe and the Canadian Arctic Control Area, for flight levels between FL 280 and FL 390. This track system is called Polar Track Structure (PTS).
The PTS includes ten fixed tracks in the Reykjavik CTA and five fixed tracks in the Bodo Oceanic Control Area (OCA). Example: PTS 4, PTS O.





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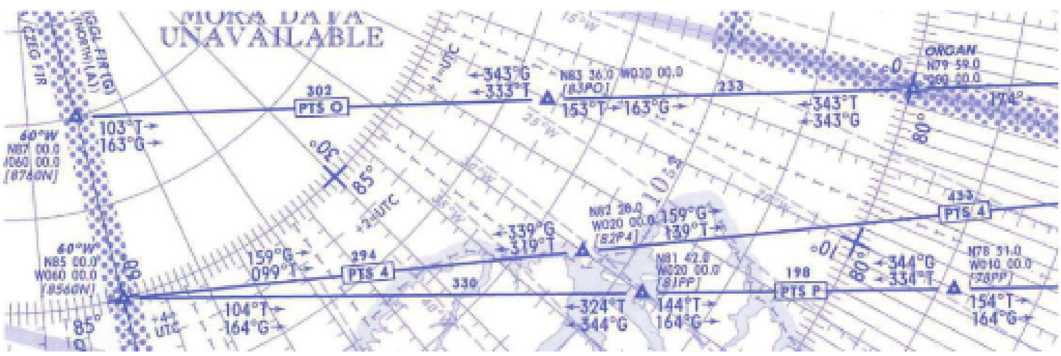
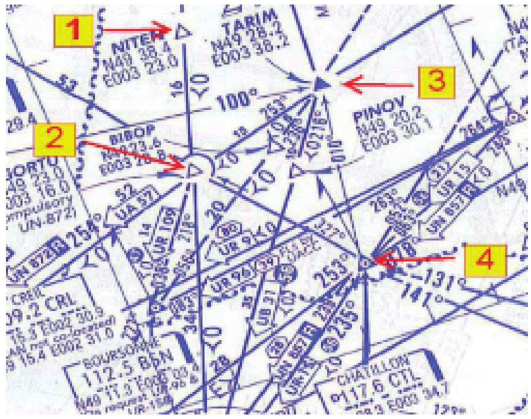


1.4 - Reporting points

Drawing up airways is based on significant geographic points, which may or may not correspond to the location of a radio navigation aid.
On tracks defined by designated significant points, the position reports will be generated when crossing each reporting point, or as early as possible after this crossing.
Reporting points may be defined in various ways:

- through radio navigation aids (VOR, ADF);
- through radio axes intersections;
- through geographic points determined by their latitude and longitude coordinates.



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1	Optional reporting point (blank triangle).
2	Optional reporting point, concerning track UA 57 only. Thus, the route going through the Chatillon VOR-DME (CTL) is not concerned by this reporting point.
3	Mandatory reporting point (solid triangle), not associated with a radio facility.
4	Mandatory reporting point (solid triangle), associated with a radio navigation facility.

The reporting points are specified on the en-route charts (solid triangle for mandatory reporting points, and blank triangle for optional reporting points).

1.5 - Selecting routes

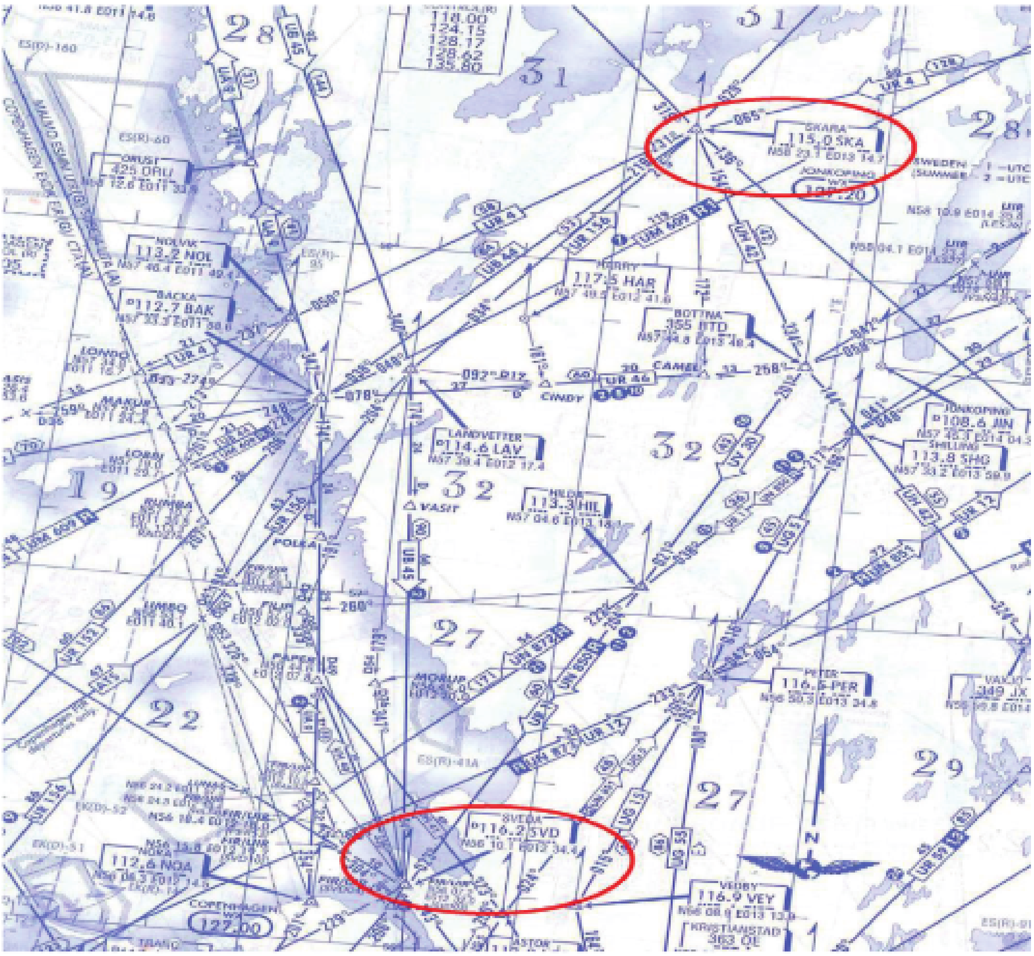
For obvious reasons of fuel and flight time economy, it is necessary to identify the most direct route (minimum ground distance) between the departure airport leaving point and the destination airport entry point, while applying the following instructions:

- taking account of the restricted areas, distinctive features (e.g. not planning a flight on weekdays along a track exclusively reserved for the weekend), and restrictions due to conflicts or military drills;
- considering the airway direction and the specific routes, such as one-way airways;
- taking account of the maximum and minimum en-route altitudes, in order to comply with the obstacle clearance (see "En-route altitudes");
- considering the ATC restrictions with regard to air traffic management; in particular, the airways with the "by ATC only", which cannot be filed with the ATC flight plan, as they may only be used on flight control instruction.

Example 1: extract of an E(HI) 2 chart

An aircraft must make a flight on airways routing from SVEDA (56°10'N 012°34'E) to SKARA (58°23'N 013°15'E). Among the following tracks, which one is correct?

A) SVD UB45 LAV UR156 SKA
B) SVD UH40 PAPER UA9 BAK UB44 SKA
C) UR1 HIL UV30 BTD UH42 SKA
D) SVD UH40 PAPER UA9 BAK UR156 SKA



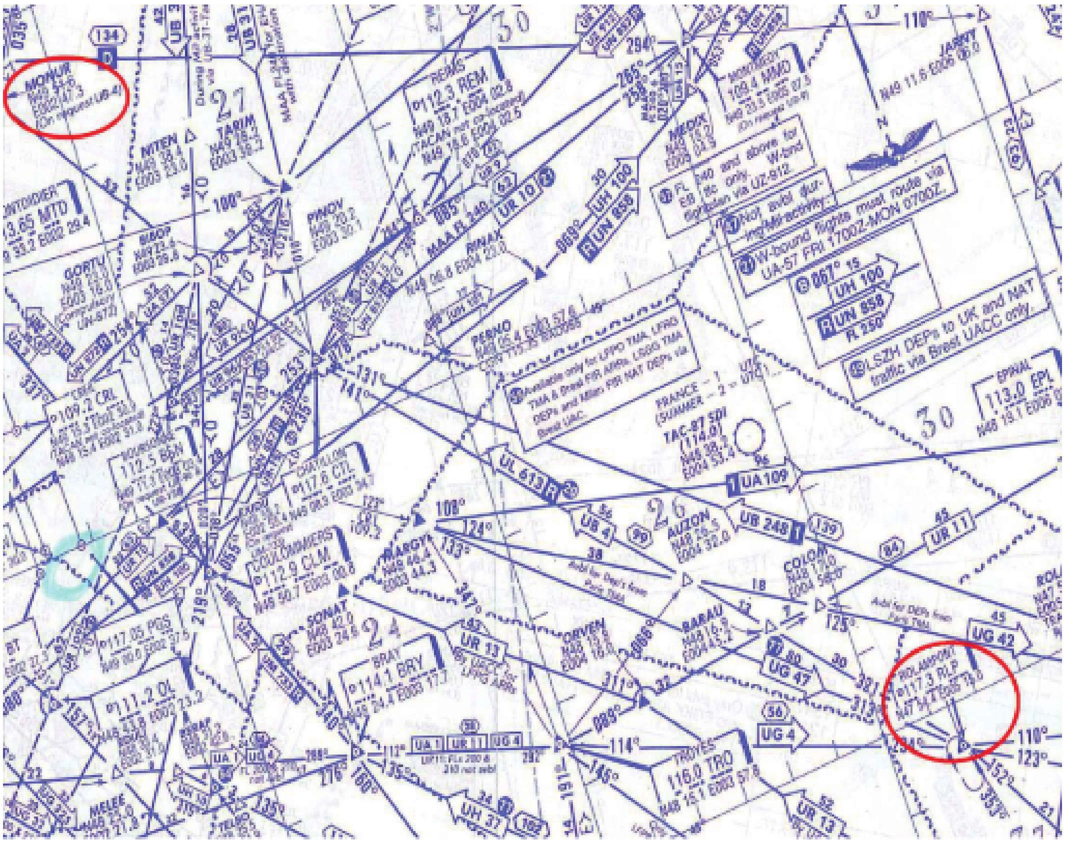
Answer
Identify both VOR on the chart.
The usable route from the SVD VOR to the SKA VOR is:
SVD → UH40 → PAPER → UA9 → BAK → UB44 → SKA.
The tracks via UR1 and UB45 can be used only for a southward traffic (refer to the arrow direction in the track box), whereas the direction of our track is northwards.
The proposed answer D is incorrect, because it is not possible to follow the UR156 track starting from the BAK point.
Answer **B**.

02 COURSES AND DISTANCES FROM EN-ROUTE CHARTS

2.1 - Case of low and high altitude en-route charts – E(LO) and E(HI)

On the Jeppesen en-route charts, all the tracks and all the bearings are specified in magnetic North orientation. The distance information is indicated in NM between all the reporting points of a track. The distance value is indicated on the track.

Example 2: extract of the E(HI) chart



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Determine the initial magnetic track and the total distance from ROLAMPONT (47° 54,4′ N – 005° 15,0′ E) to MONUR (49° 51,6′ N – 002° 47,3′ E) along the UB4 airway:

A) 321° and 99 NM B) 328° and 53 NM
C) 322° and 69 NM D) 321° and 152 NM

Answer

The initial magnetic track of the VOR RPL at the MONUR intersection point along the UB4 airway is 321°. The distance from the VOR RPL to MONUR is the sum of the following segments:

- 99 NM (30 + 13 + 56) from VOR RLP to VOR CTL;
- 53 NM from VOR CTL to the MONUR point.

The total distance is 99 + 53 = **152 NM**.

Answer **D**.

2.2 - Case of the Atlantic polar high altitude en-route charts

2.2.1 - Computing the grid track of the AT(HI) 5 charts

The magnetic references for navigating in this region at high altitude cannot be used for various reasons:

- quick change in the magnetic variation on relatively short distances;
- quick convergence of meridians as the latitude increases; this results in a quick change of the true track direction on short distances.

Therefore, in order to measure and keep a track with constant direction, the North grid is used as a reference.

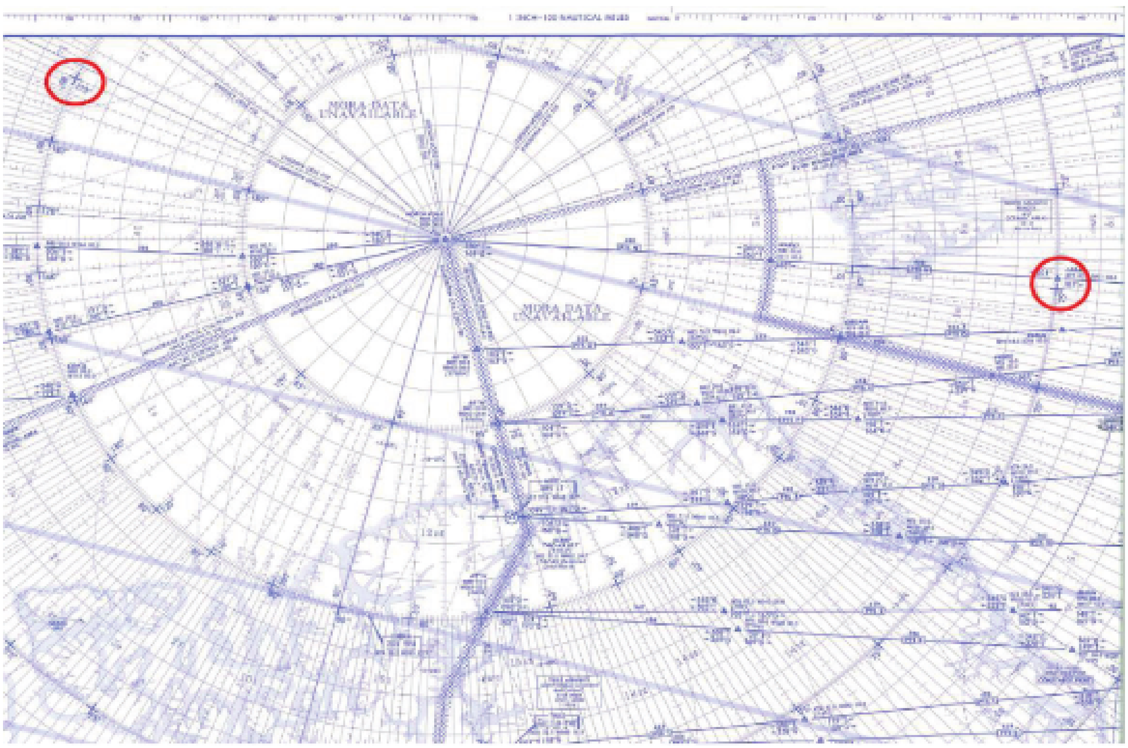
On the Jeppesen polar en-route charts, the Greenwich meridian is used as the North grid reference separating the East and West longitudes. The grid tracks are shown as parallel thick blue lines from East to West with a 300 NM interval (see the extract of the chart below).
The formula for computing the grid track is indicated in the right-hand bottom corner of the AT(HI) 5 chart:
Grid bearing = true bearing + west longitude (or – east longitude).

+ WEST longitude

Grid track = true track

– EAST longitude

Example 3: extract of the AT(HI) 5 chart



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A flight from position A (80° N – 170°E) to position B (75° N – 011° E). The initial grid track is 177°. What is the initial true track?

A) 177° B) 357° C) 347° D) 167°

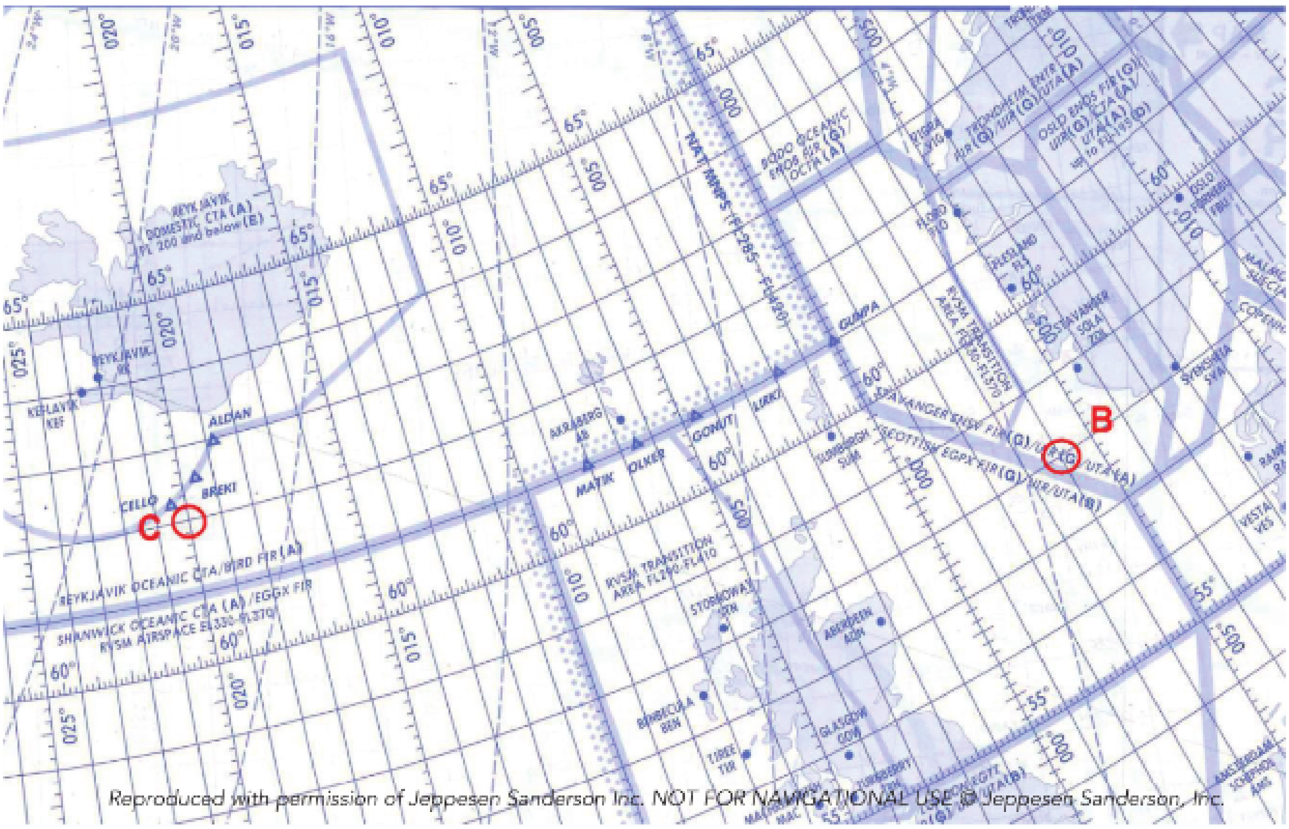
Answer
Applying the previous computing formula for this type of chart.
Initial grid track = initial true track – East longitude
Hence, initial true track = initial grid track + East longitude from position A.
= 177 + 170
= **347°**
Answer **C**.

2.2.2 - Distance calculation

On the Atlantic polar high altitude charts, distances are determined according to various methods: either by measuring distances and applying the chart scale to obtain the earth distance; chart scale = chart distance / earth distance;
or by computing the distance using the latitudes and longitudes of both points on the chart (refer to the "Navigation" course to go further into this point).

Example 4:
Use the following NAP chart extract and determine the distance in NM from C (62° N – 020° W) to B (58° N – 004° E).

A) 760 B) 775 C) 725 D) 700



Answer

Identify both points on the chart and plot the track between these two points.

• Measure the distance between both points on the chart and apply the chart scale: the approximate distance should be 760 NM (this method is applicable only if the scale of the chart extract is identical to the chart scale, which is not the case here; therefore, this method cannot be selected).

• It is also possible to determine this distance with the following computation:

$D = \sqrt{(X + Y)}$

With

$X = x^2$ and with an arc centered to 60° N (average value between 62° N and 58° N):

$x = \cos 60° \times 60 \times (20° W + 4° E) = \cos 60° \times 60 \times 24 = 720$ NM.

And $Y = y^2$ with $y = (62° N - 58° N) \times 60 = 240$ NM

Hence:

$D = \sqrt{(720^2 + 240^2)} = 760$ NM

Answer **A**.

03 ALTITUDES

The air traffic regulation requires flight crews to define minimum flight altitudes, in order to comply with the terrain/obstacle clearance throughout the route by taking account of factors such as temperature, terrain and unfavourable meteorological conditions.
In order to perform this task, they use the en-route charts indicating different types of minimum flight altitudes to be applied on the airways. Among other things, these altitudes ensure safety with regards to obstacle clearance.

The charts also sometimes display information concerning the maximum altitudes to be applied on the airways.

The minimum altitudes are usually defined by the Authorities of the country concerned and are used by the chart providers (Jeppesen, Lido, etc.).
When these altitudes are not defined, the chart providers propose an approved method for determining them to ensure obstacle clearance.

For safe navigation, it is important that candidates and future pilots know the definition and characteristics of these altitudes, as well as their codes.

Caution. *The obstacle clearances specified below are values displayed on the Jeppesen charts; values can be different depending on the method for defining the minimum altitudes adopted by other chart providers.*

3.1 - MEA (Minimum En-route Altitude)

The MEA determination is based on the highest obstacle along the track segment between two radio navigation aids, in order to receive the radio signals; this minimum altitude ensures obstacle clearance between those two aids.
The MEA applies on a width ranging from 5 NM to 60 NM (usually 10 NM) on either side of the airway or track segments between the two radio navigation aids. On the Jeppesen charts, it ensures (among other things) a 1,000 ft obstacle clearance (except in mountainous areas where the clearance is 2,000 ft).
The MEA is published on the airways as an altitude or a flight level, with no suffix or prefix.
Examples: 5,000 or FL 70.

3.2 - MOCA (Minimum Obstacle Clearance Altitude)

The MOCA is the minimum obstacle clearance altitude between two radio navigation aids. Like the MEA, it covers the full width of the airway; however, it does not enable perfect reception of radio signals.
Therefore, the MOCA is always less than the MEA.
The MOCA is identified with an altitude specified on the airways, followed by letter "T".
Example: 3,900T.

3.3 - MORA (Minimum Off-Route Altitude)

Two types of MORA are available: the en-route MORA; the grid MORA.
These are OFF-Route minimum altitudes. These altitudes are mainly displayed on the Jeppesen en-route charts and are published as a supplement to the MEA.

The en-route MORA is computed from a 10 NM corridor on either side of the centre line of the airway, and including a 10 NM arc beyond the radio aid or the reporting point.
The value of the MORA provides the following obstacle clearance:
1,000 ft above any relief/obstacle where the highest relief/obstacle is less than or equal to 5,000 ft;
2,000 ft for any area where the relief of obstacles is equal to 5,001 ft or more.

The MORA is identified with an altitude specified on the airways, followed by letter "a".
Example: 4,500a

3.4 - Grid MORA or minimum safety grid altitude

Computing this altitude is based on the highest off-route relief located in the grid area which is displayed as a quadrangle (surface between two meridians and two parallels) with a 1° latitude and longitude.
It should be noted that on the Jeppesen en-route charts, the grid MORA has the same obstacle clearance criteria as the route MORA above within the protection zone being considered.
The grid MORA is specified in thousands and hundreds of feet above sea level, omitting the last two digits in order to avoid complicating the chart.
Example: 134 = 13,400 ft.

3.5 - MAA (Maximum Authorized Altitude)

The MAA is the highest altitude or flight level that can be used in an airway or in a specified airspace.
The MAA is expressed in altitude or flight level, preceded by the MAA mention.
Example: MAA FL290 or MAA 29,000.

3.6 - MCA (Minimum Crossing Altitude)

Airways are usually designed so that, when an aircraft crosses an airway segment with a specified MEA to another segment with a higher MEA, the aircraft can safely start a normal climb to the higher MEA. In principle, climb is performed by crossing the reference radio navigation aid that divides the two segments concerned.

Thus, the MCA (minimum crossing altitude) is defined as the lowest altitude at which the radio navigation aid specified in the above paragraph can be crossed, while safely clearing all the obstacles when crossing from one airway to another.

3.7 - MHA (Minimum Holding Altitude)

The MHA is the lowest prescribed altitude for a holding pattern ensuring the coverage of the radio navigation and communication aids and complying with the obstacle clearance requirements.
See the illustration in section "STAR" of this Chapter (page 61).

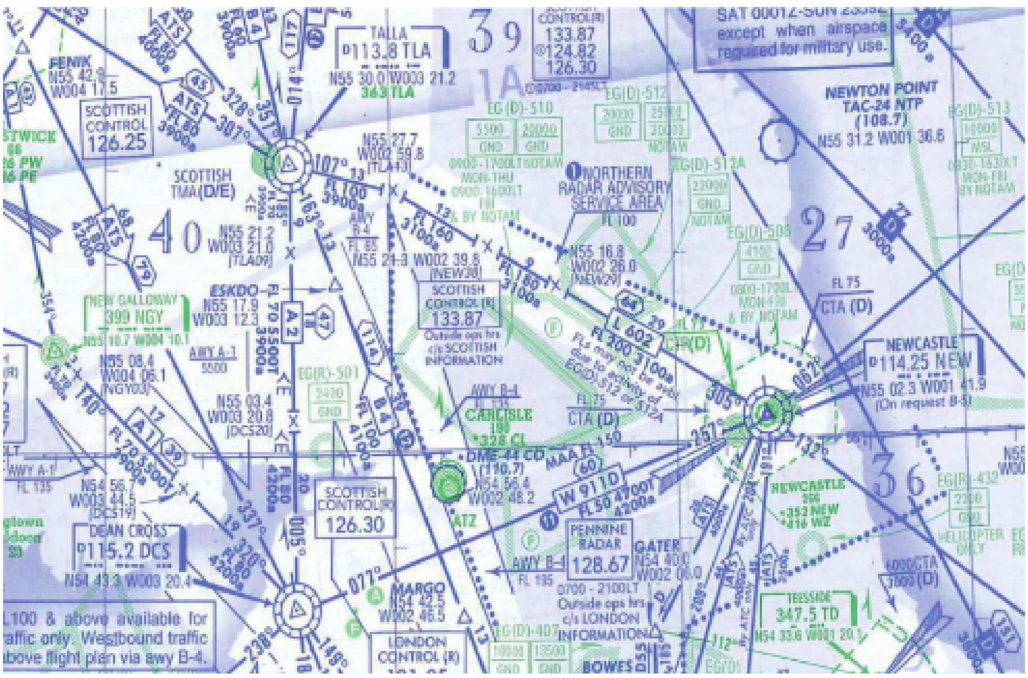
3.8 - Other information

The "< E" mention (E, Even) specified on the airways means that:
the even altitudes/flight levels should be used in the direction of the arrow specified on the track; the odd altitudes/flight levels should be used in the opposite and reverse direction to the semi-circular rule.

The "< O" mention (O, Odd) means that the odd altitudes/flight levels should be used in the direction of the arrow specified on the route.
Note. Opposite to the "< E" code, which allows flying in both directions depending on the even or odd flight level, the "< O" mention does not allow flying in the opposite direction to the one specified on the chart, even if the flight level is even.

The abbreviation PPR (Prior Permission Required) means that the ATC clearance is required before using the track according to the arrow direction.

Example 5: extract of the E(LO) 1 chart



What is the minimum en-route altitude (MEA) on airway W911D from NEWCASTLE 114,25 NEW (55° 02′ N – 001° 41′ W) to DEAN CROSS 115,2 DCS (54° 43′ N – 003° 20′ W)?

A) 4,200 ft B) FL 50 C) 4,700 ft D) FL 150

Answer
On airway W911D, between the NEW VOR and the DCS VOR, several bold figures are specified below and above the airway:
• Below the airway
FL 50 = MEA (Minimum En-route Altitude).
4,700T = MOCA (Minimum Obstruction Clearance Altitude).

4,200a = MORA (Minimum Off-Route Altitude).
• Above the airway
MAA FL 150 = (Maximum Authorized Altitude), the minimum authorized altitude is FL 150.
Answer **B**.

Example 6.

Refer to the extract of the E LO 1 chart in the previous example.
What is the appropriate flight level for a flight on airway A2 from TALLA 113,8 TLA (55° 30′ N – 003° 21′ W) to DEAN CROSS 115,2 DCS (54° 43′ N – 003° 20′ E)?
A) FL 100
B) FL 80
C) FL 90
D) FL 50

Answer
Identify airway A2 between the TLA VOR and the DCS VOR. The magnetic track from TLA is 185°, according to the semi-circular rule for an IFR flight, the flight level should be an even level (see section "Semi-circular rule" hereinafter). But, the "< E" symbol indicates that, along this track, the flight level should be an even level following the arrow direction; i.e. from DCS to TLA. As the flight concerned is in the reverse direction, the flight level should be an odd level.

FL 50 cannot be selected, because the MEA (minimum en-route altitude) along this track is FL 70; therefore, the appropriate flight level is FL 90.
Answer **C**.

3.9 – Terrain separation

3.9.1 - Responsibility for terrain separation

The distance by which an aircraft avoids obstacles or other aircraft is termed *separation*. The most important concept of IFR flying is that separation should be maintained regardless of weather conditions. Let us consider an IFR flight.

- In controlled airspace, Air Traffic Control (ATC) separates IFR aircraft from obstacles and other aircraft using a flight *clearance* based on route, time, distance, speed, and altitude. ATC monitors IFR flights on radar, or through aircraft position reports in areas where radar coverage is not available. Aircraft position reports are sent as voice or automatic (transponder) radio transmissions.

  It should be noted that the determination of the lowest usable flight levels by the air traffic control units within controlled airspace does not relieve the pilot-in-command of the responsibility to ensure that adequate terrain clearance exists, except when an IFR flight is being vectored or given direct routing assisted by radar. Indeed, the pilot-in-command is responsible for the safety of the operation of the aircraft and the safety of the aeroplane and all persons on board during flight.
  It should be noted that when ATC is not providing a surveillance service (radar) and a pilot accepts a direct route which is off of the published route, then the pilot is wholly responsible for maintaining obstacle clearance.

- **In uncontrolled airspace**, ATC clearances are unavailable. In some case, a form of separation is provided but this service is not mandated nor widely provided. In this case, an appropriately rated pilot, in an appropriately equipped aircraft, may fly IFR in this airspace and he is responsible for the prevention of collision with terrain.

To accomplish this task, the pilot-in-command shall closely monitor the aircraft's position with reference to pilot-interpreted navigation aids and he refers to the minimum altitudes (MEA, MOCA, MORA, Grid MORA) published in the en-route charts which provide a minimum height above the non-mountainous terrain areas of 1000 ft and at least 2000 ft above the highest obstacle over high terrain, or in mountainous area.

When flying in the vicinity of an aerodrome, the minimum safe altitude (MSA) must be observed.

If there is no specification of minimum altitudes in the en-route chart, the minimum obstacle clearance which should be applied for the en-route phase of an IFR flight is 300 m (984 ft).

3.9.2 – Calculation of true altitude according to QNH and temperature

a) QNH correction

As the elevation of the obstacle is relating to mean sea level and the altitude of an IFR flight during the en-route phase is usually flight level, to ensure obstacle separation, pilots need to convert:
- his flight level in QNH altitude or,
- the obstacle elevation in flight level
by applying the difference between 1,013.25 hPa and the QNH of the area in which an IFR flight is operated. A barometric error of approximately 30 ft/hPa could be used.

b) Temperature correction

The calculated minimum safe altitudes must be adjusted when the ambient temperature on the surface is much lower than that predicted by the standard atmosphere. As we have already stated in the 01 chapter, the approximate rule of thumb correction is 4 % height increase for every 10°C below standard temperature as measured at the altimeter setting source.

It should be noted that this correction is safe for all altimeter setting source altitudes for temperatures above –15°C. For colder temperatures, a more accurate correction should be obtained.

<u>Pilot:</u>

During the <u>en-route phase</u> of flight, for practical operational use, it is appropriate to apply a temperature correction only in significantly colder than standard conditions. According to the regulation in force, the temperature correction should be taken into account when the correction exceeds 20% of the required minimum obstacle clearance.

For example, in mountainous areas, the minimum obstacle clearance for MOCA is 2000 ft → 20% of 2000 ft equals 400 ft; thus, temperature correction should be applied only if it is greater than 400 ft.

Note: this rule is not applicable when the minimum altitude is referring to MSA.

Example

An IFR flight on an airway with magnetic course of 135° and MSA of 7800 ft. Knowing the QNH is 1025 hPa and the temperature is ISA + 10°C, the minimum flight level to be carrying out is…

A) FL 075 B) FL 080
C) FL 090 D) FL 070

Answer

QNH correction: as the question is referred to flight level (FL); thus, the MSA should be "converted" in flight level.

With a MSA of 7800 ft and the local QNH of 1025 hPa, the altimeter with 1013 hPa set in the reference window will indicate an altitude = 7800 + (1013 – 1025) x 30 = 7440 ft

Temperature correction: with ISA + 10°C, the temperature correction will be 10 x 0.4 = 4% of 7800 ft = 312 ft.

Thus, the flight level selected must correspond to : 7440 – 312 = 7128 ft.

Since, the magnetic course is 135°, an ODD FL has to be used and the first ODD FL above 7128 ft is FL 090 (refer to the semi-circular rule for IFR flight below in this chapter).

ATC

When designing the structure of airspace where air traffic control is provided, an ATS authority will have to consider annual and seasonal variation of temperature when establishing the minimum flight altitudes.

The analysis of recorded meteorological data will be the basis for considering how the effect of cold temperatures should be mitigated in operations.
According to the airspace requirements and the surrounding environment, an airspace designer may consider a lower temperature as a temperature reference for establishing the minimum flight altitudes.

3.9.3 – Minimum radar vectoring altitudes (MVA)

When an IFR flight is being vectored by radar, a Minimum Vectoring Altitude is established for use by ATC. is the lowest altitude, expressed in feet AMSL (Above Mean Sea Level), to which a radar controller may issue aircraft altitude clearances during vectoring/direct routing except if otherwise authorized for radar approaches, departures and missed approaches. MVA may also be referred to as Minimum Flight Altitude (MFA), Minimum Radar Vectoring Altitude (MRVA) or ATC Surveillance Minimum Altitude (ASMA).

The MVA provides 1,000 feet of clearance above the highest obstacle in non-mountainous areas and 2,000 feet above the highest obstacle in designated mountainous areas. Because of the ability to isolate specific obstacles, some MVAs may be lower than MEAs, MOCAs, or other minimum altitudes depicted on charts for a given location.

Whenever possible, minimum radar vectoring altitudes should be sufficiently high to minimize the risk of activation of aircraft ground proximity warning systems (GPWS). Activation of the GPWS will induce the pilot to pull up immediately and climb steeply to avoid hazardous terrain, possibly compromising separation with other aircraft in close vicinity.

As like the other altitudes, MVA must be corrected for temperature. This temperature correction shall be based on seasonal or annual minimum temperature records. ATC authorities are required to provide the controller with minimum altitudes corrected for temperature effect.

04 SID AND STAR ROUTES

The "Terminal" section in the Jeppesen *Student Pilot Route Manual* contains a set of airport charts for the various airports. In the context of the syllabus, we shall basically study the following charts:

- standard instrument departure (SID) procedures;
- standard terminal arrival routes (STAR) procedures;
- instrument approach procedures.

It should be noted that the tracks specified on the airport charts are magnetic tracks (true track corrected with the magnetic variation), not magnetic headings.
By studying the SID and STAR charts the flight crews can identify the various departure and arrival routes procedures and link them to the airways shown on the en-route charts.

This section will describe the information specified on the standard instrument departure charts (SID) and standard terminal arrival routes (STAR), through a case study. As each chart and each procedure have specific characteristics, it is obviously impossible to list all the particular cases that may occur.
Therefore, candidates are recommended to perform tests in the ENAC – Institut MERMOZ electronic database.

The SID or STAR procedures are a set of routes defined for each runway on the airports intended for aircraft flying in accordance with the IFR flight rules.

They basically rely on various radio navigation aids, and also on pertinent airport fixes. They are published and updated by the Authorities in each country.

It should be noted that, very often, these procedures are long (several tens of NM); therefore, in order to be easily illustrated through graphs on a chart usually in A5 format, these procedures are not shown to scale.

4.1 – Different types of SID and STAR

There are several types of SID/STAR:

- Conventional SID/STAR
- RNAV SID/STAR and,
- RNAV SID/STAR overlay

• **Conventional SIDs and STARs** are designed by the utilization of ground-based radio-navigation aid (VOR, VOR/DME, NDB); still, the design of these procedures is usually limited by the number and the allocation of ground-based beacons. This is the reason why, more or more airports implement RNAV SIDs and STARs.

• **RNAV SIDs and STARs** are designed to use advantages brought by the RNAV equipment. It means that an aircraft is able to navigate to a given set of waypoints without any reference to ground stations. They are designed by utilizing waypoints given by their type (Fly-over, Fly-by) and coordinates. As they usually follow a more desirable path because of the capability of equipment to intercept any fix given by coordinates, therefore the track can be shorter and or its design more relevant.
Of course, RNAV equipment and navigation performance are required for the RNAV SIDs and STARs and this depends on whether an aerodrome is equipped with radar or how the limiting obstacles are in the area. Usually, P-RNAV (RNAV1) is required for these procedures; however, this information is always stated in the current and approved chart.

• **RNAV SID/STAR Overlay** is usually used at airports with higher traffic where there is a requirement for departing or arriving traffic to follow the same route. Utilization of RNAV equipment is then required.
Overlay charts follow the same track as the conventional route track and it is defined by a set of RNAV waypoints.

4.2 - Specific waypoints

4.2.1 - RNAV waypoints

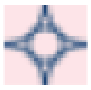
A waypoint on conventional SID/STAR is usually based on ground navigational beacons while the RNAV waypoints are specified by their exact geographic location. These RNAV waypoints on SID and STAR charts can be defined by ground-based navigation aids (such as VOR or DME) with their corresponding geographic location or references from a satellite positioning system (such as GPS or GLONASS).
These waypoints can be overflown (fly-over waypoint) or slightly bypassed (fly-by waypoint) if they are to join the next leg of the route and they are defined by their geographical coordinates (latitude and longitude WGS84) and named according to the following reference codes:

- a 5-letter code (e.g. CAPRIL),
- 3 letters if they are co-located with a ground station (e.g. IRD),
- alphanumeric in terminal fields (e.g. CR596).

4.2.2 - Fly-by and fly-over waypoints

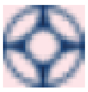
The calculation of the start of a turn in a flight path depends on the waypoint type and there are 2 types: fly-by and fly-over waypoints

Fly-by: identified on the chart by the attached symbol



A fly-by is a waypoint which requires a turn anticipation i.e. the start of a turn is executed before this waypoint in order to allow a tangential interception of the next segment of a route or procedure. The aircraft navigational system calculates the start of the turn onto the next route leg before the waypoint. This is the preferred type of waypoints for RNAV SIDs and STARs.

Fly-over: identified on the chart by the attached symbol



The fly-over waypoint is, as its name suggests, compulsory to overfly i.e. it is a waypoint at which a turn is initiated. The aircraft starts to turn onto the next route leg as it passes over the waypoint. A fly-over waypoint is used in TMAs when it is not possible to use a fly-by; thus, it is crucial to follow the designated track because the structure of obstacles protection areas is designed accordingly. In case of doubt of the type always refer to actual charts, as they have priority over electronics databases.

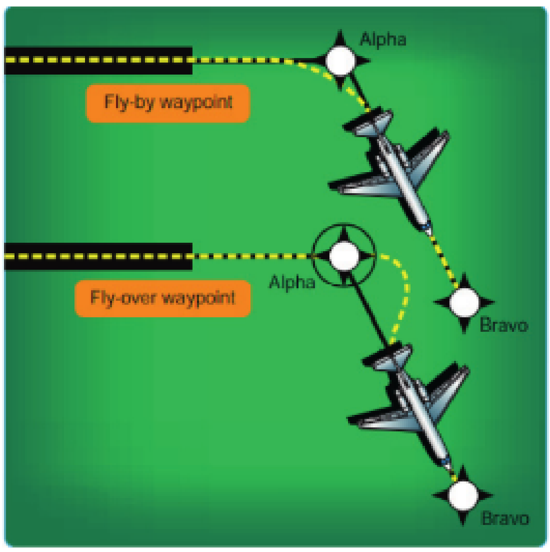


Illustration of the concept of "fly-by" and "fly-over" waypoint

4.3 - SID description

The standard instrument departure procedures defined in controlled airspace in TMA are called SID. Off controlled airspace, omnidirectional departure procedures may be proposed. In the context of the syllabus, we only focus on the SID.

The standard instrument departure procedure (SID) includes all the routes to be followed by an aircraft from the Departure End of Runway (which corresponds to the end of the runway or clearway), up to the first connection waypoint with the en-route phase.

One or more departure procedures are defined for each runway. These procedures are published as magnetic tracks and are designed in order to include:

- the airport environment, especially the presence of obstacles. The climb gradient with all the aircraft engines operative should be 3.3 % minimum; this gradient may be increased in order to ensure a minimum obstacle clearance;

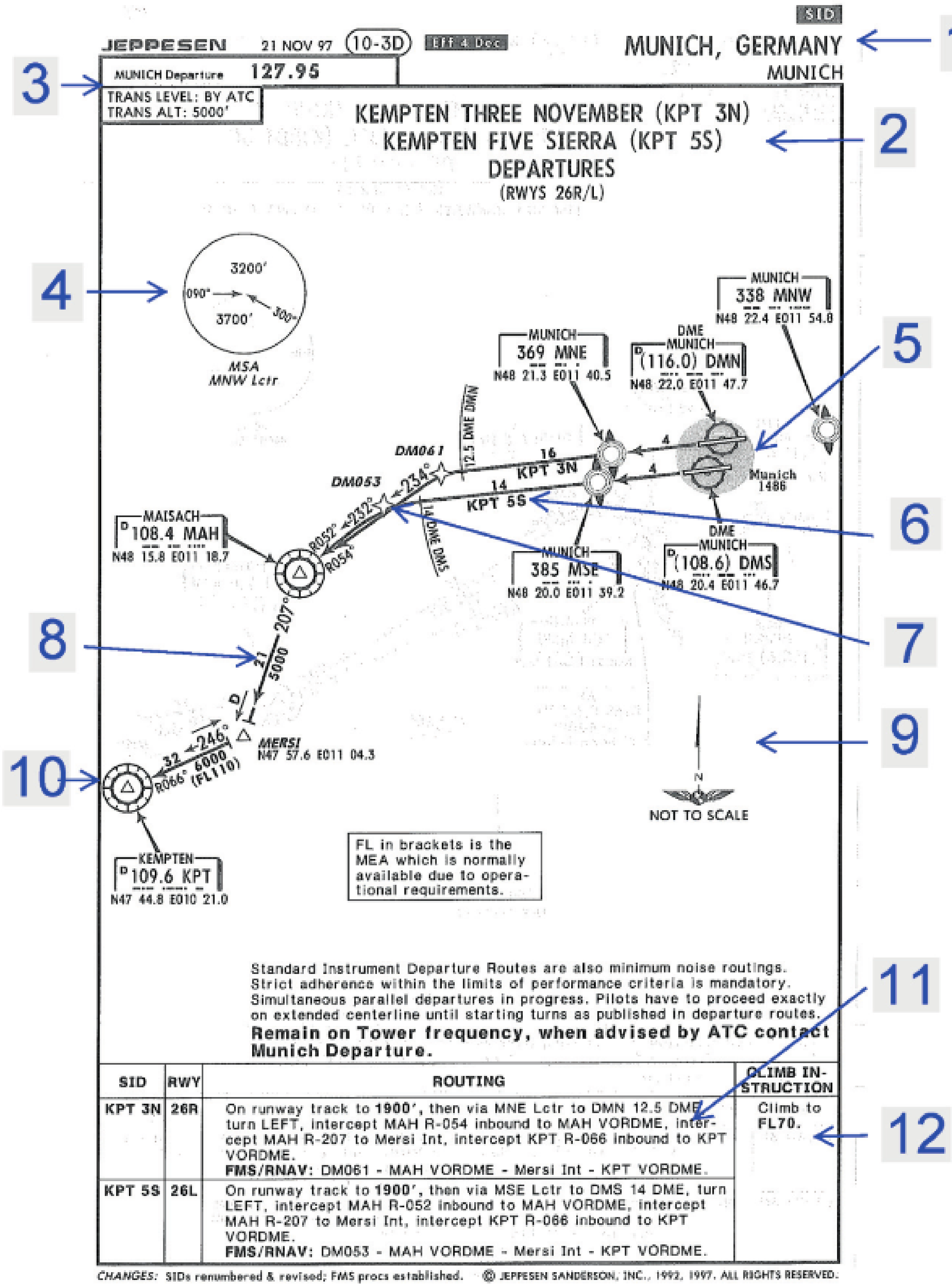
- the ATC requirements, in order to ensure a minimum separation between routes or possible restrictions in protected airspaces;
- environmental issues, in terms of protection against noise pollution.

Sample SID

For easy radio communication exchanges with the ATC, the SID are identified by a name. Usually the name of the SID corresponds to the connection waypoint with the en-route phase.
Several types of display are available:

- one SID name per chart: e.g. the Munich or Amsterdam charts;
- several SID names on the same chart, grouped according to the geographical orientations: e.g. the Paris – Charles-de-Gaulle SID charts.
- SID type is identified by the title usually on the top right corner of the chart:
  - "SID" for conventional SID
  - "RNAV SID" to characterise RNAV SID, and
  - "RNAV SID overlay"

We shall explain the information specified on the Jeppesen conventional SID charts; the other types of charts have similar displays and information.
The Munich SID 10-3D chart will be used as a guide for this purpose.



SID	RWY	ROUTING	CLIMB IN-STRUCTION
KPT 3N	26R	On runway track to 1900', then via MNE Lctr to DMN 12.5 DME turn LEFT, intercept MAH R-054 inbound to MAH VORDME, intercept MAH R-207 to Mersi Int, intercept KPT R-066 inbound to KPT VORDME. **FMS/RNAV:** DM061 - MAH VORDME - Mersi Int - KPT VORDME.	Climb to FL70.
KPT 5S	26L	On runway track to 1900', then via MSE Lctr to DMS 14 DME, turn LEFT, intercept MAH R-052 inbound to MAH VORDME, intercept MAH R-207 to Mersi Int, intercept KPT R-066 inbound to KPT VORDME. **FMS/RNAV:** DM053 - MAH VORDME - Mersi Int - KPT VORDME.	

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1	Chart identification: this is a Munich SID chart.
2	The various SID of the 26R/L runways: KPT 3N and KPT 5S. The names of the SIDs corresponding to the KEMPTEN (KPT) VOR-DMA, which is the first en-route waypoint.
3	Inset indicating: - the departure ATC frequency: Munich Departure 127.95; - the transition level, computed by the ATC and provided via the ATIS; - the transition altitude: 5,000 ft QNH.
4	The Minimum Sector Altitude (MSA). This minimum altitude ensures a 1,000 ft obstacle clearance within a 25 NM circle centered either over the airport, or a radio navigation aid. Usually, the MSA is divided into different sectors, with a different minimum safety altitude (in ft QNH) for each sector. In our example, the 25 NM circle is centered over the MNW locator, and is divided into two sectors with different MSA: 3,200 ft for the North sector, and 3,700 ft for the South sector. So, we can say that the minimum sector altitude to comply with for the KPT 3N and KPT 5S SID is 3,700 ft.
5	Display of the Munich airport runways, with the airport elevation indicated in ft (1,486 ft).
6	SID name.
7	Turn point, with its name DM053: left turn at 14 NM DME of DMS
8	Distance between two waypoints (21 NM) and the MEA in QNH altitude (5,000 ft).
9	Keep in mind that the SID graphical display is not to scale. For illustration purposes, it can be noted that the distance between the MSE and MAH points is 14 NM and the distance between point MAH and the MERSI intersection point, shown by a shorter segment on the chart, is 21 NM.
10	Leaving point. This is the first waypoint of the en-route phase.
11	Detailed description of the route for each SID.
12	Climb instruction to join the first flight level.

On some charts, the following additional information is provided.

- The minimum required altitudes when crossing some waypoints of the SID.

ALTITUDE
UB 1, if requested FL above **FL245**:
Cross Arkon Int above **FL230**, Gisar Int at or above **FL250**.

UG 9, if requested FL above **FL245**:
Cross RKN VORDME above **FL210**, D7.5 RKN above **FL230**,
Remko Int at or above **FL250**.

- The maximum climb speed to apply.

MAXIMUM CLIMB SPEED
250 KT IAS BELOW FL 100.

4.4 - STAR description

The standard terminal arrival routes (STAR) procedure is a set of routes to be followed by an aircraft from the last waypoint of the en-route phase to join the initial approach fix (IAF), i.e. the approach procedure start point that will be described in the following section.

Like for the SIDs, the STARs are identified by a name, for easy radio communication exchanges with the ATC. Usually the name of the STARs corresponds to the last waypoint of the en-route phase.

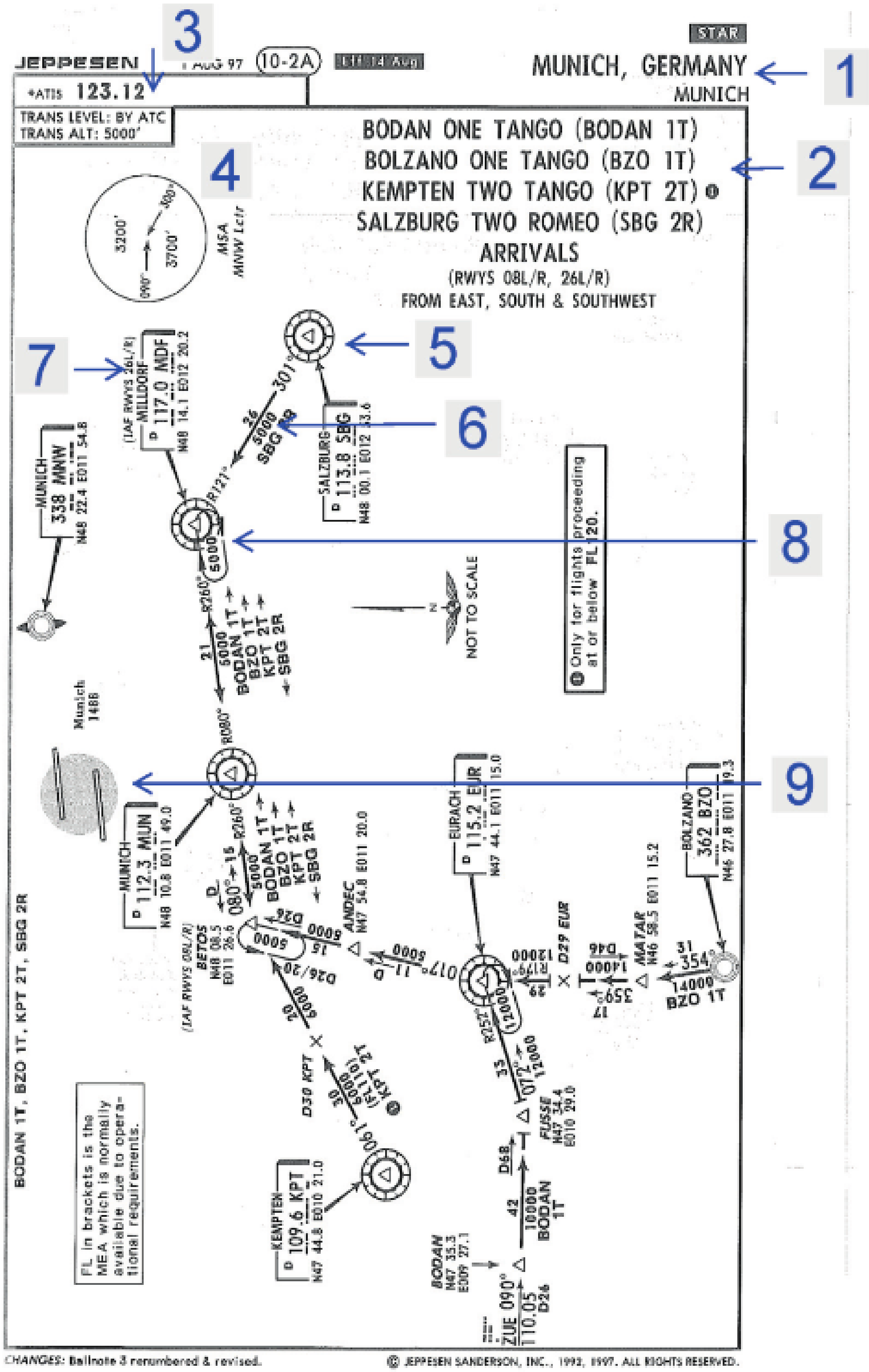
STAR type is identified by the title usually on the top right corner of the chart:
- "STAR" for conventional STAR
- "RNAV STAR" and,
- "RNAV STAR overlay"

Opposite the SID charts, each chart usually includes several STARs. The symbols and displays are the same as those used for the SIDs.

Sample of STAR

We shall study the information displayed on these charts in more detail. As an example, we use the Munich STAR chart 10-2A, a conventional STAR. The other types of STAR charts have the same presentation.

1	Chart identification: this is a Munich STAR chart.
2	The various STARs of runways 26R/L and 08L/R: BODAN 1T, BZO 1T, KPT 2T, SGB 2R. The name of the STARs corresponds to the last waypoints of the en-route phase.
3	Inset indicating: - The ATIS frequency: 123.12 MHz; - the transition level, computed by the ATC and provided via the ATIS; - the transition altitude: 5,000 ft QNH.
4	The Minimum Sector Altitude (MSA). The 25 NM sector protection circle is centered over the MNW locator and includes two sectors: the MSA for the North-East sector is 3,200 ft and 3,700 ft for the South sector.
5	Starting point of the SGB 2R STAR, i.e. the last waypoint of the en-route phase, shown here by the SBG VOR-DME.
6	This segment indicates: - the distance between two waypoints, SBG and MDF: 26 NM; - the MEA: 5,000 ft; - The STAR name (SBG 2R).
7	IAF (Initial Approach Fix) for runways 26L/R. This is the connection point with the instrument approach procedures on runways 26L/R; it is represented by the MDF VOR-DME. For runways 08L/R, the IAF is represented by the BETOS point.
8	Holding pattern. The number 5000 corresponds to the minimum holding altitude (MHA) in ft QNH. The MHA is the altitude for which the holding sector is protected. This is the lowest altitude allowing a safe holding above a radio navigation aid. Usually, this is the altitude for starting the approach procedure.
9	Display of the Munich airport runways, with the airport elevation indicated in feet (1,486 ft).



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On some charts, the following additional information is provided:

- A detailed description of each STAR procedure;
- the speed limitation in the TMA.

05 INSTRUMENT APPROACH CHARTS

The approach procedure is defined as a set of predetermined manoeuvres, exclusively using the instrument references from the initial approach fix to the point from which landing can be performed or, if landing is not achieved, to the point where the obstacle clearance criteria during holding or en-route are again applicable.

In other words, the instrument approach procedure is a set of flight paths based on the radio navigation aids or fixes that allow joining the connection point to the IAF, up to the runway or to the missed approach point (MAPt).

On large airports, several instrument approach procedures are usually available for each of the runways.

At the flight preparation stage, the pilot refers to the TAF (Terminal Aerodrome Forecast) of the destination airport offering the best IFR approach conditions according to the meteorological conditions and NOTAMs (Notice To Airmen), in order to determine the highest performance procedure in terms of landing minimums.

In flight, and before landing, the selection of this procedure is then confirmed or denied via the latest ATIS (Automatic Terminal Information Service) which indicates, among other things, the operating landing runway and type of instrument approach.

5.1 – Different types of instrument approach procedure

From the Annex 6 – Operation of aircraft – Part 1, ICAO makes the different types of instrument approach procedure (IAP) which are based on minimum descent altitude/height (MDA/H) or decision altitude/height (DA/H) which are further divided into subcategories according to the RVR and visibility. With the introduction of PBN (Performance Based Navigation), other approaches are described in Annex 10, PANS-OPS which we detail below.

These different types of approach are depicted as follow:

a) Type A and B approaches
- **Type A** is based on a minimum descent height (MDH) or decision height (DH) at or above 250 ft (75 m)
- **Type B** is based on a decision height (DH) below 250 ft

b) 2D and 3D approaches
- **2D**: it is a **Non-precision approach (NPA)** procedure which is an instrument approach procedure designed for instrument approach operations Type A.
  When pilot fly a 2D approach, he will only receive lateral guidance and not vertical guidance; he must therefore calculate a suitable rate of descent when a Continuous Descent Final Approach (CDFA) is conducted.

- **3D**: it is an approach that provides both lateral and vertical guidance so the pilots can compare their flight path to a Course Deviation Indicator (CDI) and a Glide Path (GP) indicator on board.

c) CAT I, II and III operations

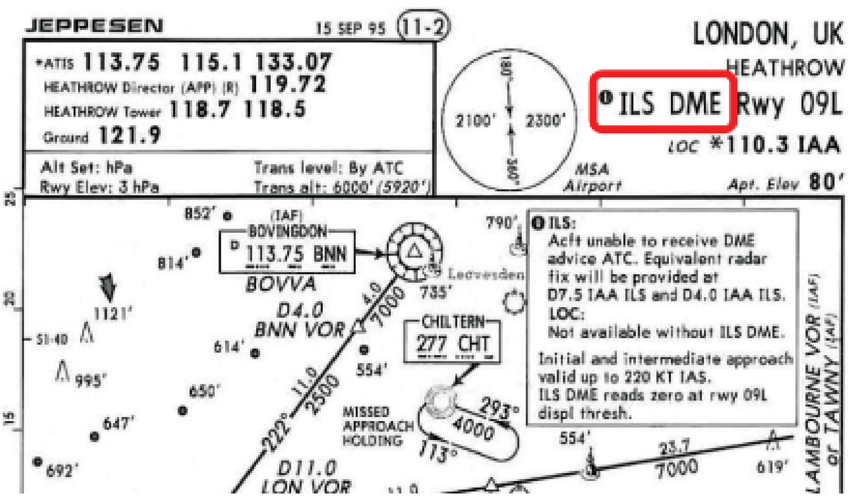
These are type B instrument **precision approach**. They are categorized in CAT I, II and III according to the applicable minima which are DH and RVR or visibility.

- **Category I (CAT I)** operations means a precision instrument approach and landing with a DH not lower than 200 ft (60 m) and with either a visibility of not less than 800 m or a RVR of not less than 550 m.
- **Category II (CAT II)** operations means a precision instrument approach and landing with a DH lower than 200 ft (60 m) but not lower than 100 ft (30 m) and a RVR of not less than 300 m.
- **Category IIIA (CAT IIIA)** operations means a precision instrument approach and landing with a DH lower than 50 ft (15 m) or no DH, and a RVR of not less than 200 m.
- **Category IIIB (CAT IIIB)** operations means a precision instrument approach and landing with a DH lower than 100 ft (30m) or no DH, and a RVR less than 200 m but not less than 50 m.
- **Category IIIC (CAT IIIC)** operations means a precision instrument approach and landing with no DH and no RVR limitations.

d) Different types of precision approach

A precision approach is an instrument approach and landing using precision lateral and vertical guidance with minima as determined by the categories of operations described above.

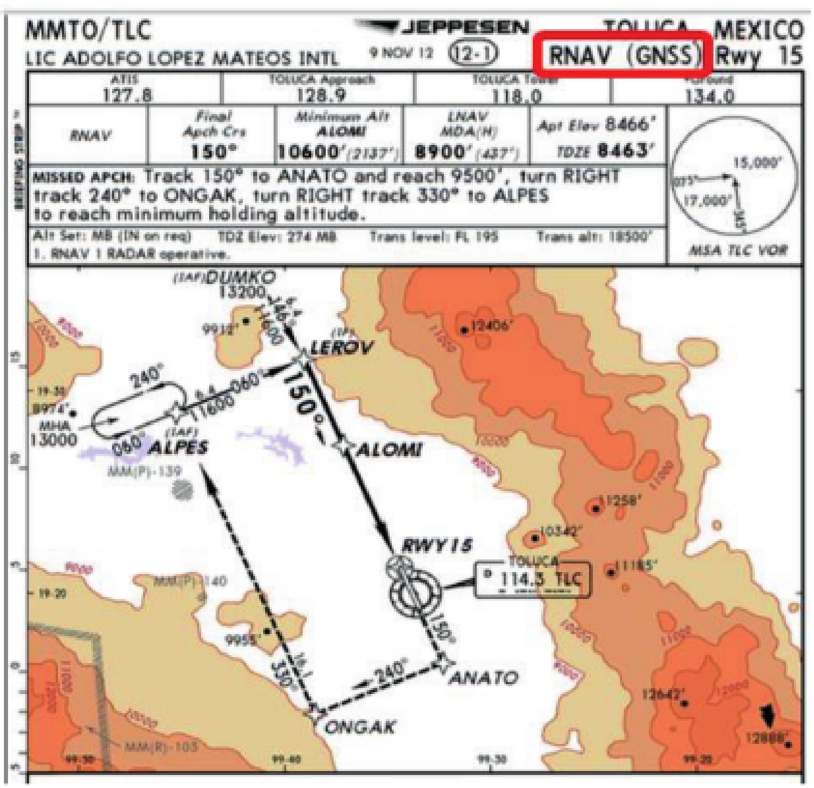
- **Conventional precision approach**: this procedure uses a ground-based navigation aids (ILS or MLS) that provides course and glidepath guidance. The most common system is ILS which is a widely used and is available on all major and many medium sized airports. When flying an ILS approach, the pilots are presented with localizer and glide path indications on the instruments in the cockpit.
  Conventional precision approaches are generally charted under the type of the ground-based aid, usually coupled with DME, on the upper right corner of the chart (for instance: ILS or ILS-DME).



- **RNAV (GNSS) approach**: it is an instrument approach procedure that eliminates the need of using conventional ground-based radio navigation systems.
  GNSS (Global Navigation Satellite System) is based on a constellation of satellites supporting navigational positioning (GPS). Still, GPS alone performance does not meet ICAO requirements for navigation; thus, for instrument approaches, the GPS can be completed with:
  - ✓ a Ground-Based Augmentation Signal – GBAS. This system is used for precision approaches.
  - ✓ a Satellite-Based Augmentation Signal – SBAS. In Europe the SBAS is EGNOS (European Geostationary Navigation Overlay Service); while in North America, WAAS (Wide Area Augmentation System). This system increases precision and integrity of the satellite positioning information and it is used for approaches with vertical guidance (refer to RNP non precision approach below)

GPS + GBAS = GNSS
GPS + SBAS = GNSS

Those approaches are generally charted under the name **RNAV (GNSS)** at the upper right corner of the chart.

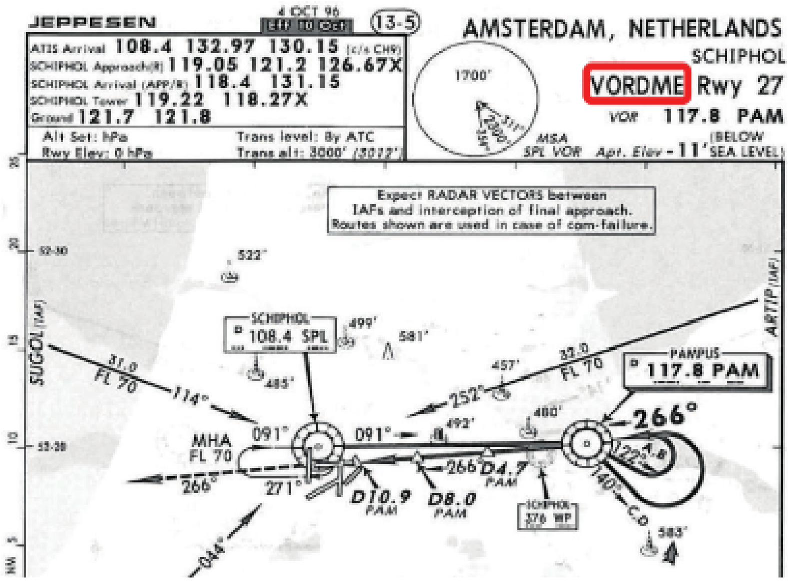


In the **RNAV precision approach**, as specified above, the GNSS augmentation system used is the **GBAS** and it should allow Category I, II, and III precision approaches; similar to Category I, II, and III ILS approaches. It is sometimes referred as GBAS landing system (GLS). It is for this reason that some approach charts have the title "GLS" associated with this type of approach.
Note: the *GBAS Landing System* (GLS) is the airplane-based function that uses the GBAS.

The primary role of GBAS is precision approach and landing guidance (including Autoland) as it provides lateral and vertical guidance.

e) Non-precision approach types

- **Conventional non-precision approach (NPA)**: it is an instrument approach and landing having only lateral guidance. There are different types of conventional non-precision according to the type of radio-navigation aids installed on the ground. Common ground-based navigation aids used for this type of approach are LOC (Localizer), NDB, VOR, VOR-DME.
  The conventional NPA approaches are generally charted under the type of the ground-based aid on the upper right corner of the chart.

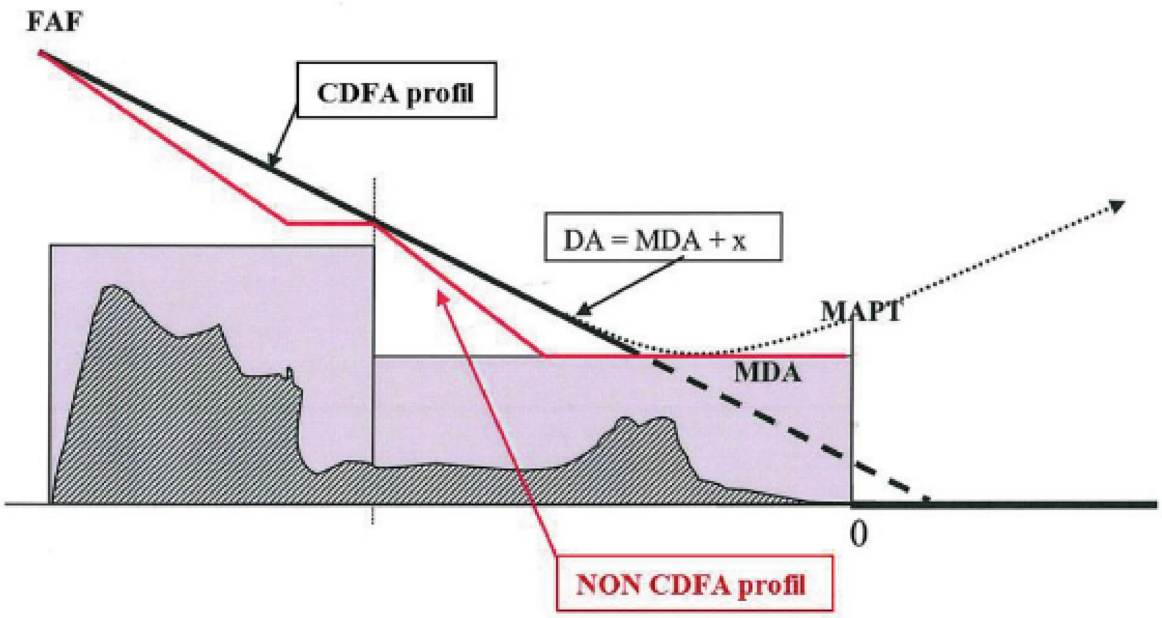


<u>Continuous Descent Final Approach (CDFA) technique</u>

Non-precision approaches imply one or more level-offs during descent from the Final Approach Fix (FAF). In order reduce the crew workload, fuel consumption…more and more airports have implemented CDFA technique during non-precision approaches. This technique is defined as follows:

> "Special technique consisting in flying the final approach segment of a conventional instrument approach in continuous descent, **with no level-off**, from an altitude/height equal to or higher than the altitude/height of the final approach point to a point located approximately 15 m (50 ft) above the landing runway threshold or to the point where the flare manoeuvre should be initiated for the type of aircraft being operated."

See figure below.



- **Required Navigation Performance (RNP) approach**: RNP is a family of navigation specifications under Performance Based Navigation (PBN) which permits aircraft to fly a precise 3D flight paths with a high level of accuracy through the airspace system. Currently, PBN is strongly associated with GPS/GNSS navigation; this means that these procedures do not require ground facilities for navigation as they use the navigation performance of the aircraft. These procedures have a predefined path, which is stored in the aircraft's navigation database, and used by the Flight Management Systems (FMS) to provide lateral and, for some approaches, vertical guidance.
  RNP has another feature: it is a system in place to monitor and alert the crew in case the accuracy deteriorates outside of approved limitations. The RNP value, e.g. RNP 0.3, designates the lateral navigational performance required associated with a navigation precision within 0.3 NM.

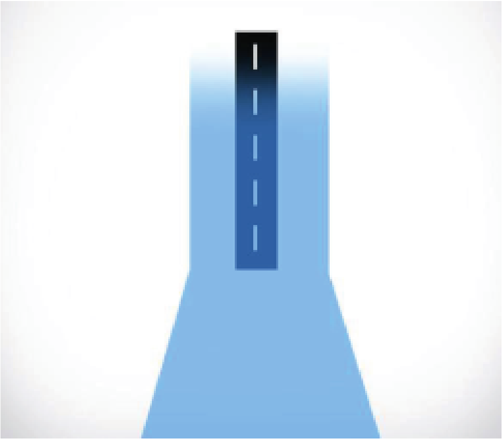
  There are two main set of RNP approaches: RNP approaches and RNP Authorisation Required approaches (RNP AR APCH).

- RNP approaches
  They encompasses all types of point-to-point navigation and acts as an umbrella-term for LPV, LP, LNAV/VNAV and LNAV approaches. These different approach types have different tolerances for precision. Another important point to keep on mind is that for LPV and LNAV/VNAV approaches, although they have vertical guidance, they are NOT precision approaches.

  - **Localizer Performance with Vertical guidance (LVP):** it can only be flown with an approved Satellite-Based augmentation system (SBAS) Avionics receiver. Lateral and vertical guidance use the RNAV/GNSS system and are based on GNSS positioning using the GPS signal and the SBAS.

LPV approaches are operationally equivalent to the legacy instrument landing systems (ILS), but are more economical because no navigation infrastructure is required at the runway. The design of an LPV approach incorporates angular guidance with increasing sensitivity as an aircraft gets closer to the runway.

The decision heights on these approaches are usually 200-250 feet above the runway.



- **Localizer Performance (LP)**: an LP approach has the same accuracy requirements as an LPV approach as it uses SBAS precision of LPV for lateral guidance, but no glide path or vertical guidance is provided. There could be several reasons for using LP approach procedure is published instead of LPV approaches, but one of the more common reasons is that it might not be possible to design an LPV approach for a particular airport due to obstacles on the approach path.

  The MDH for the LP approach is expected to be nominally 300 to 400 feet above the runway.

- **Lateral NAVigation / Vertical NAVigation (LNAV/VNAV)**: this procedure uses lateral guidance by means of the RNAV/GNSS system and is based on GNSS positioning. The vertical guidance is provided by either the barometric altimeter or SBAS. Aircraft that don't use SBAS for the vertical guidance portion must have a Baro-VNAV system, which are typically part of a flight management system (FMS).

  Unlike LPV approaches, LNAV/VNAV approaches don't have increasing angular guidance when approaching the runway.

  The DH on these approaches are usually 350 feet above the runway.

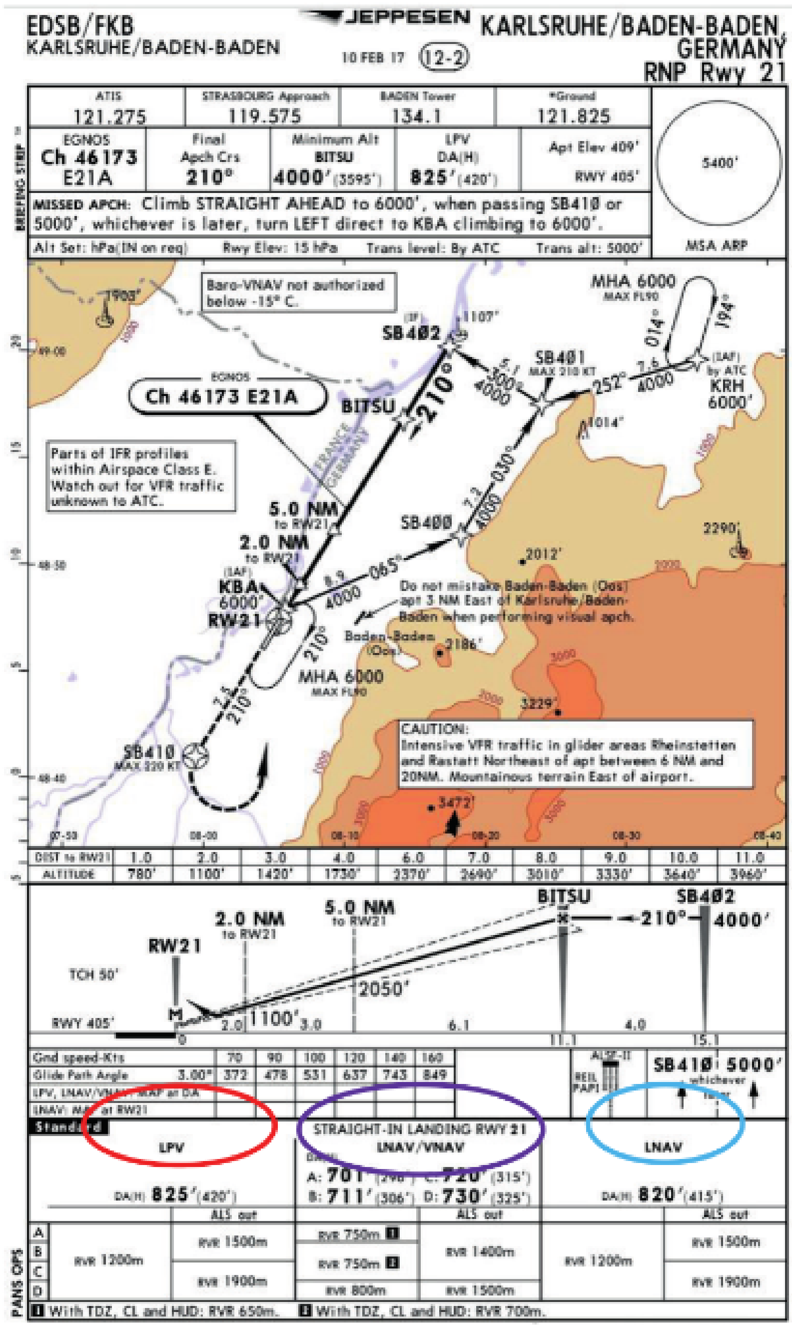
- **Lateral NAVigation (LNAV)**: On an LNAV approach, the pilot flies the final approach lateral course, but does not receive vertical guidance for a controlled descent to the runway. Instead, when the aircraft reaches the final approach fix, the pilot descends to a minimum descent altitude using the barometric altimeter.

  Typically, LNAV procedures achieve a minimum descent height (MDH) of 400 feet above the runway.

To summarize:

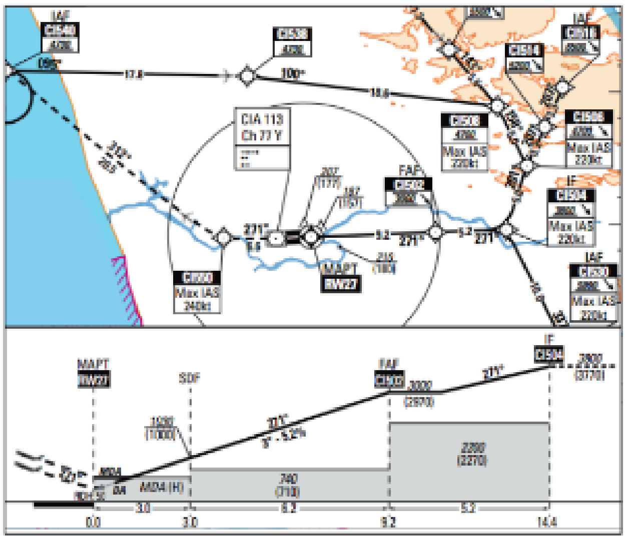
- ✓ LPV approches: vertical guidance with an increasingly sensitive glideslope, SBAS required, minimums = DA/H
- ✓ LP approaches: no vertical guidance, SBAS required, minimums = MDA/H
- ✓ LNAV/VNAV approaches: vertical guidance without increasing angular guidance, SBAS or baro-VNAV required, minimums = DA/H
- ✓ LNAV approaches: no vertical guidance, SBAS not required, minimums = MDA/H

These approaches are generally charted under the name RNAV(GNSS) or RNP and they are differentiated in the minimums line.

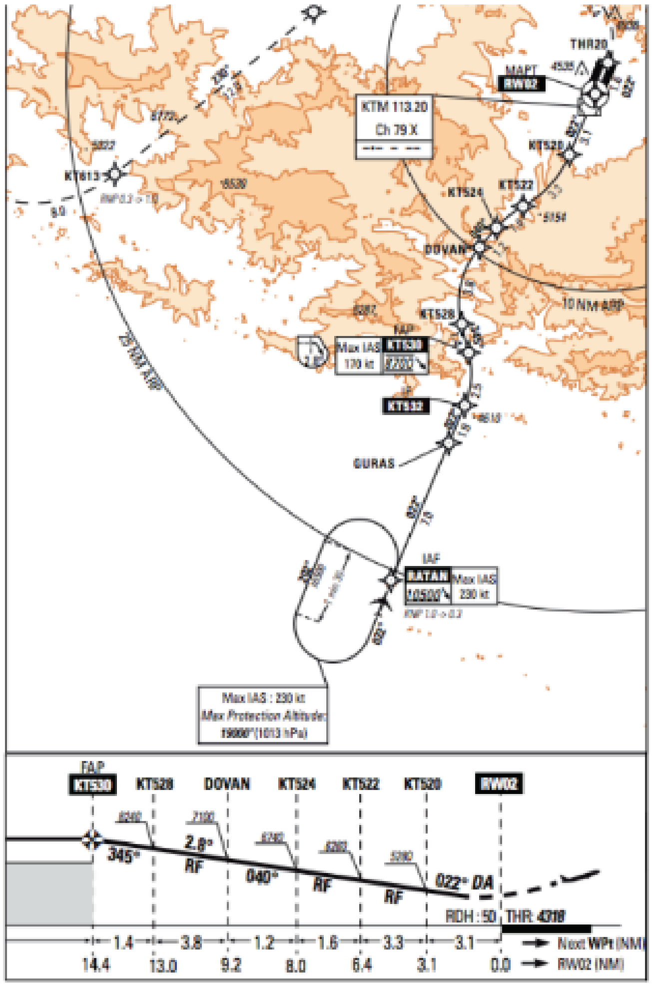


- <u>RNP AR APCH (RNP Authorization Required Approach)</u>

The RNP approaches described above are characterized by straight segments between the FAF and the runway (refer to fig. RNP approach below); while in RNP with Authorization Required the segment between the FAF and the runway is might have been "curved" final segments. These approaches are therefore colloquially called "curved approaches" (refer to fig. ARP AR APCH below). Furthermore, it should be noted that RNP AR APCH approaches allow reduced obstacle clearance compared to RNP approaches.



RNP approach



ARP AR ApCH

f) Approach Procedure with Vertical guidance (APV)

As specified above, approaches with Vertical guidance (APV) are intermediate approaches between precision and non-precision approaches; even though, they are not precision approaches. There are two types of APV approaches which are RNAV GNSS approaches.

- APV Baro approach = LNAV/VNAV approach described above. The vertical guidance is done with VNAV track encoded in the aeroplane's navigation data base and the vertical measurement source is barometric (altimeter).

- APV SBAS approach = LPV approach. Here, the vertical guide is not barometric but geometric.

5.2 - Instrument approach chart description

The instrument approach procedure can be divided into several segments:

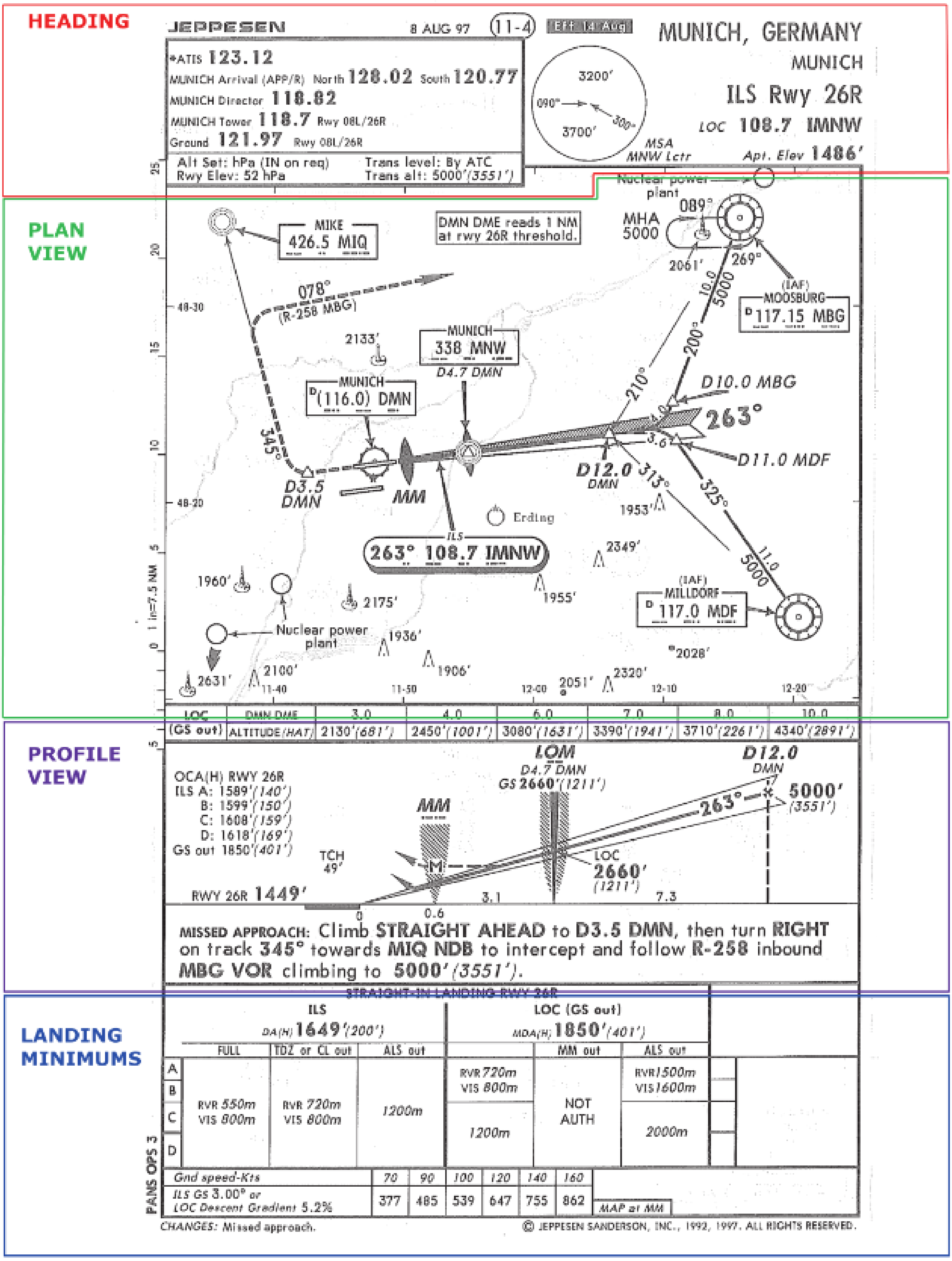
- arrival segment;
- initial approach segment: from the IAF (Initial Approach Fix) to the IF (Intermediate Fix);
- intermediate approach segment: from the IF to the FAF (Final Approach Fix);
- final approach segment: from the FAF to the missed approach point (MAPt);
- go-around segment: from the MAPt.

We shall study the description of the instrument approach procedure using the Munich 11-4 chart.

Opposite the SID and STAR charts, the instrument approach procedure chart is a graphical layout often **to scale**.

The instrument approach procedure chart is published for each runway of the airport, in a standard format organized around four different sections:

- heading;
- planview;
- profile view;
- landing minimums.


HEADING
JEPPESEN
8 AUG 97
11-4
Eff 14 Aug
MUNICH, GERMANY
MUNICH
ILS Rwy 26R
LOC 108.7 IMNW
Apt. Elev 1486'
*ATIS 123.12
MUNICH Arrival (APP/R) North 128.02 South 120.77
MUNICH Director 118.82
MUNICH Tower 118.7 Rwy 08L/26R
Ground 121.97 Rwy 08L/26R
Alt Set: hPa (IN on req)
Rwy Elev: 52 hPa
Trans level: By ATC
Trans alt: 5000'(3551')
3200'
090°
300°
3700'
MSA
MNW Lctr
PLAN VIEW
Nuclear power plant
089°
MHA 5000
2061'
269°
MIKE
426.5 MIQ
DMN DME reads 1 NM at rwy 26R threshold.
078°
(R-258 MBG)
(IAF)
MOOSBURG
117.15 MBG
2133'
MUNICH
338 MNW
D4.7 DMN
MUNICH
(116.0) DMN
D10.0 MBG
263°
210°
200°
10.0
5000
345°
D3.5 DMN
MM
D12.0 DMN
313°
3.6
D11.0 MDF
325°
Erding
1953'
ILS
263° 108.7 IMNW
2349'
1960'
2175'
1955'
(IAF)
MILLDORF
117.0 MDF
11.0
5000
Nuclear power plant
1936'
1906'
2028'
2631'
2100'
2051'
2320'
48-30
48-20
11-40
11-50
12-00
12-10
12-20
1 in=7.5 NM
LOC (GS out)
DMN DME
ALTITUDE (HAT)
3.0 2130'(681')
4.0 2450'(1001')
6.0 3080'(1631')
7.0 3390'(1941')
8.0 3710'(2261')
10.0 4340'(2891')
PROFILE VIEW
OCA(H) RWY 26R
ILS A: 1589'(140')
B: 1599'(150')
C: 1608'(159')
D: 1618'(169')
GS out 1850'(401')
LOM
D4.7 DMN
GS 2660'(1211')
D12.0 DMN
5000'
(3551')
263°
MM
TCH 49'
LOC
2660'
(1211')
RWY 26R 1449'
0
0.6
3.1
7.3
MISSED APPROACH: Climb STRAIGHT AHEAD to D3.5 DMN, then turn RIGHT on track 345° towards MIQ NDB to intercept and follow R-258 inbound MBG VOR climbing to 5000'(3551').
LANDING MINIMUMS
STRAIGHT-IN LANDING RWY 26R
ILS
DA(H) 1649'(200')
LOC (GS out)
MDA(H) 1850'(401')
FULL
TDZ or CL out
ALS out
MM out
ALS out
A
B
C
D
RVR 550m VIS 800m
RVR 720m VIS 800m
1200m
RVR 720m VIS 800m
1200m
NOT AUTH
RVR 1500m VIS 1600m
2000m
Gnd speed-Kts 70 90 100 120 140 160
ILS GS 3.00° or LOC Descent Gradient 5.2% 377 485 539 647 755 862
MAP at MM
PANS OPS 3
CHANGES: Missed approach.
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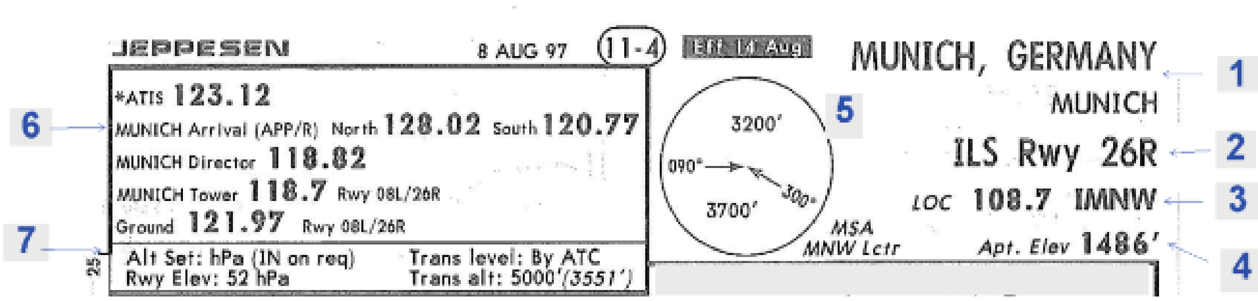
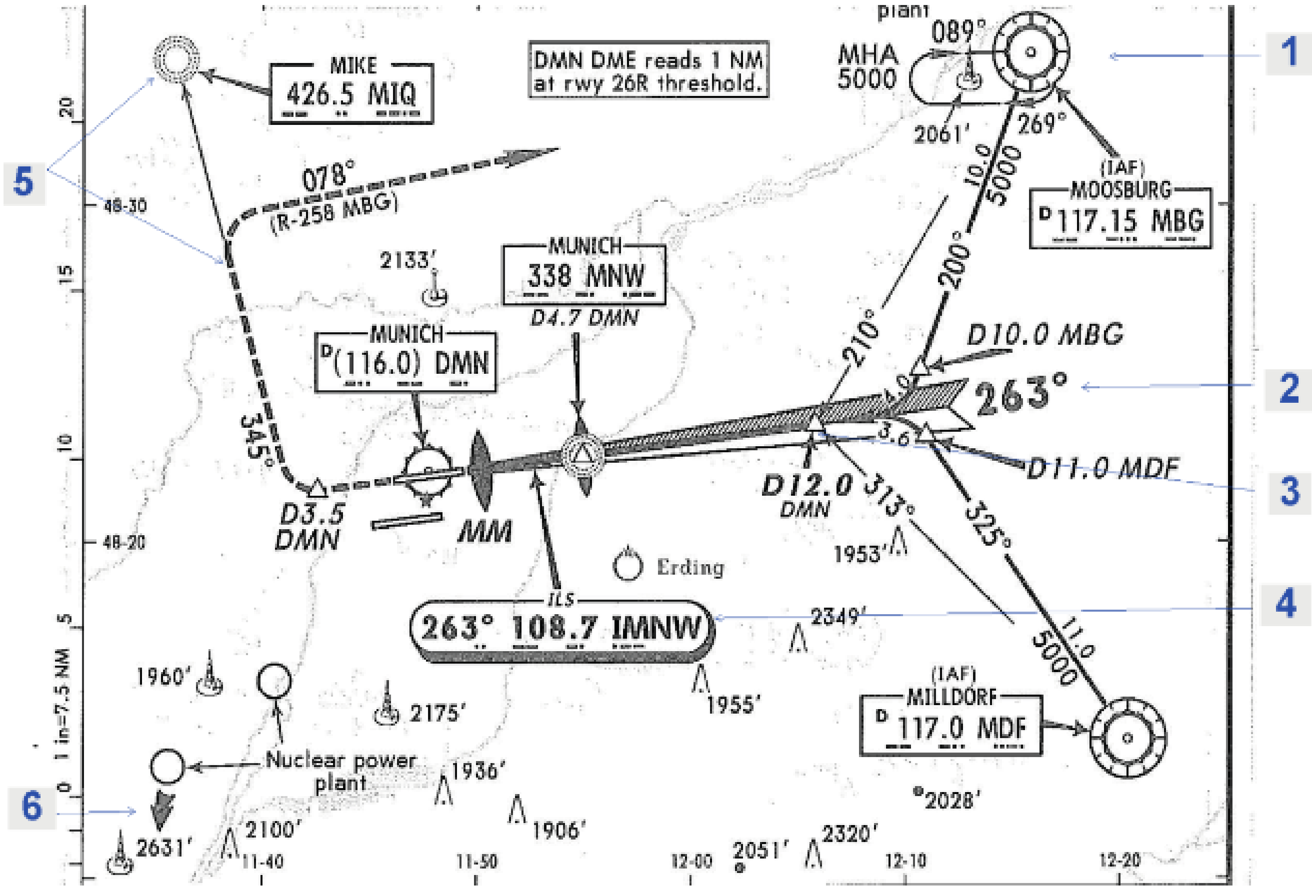
5.2.1 - Heading



1	Town and country, followed by the airport name.
2	Procedure category for runway 26R. The procedure category depends on the radio navigation aids being used to perform the procedure on the runway concerned. The following instrument approach categories can be mentioned: ILS, ILS-DME, NDB-DME, VOR-DME, VOR-ILS-DME…but also RNAV (GNSS) procedures, based on geographic points instead of navigation aids.
3	Radio navigation aid(s) being used for the procedure, with frequency (108.7 MHz) and call sign (IMNW).
4	Airport reference altitude (1,486 ft).
5	The Minimum Sector Altitude (MSA) is shown here. As a reminder, the 25 NM sector protection circle is centered over the MNW locator with two sectors: the MSA for the North-East sector is 3,200 ft and 3,700 ft for the South sector.
6	This inset indicates the communication frequencies with the ATC, in chronological order of their use during approach: ATIS, APP, TWR and GND. Note 1. *The asterisk before a frequency (here, the ATIS case) indicates part time operations (non H24).* Note 2. *"Munich Director" is an approach service and delivers a radar service on the specified frequency.*
7	Details of altitude information, including: - Alt Set (Altimeter Setting): altimeter setting reference in hPa (in inches on request); - Rwy Elev (Runway Elevation): height of the threshold of runway 26R indicated in ΔhPa between QNH and QFE setting (1 hPa ≈ 28 ft); - Trans level (Transition Level): the transition level is provided by the ATS; - Trans alt (Transition Altitude): the transition altitude is 5,000 ft in QNH and, in brackets, 3,551 ft in QFE.

5.2.2 - Planview

The planview depiction is facing the true North. It is depicted in compliance with the scale specified in the bottom left-hand corner of the box (1 in = 7.5 NM).

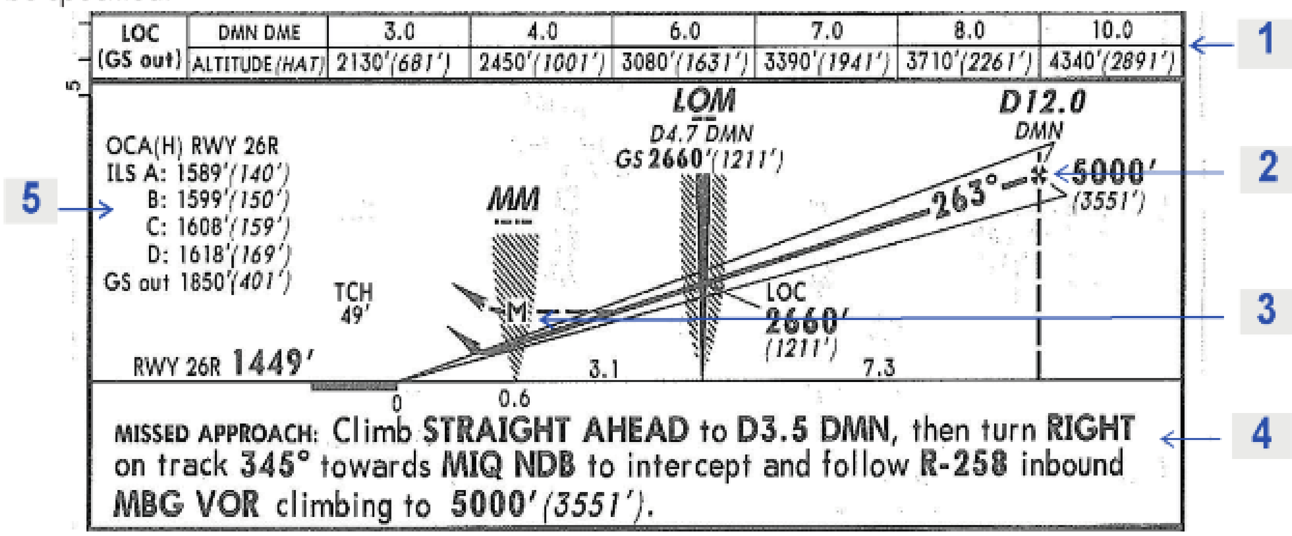


Reading the various symbols is fairly straightforward; the key points of the plan view are described below.

1	One of the two IAF (Initial Approach Fix) in the instrument approach procedure for runway 26R. This point is based on the 117.15 MHz VOR-DME, MBG call sign.
2	The final approach QDM radial of the localizer for runway 26R is 263° magnetic.
3	FAF point (the final approach fix is identified by a cross on the profile view hereinafter). Here, the ILS approach FAF is located 12 NM DME from the DMN VOR-DME. **Note.** *The IF point (intermediate fix) is not systematically specified on the chart.*
4	The ILS frequency is 108.7 MHz, the call sign is IMNW. The Morse code is also indicated in the box.
5	Depiction of the missed approach procedure. This procedure is based on the MIKE NDB-Locator, with a 426.5 kHz frequency and call sign MIQ. The detailed description of the missed approach procedure is indicated in clear in the "Profile view" section hereafter.
6	The highest point of the chart is indicated by the black double arrow.

5.2.3 - Profile view

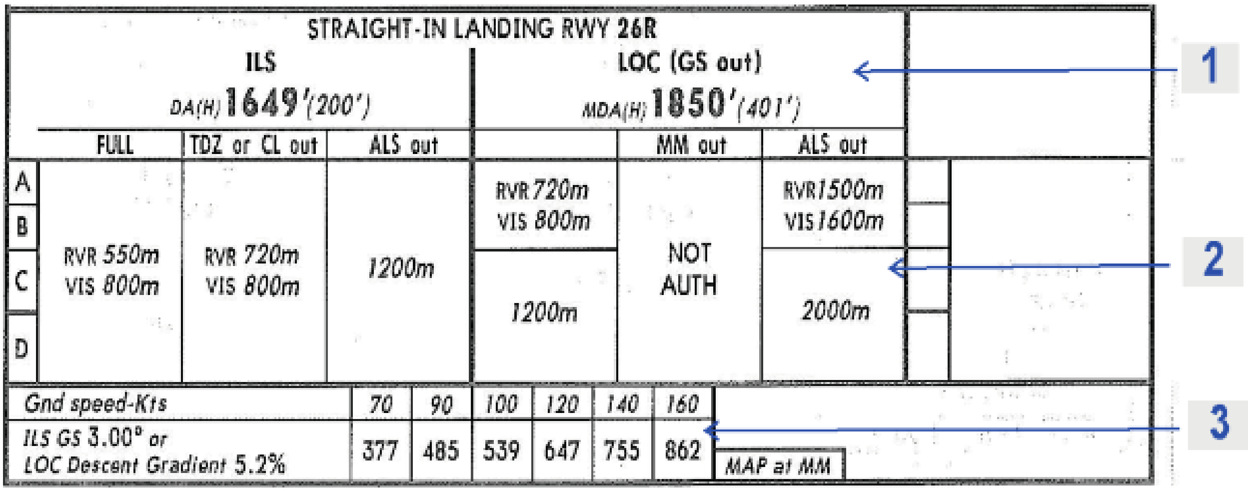
This depiction shows the final approach profile in the vertical plane. The following points need to be specified.



1	When the glide slope is inoperative, this table indicates a recommended altitude to observe in order to comply with the glide path according to the aircraft DME distance with regard to the DMN VOR-DME. Example: 4 NM DME, the altitude must be 2,450 ft QNH (1,001 ft QFE).
2	The cross indicates the FAF for ILS approach, this point is located 12 NM DME from the DMN VOR-DME and the recommended altitude at this point is 5,000 ft QNH (3,551 ft QFE).
3	Point M indicates the missed approach point (MAPt). This is the point where, or before which, the prescribed missed approach procedure must be initiated, in order to ensure the obstacle clearance in missed approach. Here, the MAPt is located 0.6 NM from the runway threshold.
4	The missed approach procedure is indicated in clear text.
5	For precision approach procedure or a conventional approach, the OCA/H (Obstacle Clearance Altitude/Height) is the lowest altitude/height above the runway threshold, at which the missed approach procedure must be initiated in order to ensure the regulatory obstacle clearance. This altitude/height is defined in accordance with the aircraft category (A, B, C and D); the latter depends on the approach speed. In case of glide slope failure, the OCA/H is unique, regardless of the aircraft category.

5.2.4 - Landing minimums

This table indicates the altitude/height values of the decision altitude/height - DA/H (or minimum descent altitude/height - MDA/H) and Runway Visual Range/Visibility (RVR/Visi) being the lowest permissible for a conventional approach with the ILS operative (or with the glide slope inoperative).



1

For an approach, a decision altitude/height (DA/H) is defined when the ILS is operative, or a minimum descent altitude/height (MDA/H) when the glide slope is inoperative.
The MDA/H is the minimum descent altitude/height which should not be exceeded if the visual references are not acquired; in such case a go-around is imperative.
The OCA/H is the basis for computing the DA/H or the MDA/H; therefore, the DA/H or the MDA/H cannot be less than the OCA/H defined above.

2

The RVR (Runway Visual Range) is defined as the maximum distance at which a pilot placed on the runway centre line can see the marks on the runway surface or the runway lights.

The RVR is used to define the minimums for all approaches, either conventional or precision. This value varies depending on the aircraft category and the type of approach.

The **aircraft approach categories** are defined according to VAT (velocity at threshold):

Aircraft approach category	VAT (KIAS)
A	90 kt
B	91 – 120 kt
C	121 - 140 kt
D	141 – 165 kt
E	166 – 210 kt

Note: category E is applicable for military and supersonic aircraft

3

Table indicating the rate of descent (in ft/min) depending on the approach ground speed to comply with the 3° glide slope.
Example: for a 1,000 kt ground speed, the descent rate of descent to be displayed is 539 ft/min.

A new method for determining the operational minimums indicated on the instrument approach charts was introduced in order to comply with the European regulation.
Therefore, since June 30, 2011, the operational minimums are indicated on the instrument approach charts (IAC) published by the air traffic services.

Note 1. The criteria for determining the operational minimums for departures are not concerned by this rule.

CFDA DA/H

From now on, the following two assumptions are used for determining the operational minimums.

- Conventional approaches are performed in accordance with the continuous descent in final approach (CDFA) technique;
- Precision approaches with an RVR less than 750 m are performed with an auto-pilot (AP) or a flight director system (FDS).

The minimums for precision approaches do not change; but, a stated above, new minimums published for conventional approaches imply using the continuous descent in final approach (CDFA) technique.

When the approach is not performed in accordance with the CDFA technique, the regulation specify:

> "All conventional approaches are performed in accordance with the continuous descent final approach (CDFA) technique, except if the Authority approves a different procedure for a specific approach to a specific runway. When computing the minimums accordingly, **the operator ensures that the minimum RVR value is increased by:**
> **200 m for cat. A/B aircraft and,**
> **400 m for cat. C/D aircraft** for approaches that are not performed in accordance with the CDFA technique, it being understood that the resulting RVR/CMV value does not exceed 5,000 m."

OCA/H, MDA/H, DA/H

It was previously explained that the MDA/H is the minimum descent altitude/height which must not be exceeded if the visual references are not acquired.

It is determined from an OCA/H (obstacle clearance altitude/height) which does not incorporate the aircraft altitude loss upon a missed approach.

The CDFA technique requires a missed approach in case the visual fixes are not acquired at the DA/H (decision altitude/height).

The compliance with the obstacle clearances in missed approach then relies on an initiation of the manoeuvre by the pilot early enough to avoid descending below the MDA/H.

Using the MDA/H in DA/H

In order to avoid exceeding the MDA/H, it is recommended to add an additional vertical margin to the MDA/H (descent) for conventional approaches in order to convert it into a DA/H (decision).

This margin depends on the true indicated airspeed of the aircraft, and thus varies according to its category. The following values are proposed (based on a final 3° final glide slope).

Aircraft category	Margin
A	20 ft
B	30 ft
C	40 ft
D	60 ft

5.2.5 - Approach and landing lights system

In order to maintain an appropriate approach plan in the runway centreline, the pilot may be assisted by a light visual system, such as PAPI (Precision Approach Path Indicator) or VASI (Visual Approach Slope Indicator), ALS (Approach Light System), etc.
At the MDA/H or DA/H, if the pilot can see the ground (and thus, the runway) and thinks that he may land, he continues the approach and landing, referring to light visual fixes, such as the threshold lights, the threshold identification lights, the touchdown zone lights or the runway edge lights for example.
Al this information is indicated on the airport charts.
On the Jeppesen charts, they are in the "Additional Runway information" section of the "Airport" chart.

Example: extract of the London "Airport" chart

ADDITIONAL RUNWAY INFORMATION

RWY		USABLE LENGTHS – LANDING BEYOND Threshold	USABLE LENGTHS – LANDING BEYOND Glide Slope	TAKE-OFF	WIDTH
09L	HIRL(25m) CL(15m) HIALS TDZ PAPI-L(3.0°) (1) RVR	11,801' 3597m	10,889' 3319m		(4) 148' 45m
27R	HIRL(25m) CL(15m) HIALS TDZ PAPI-L(3.0°) (2) RVR		11,647' 3550m	(3)	

(1) HST-Block 17 (2) HST-Block 10/36
(3) TAKE-OFF RUN AVAILABLE
From rwy head 12,802' (3902m)
Block 18 11457' (3492m)
(4) Western extension of runway 09L with 26'(8m) wide weight bearing shoulders along each side.

RWY		Threshold	Glide Slope	TAKE-OFF	WIDTH
09R	HIRL(25m) CL(15m) HIALS TDZ PAPI-L(3.0°) RVR	11,000' 3353m	10,030' 3057m	(6)	(7) 148' 45m
27L	HIRL(25m) CL(15m) HIALS TDZ PAPI-L(3.0°) (5) RVR		10,909' 3325m		

(5) HST-Block 81/104 and 81/109
(7) Western extension of runway 09R with 26' (8m) wide weight bearing shoulders along each side.
(6) TAKE-OFF RUN AVAILABLE
RWY 09R:
From rwy head 12,000' (3658m)
Block 79 9577' (2919m)
RWY 27L:
From rwy head 12,000' (3658m)
Block 86 10,558' (3218m)

RWY		Threshold	Glide Slope	TAKE-OFF	WIDTH
23	HIRL(60m) HIALS SFL PAPI-L (3.0°) grooved			3881' 1183m	148' 45m

For instance, for runway 09L, the lights systems installed on this runway include (see the list of abbreviations in the legend of the Jeppesen *Student Pilot Route Manual* or in the Preamble Chapter of this book):

- HIRL (High Intensity Runway Edge Lights);
- CL (standard Centreline Lights);
- HIALS (High Intensity Approach Lights);
- TDZ (Touchdown Zone Lights);
- PAPI (Precision Approach Path Indicator).

5.2.6 - Other information

During the 033's certificate examination, the Jeppesen instrument approach chart can show some supplement following points to consider (refer to figure on next page):

Point A on the illustrative chart: briefing strip
New Jeppesen charts show in the briefing strip all useful information together in the same area for, as its name suggests, crew briefing:

- communication frequencies with the ATC, in chronological order of their use during approach: ATIS, APP, TWR and GND.

- Approach primary navaid and associated frequency used by the approach procedure, final approach course bearing, crossing altitude at FAF, DA/H (this is a non-precision approach using CFDA technique), airport elevation and runway threshold elevation.
- Missed approach procedure in free text
- Altimeter Setting, transition Level, transition Altitude…

Point B: Missed approach icons

Missed approach information in new Jeppesen instrument approach charts is shown in 3 locations on the chart:

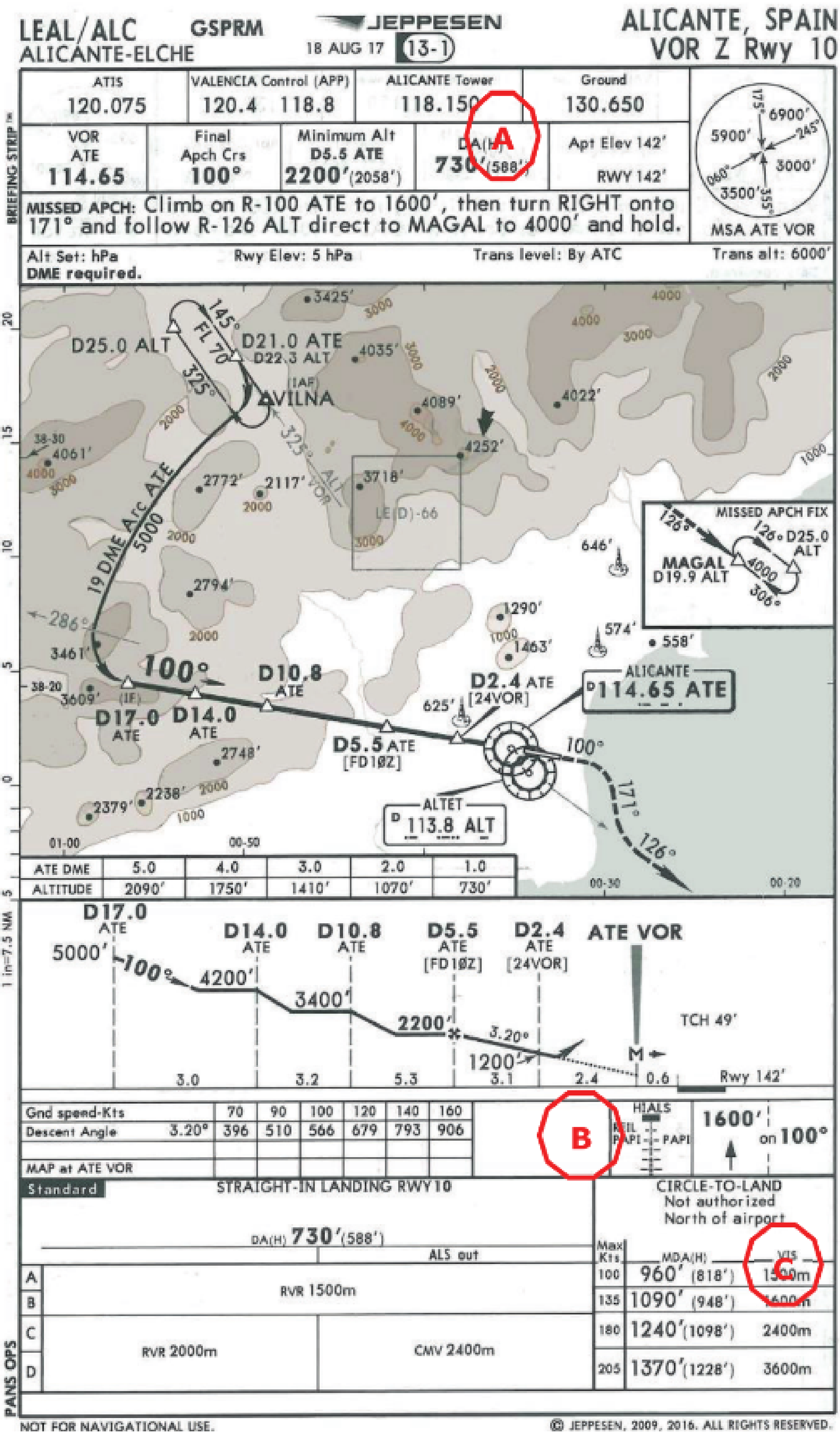
- The Briefing Strip as described above.
- The Planview - The missed approach track is drawn using a thin, hash marked line with a directional arrow.
- The Profile Box - Missed Approach Icons will be depicted in the upper left or upper right of the profile box. These Icons are intended to provide quick, at a glance intuitive guidance to the pilot, to supplement the textual missed approach instructions in the briefing strip. If space available, instructions will be graphically depicted in sequence. If space does not permit the depiction of all missed approach icons, only the main icon boxes will be shown.

  In the sample approach chart below, in order, runway end approach lights depicted for a straight-in-landing runway, missed approach icons which symbolize the initial "up" and "out" actions associated with the missed approach procedure (climb to 1600 ft on 100° course).

Point C: Circling Minimums:

The circle-to-land maneuver is an extension of an instrument approach procedure which provides for visual circling of the aerodrome prior to landing.

In this box, the maximum circling speeds and minimums for each aircraft approach category.


LEAL/ALC
ALICANTE-ELCHE
GSPRM
JEPPESEN
18 AUG 17
13-1
ALICANTE, SPAIN
VOR Z Rwy 10
ATIS 120.075
VALENCIA Control (APP) 120.4 118.8
ALICANTE Tower 118.150
Ground 130.650
VOR ATE 114.65
Final Apch Crs 100°
Minimum Alt D5.5 ATE 2200'(2058')
DA(H) 730'(588')
A
Apt Elev 142'
RWY 142'
6900'
5900'
3000'
3500'
MSA ATE VOR
MISSED APCH: Climb on R-100 ATE to 1600', then turn RIGHT onto 171° and follow R-126 ALT direct to MAGAL to 4000' and hold.
Alt Set: hPa
DME required.
Rwy Elev: 5 hPa
Trans level: By ATC
Trans alt: 6000'
BRIEFING STRIP
D25.0 ALT
D21.0 ATE
D22.3 ALT
(IAF) AVILNA
19 DME Arc ATE
5000
LE(D)-66
MISSED APCH FIX
MAGAL D19.9 ALT
D25.0 ALT
D17.0 ATE
D14.0 ATE
D10.8 ATE
D5.5 ATE [FD10Z]
D2.4 ATE [24VOR]
ALICANTE 114.65 ATE
ALTET 113.8 ALT
ATE DME 5.0 4.0 3.0 2.0 1.0
ALTITUDE 2090' 1750' 1410' 1070' 730'
ATE VOR
5000'
4200'
3400'
2200'
1200'
3.20°
TCH 49'
Rwy 142'
Gnd speed-Kts 70 90 100 120 140 160
Descent Angle 3.20° 396 510 566 679 793 906
MAP at ATE VOR
B
HIALS
1600' on 100°
Standard
STRAIGHT-IN LANDING RWY 10
DA(H) 730'(588')
ALS out
RVR 1500m
RVR 2000m
CMV 2400m
CIRCLE-TO-LAND
Not authorized North of airport
C
Max Kts 100 135 180 205
MDA(H) 960' (818') 1090' (948') 1240'(1098') 1370'(1228')
VIS 2400m 3600m
PANS OPS
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06 COMMUNICATIONS AND RADIO NAVIGATION AIDS

Among the essential elements for IFR navigation, the communication and radio navigation aids should obviously be mentioned.

6.1 - Radiocommunications

An aircraft navigating in IFR must be fitted with the radiocommunication equipment enabling a permanent bidirectional communication with the designated air traffic control services.
The allocated frequencies are in the VHF range: 118 MHz to 135.975 MHz.

The range of these frequencies is an optical range and can be determined by the following formula:

$$d = 1{,}23 \sqrt{h}$$

d: range (in NM) and h: aircraft height (in feet)

6.2 - Obtaining meteorological information in flight

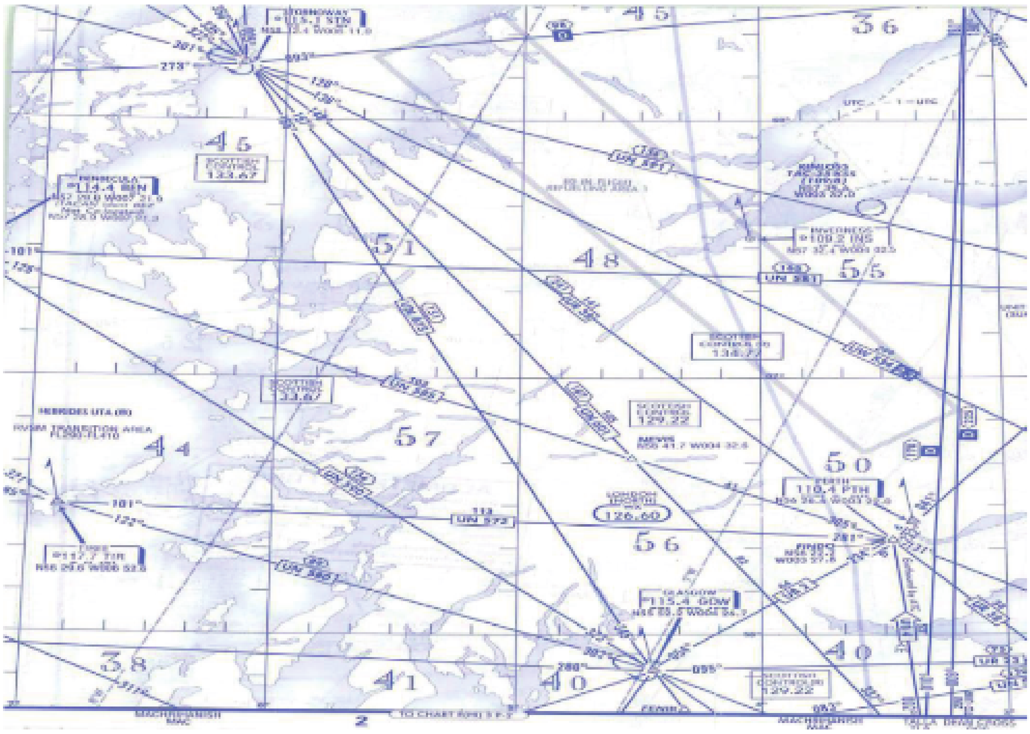
Air traffic services must also ensure the flight information service, especially weather information.

In order to obtain the latest weather information, the radio frequency to be used is specified:

- for the en-route phase, on the IFR en-route charts, as an oval preceded by the "WX" mention;
- for take-off, arrival and approach, on the associated charts (ATIS).

Example 7: extract of the E(HI) 1 chart
Refer to the extract on next page.
An aircraft flies to GOW (55° 52' N – 004° 27' W) on airway UN 615 before arrival in the London FIR. According to the information specified on the chart, what is the most appropriate radio frequency in order to obtain the latest weather information for the London sector?
A) 115.4 B) 129.22
C) 126.60 D) 133.67

Answer
Identify the GLASGOW VOR (GOW) and airway UN 615. You arrive at the GOW VOR on this North-West sector airway.
North of the GOW VOR, the following information is provided in an oval box: "LONDON (NORTH) WX 126.60".
The latest weather information is thus obtained for the London area with an arrival from North on the 126.60 MHz frequency.
Answer C.



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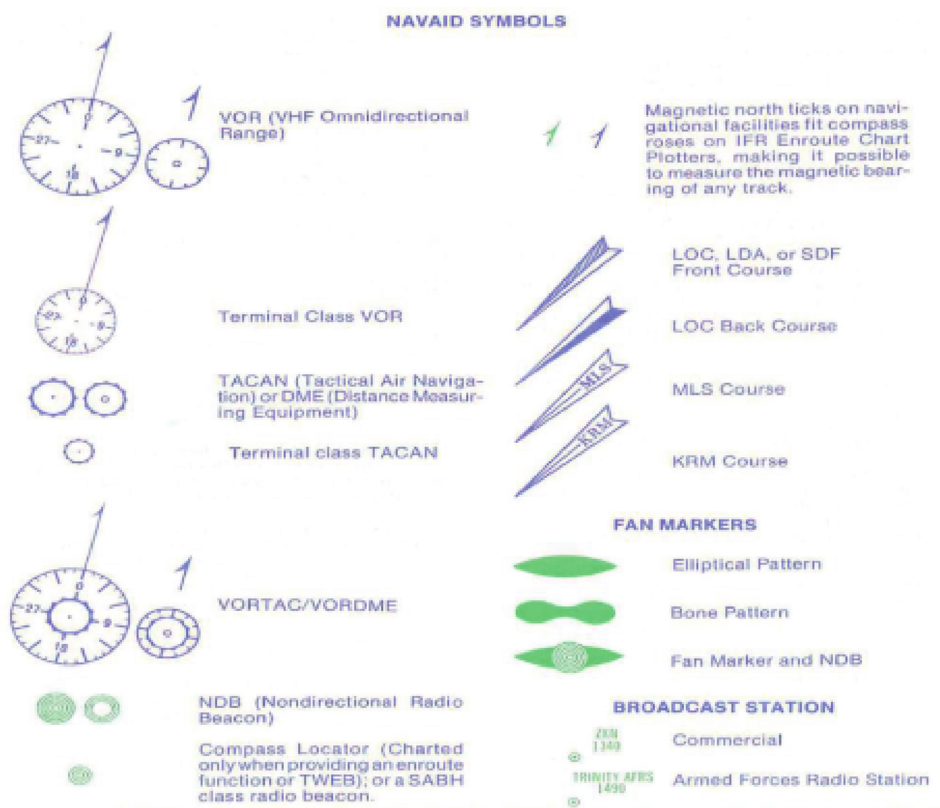
6.3 - Radio navigation aids

The following radio navigation aid symbols are mentioned on the Jeppesen en-route charts, the departure charts (SID), arrival charts (STAR) and approach charts.



6.3.1 - NDB (Non Directional Beacon) or L (Locator)

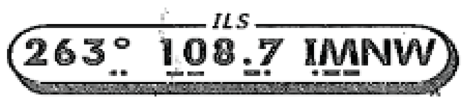
This equipment, usually installed on key points of the control regions or close to some airports on the runway centreline axis for supporting instrument approach procedures, provides a bearing information on board the aircraft.

Information: NDB symbol, station name (MIKE), frequency (426.5 kHz) call sign (MOQ, Morse code.

The NDB operates in the intermediate frequency (IF) range, 200 kHz to 1,750 kHz.

6.3.2 - ILS (Instrument Landing System)

This ground-based transmitter is a landing aid; it transmits two radio beams that materialise the runway centreline and a glide path.



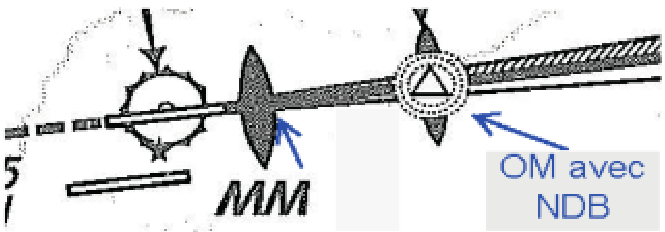
Information: ILS frequency (LOC, 108.7 MHz) call sign (IMNW), QDM radial to be followed (263°, magnetic).

The ILS includes two components:

- The localizer (LOC), providing cross track deviation indications with regard to the runway centreline. In principle, it can be received by any VOR receiver, in the frequency range from 108 to 111.9 MHz.
- The glide slope (GS), providing a glide path indication, usually set to 3°. The GS operates in ultra high frequency (UHF), on a frequency paired with the very high frequency (VHF) of the LOC. You simply need to display the LOC VHF frequency, and the GS is automatically set.

6.3.3 - Markers

Markers are radio beacons transmitting a very narrow vertical beam. When the aircraft crosses this beam during approach, a colour light flashes on the instrument panel and an audio signal is generated.



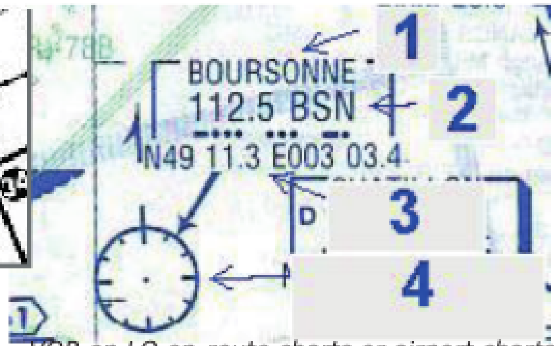
MM (Middle Marker) and OM (Outer Marker) with NDB.

The markers are associated with the ILS and three are provided from the farthest to the closest of the runway: OM (Outer Marker), MM (Middle Marker) and IM (Inner Marker).

6.3.4 - VOR (VHF Omni Range)

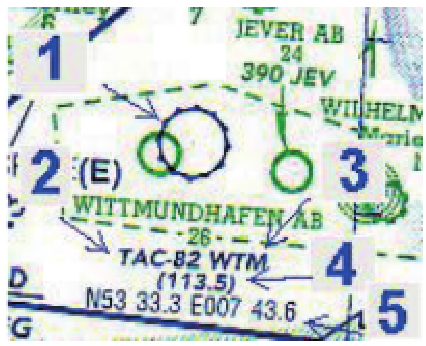
The VOR is a radio location system. This directional equipment delivers radial information (QDR/QDM). This is the most important and most used radio navigation aid. The VOR transmits in the 108 MHz to 118 MHz VHF frequency range. Very often, the VOR is paired with ILS, TACAN or DME (see hereinafter).

VOR depiction
on the HI en-route



VOR on LO en-route charts or airport charts.
1. *Station name*
2. *Frequency/call sign (112.5 MHz/BSN).*
3. *Geographic coordinates of the location.*
4. *VOR symbol.*

6.3.5 - TACAN (Tactical Air Navigation)



1. *TACAN symbol, identical to DME (see hereafter).*
2. *TACAN channel (TAC-82).*
3. *TACAN call sign (WTM).*
4. *Frequency (113.5 MHz).*
5. *Geographic coordinates of the location.*

The TACAN equipment is a full military radio navigation system, in which only the distance measurement part can be used by civilian DME on board equipment.
The VOR and TACAN frequencies are often coupled, to obtain a VOR-TAC, with a radio navigation aid consisting of two VOR and TACAN equipment items providing the following information:

- VOR azimuth;
- TACAN azimuth, not usable by civil aircraft;
- TACAN distance

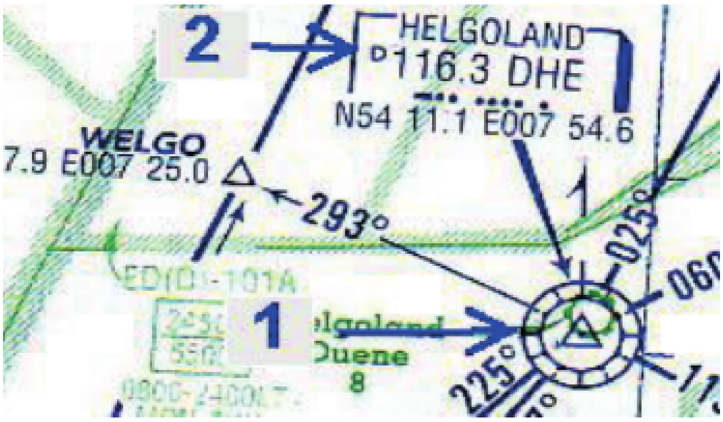
6.3.6 - DME (Distance Measuring Equipment)

On an on board receiver, this equipment delivers an oblique distance in NM between the station and the aircraft.

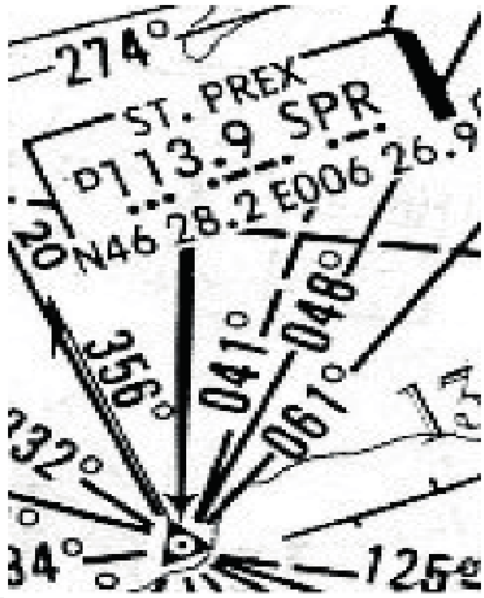
The DME operates in UHF and the frequency range for this equipment varies from 960 MHz to 1,215 MHz.

This equipment is often associated with a VOR providing a VOR-DME station or a TACAN or an ILS. In such cases, the DME frequency is paired with the VOR or TACAN or ILS frequency, so that the pilot simultaneously sets the on board equipment with the VOR, TACAN, or ILS frequency.

On the en-route charts or on the SID, STAR and approach charts, the frequency is labelled "D" and the call sign indicates the colocation.



VOR-DME on LO enroute charts or airport charts.
1. VOR-DME symbol.
*2. Letter **D** indicates the VOR-DME colocation.*



VOR-DME on the HI en-route charts.

07 FILLING THE NAVIGATION LOG

Before drafting the operational flight plan and deriving (among other things) the fuel quantity to be loaded on board, navigation information should be obtained.
The navigation is planned with all the en-route charts and airport charts previously detailed.

First examine the en-route charts and determine the most direct published routes to the destination airport, considering the airspace constraints
The route study should allow deriving:

- the airway magnetic track between waypoints;
- the flight altitudes, applying the semi-circular rule and obstacle clearance (MEA, MOCA, MORA, etc.);
- the distance of the various route segments;
- the frequencies and call signs of the radio navigation and radiocommunication aids.

By studying the SID and STAR airport charts, the various procedures can be identified and the planned route connected to the departure airport leaving routes and to the destination airport arrival procedures. The following points will be studied in particular:

- identifying the initial climb procedure, as well as the minimum climb gradients to comply with;
- studying the existence of noise abatement procedures to comply with;
- complying with the speeds limit imposed by the ATC;
- computing and identifying the top of climb (TOC) points and top of descent (TOD) points on the charts;
- identifying the approach and arrival procedure (STAR).

Most of the above mentioned items were discussed in the various sections of this Chapter. In addition, we focus more specifically on the following points:

- IFR semi-circular rule;
- computing the wind drift angle (WDA) correction and the ground speed;
- example of TOC and TOD calculation.

7.1 - Semi-circular rule

During the cruise phase of an IFR navigation, an aircraft must follow an authorized flight level according to the "semi-circular rule". However, in case of exemption from this rule, instructions are communicated to the flight crews via the publications of aviation information specified on the en-route charts.
The semi-circular rule varies depending on the type of airspace: RVSM airspace (Reduced Vertical Separation Minimum) or non RVSM airspace.

In RVSM airspace, the vertical separation between two aircraft is 1,000 ft up to flight level 410 included. Above flight level 410, the vertical separation is 2,000 ft.

In non RVSM airspace, the reference level is FL 290:
below FL 290, the vertical separation between two aircraft is 1,000 ft;
above FL 290, the vertical separation is 2,000 ft.

It should be noted that the flight level to comply with depends on the magnetic track (not the magnetic heading) followed by the aircraft.

In non RVSM airspace:

- From 000° to 179°: the flight level must be an odd level: FL 10, 30, 50… 290 then, 330, 370, 410, 450, etc.

- From 180° to 359°: the flight level must be an even level: FL 20, 40, 60… 280 then, 310, 350, 390, 430, etc.

TO SUMMARIZE

Below FL290

EVEN	*ODD*
2000 ft	*1000 ft*
4000 ft	*3000 ft*
FL60	*FL50*
FL80	*FL70*
FL100	*FL90*
FL120	*FL110*
FL140	*FL130*
FL160	*FL150*
FL180	*FL170*
FL200	*FL190*
FL220	*FL210*
FL240	*FL230*
FL260	*FL250*
FL280	*FL270*

From FL290 to FL400

NON RVSM	
Equivalent EVEN	*ODD*
	FL290
FL310	
	FL330
FL350	
	FL370
FL390	

RVSM	
EVEN	*ODD*
	FL290
FL300	
	FL310
FL320	
	FL330
FL340	
	FL350
FL360	
	FL370
FL380	
	FL390
FL400	

Above FL410

Equivalent EVEN	*ODD*
	FL410
FL430	
	FL450
FL470	
	FL490
FL510	

7.2 - Computing the wind drift angle (WDA) correction and ground speed

The wind drift angle correction, ground speed, etc. are computed using the navigation computer. The example below explains these calculations.

Note. *We have already seen that the magnetic track is indicated on the IFR en-route charts and airport charts. Thus, to determine the airspeed and the drift, it is first necessary to determine the true track (TR(T) = TR(M) + magnetic variation), as the wind direction in altitude is indicated with regard to the true North.*

Example 10: Paris Charles-de-Gaulle 20-3 SID chart
See the chart on page 88.
An IFR flight is planned between Paris-CDG and London. The SID is ABB 8A.
Magnetic variation: 3° W.

Airspeed: 430 kt.
Wind: 280°/40 kt.
The climb distance is 50 NM. Determine the magnetic track, the ground speed and the WDA correction from the top of climb (TOC) to VOR ABB 116.6.
A) Magnetic track 349°, ground speed 414 kt and WDA correction – 5°.
B) Magnetic track 169°, ground speed 450 kt and WDA correction + 4°.
C) Magnetic track 349°, ground speed 414 kt and WDA correction + 5°.
D) Magnetic track 169°, ground speed 414 kt and WDA correction + 5°.

Answer
The ABB 8A SID indicates the following distances of the various segments, from the runway 27 (DER27) end to the ABB VOR: 2 + 7 + 0,5 + 9 + 56 = 74.5 NM.
As the climb distance is 50 NM, it can be derived that the distance from top of climb (TOC) to the ABB VOR is: 74.5 – 50 = 24.5 NM.
On this 24.5 NM segment, the magnetic track TR(M) is **349°** (value indicated on the segment of the flight path segment to the ABB VOR).
True track TR(T) = TR(M) + magnetic variation = 349 + (–3°) = 346° (the variation is negative because it is West).

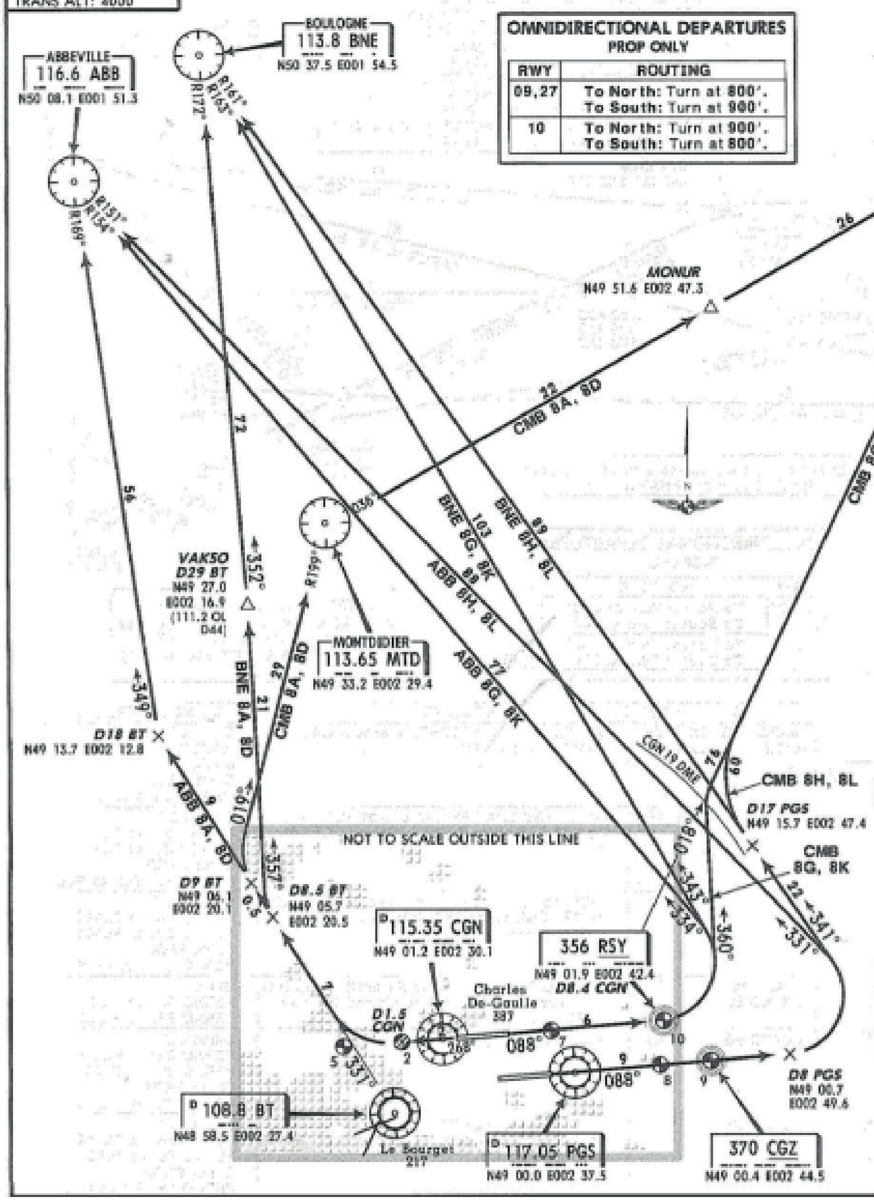
Using the navigation computer:
TR(T) = 346°
Wind = 280°/40 kt → **Ground speed = 414 kt and WDA correction = – 5°**
TAS = 430 kt
Answer **A**.

JEPPESEN 4 OCT 96 EFF 10 Oct (20-3) PARIS, FRANCE
CHARLES-DE-GAULLE

SID

DE GAULLE Departure 124.35 133.37

TRANS LEVEL: BY ATC
TRANS ALT: 4000'



ABBEVILLE, BOULOGNE CAMBRAI DEPARTURES

(RWYS 27, 09, 10)

Noise monitoring point

SPEED CONTROL PROCEDURES
MAX IAS 250 KT below FL100 unless otherwise instructed by ATC

RWY 09/RWY 10 SID DESIGNATION
Letter G (Rwy 09), letter H (Rwy 10) assigned when easterly take-offs/landings (same direction) in use at Orly.
Letter K (Rwy 09), letter L (Rwy 10) assigned when westerly take-offs/landings (reverse direction) in use at Orly.

RWY 27 SID DESIGNATION
Letter A (Rwy 27), assigned when westerly take-offs/landings (same direction) in use at Orly.
Letter D (Rwy 27), assigned when easterly take-offs/landings (reverse direction) in use at Orly.

Gnd speed-Kts	75	100	150	200	250	300
5.5% 334' per nm	418	557	835	1114	1392	1671

Above **FL100** aircraft can accelerate without clearance.
If unable to comply with specified minimum climb gradient, advise ATC upon initial contact with De Gaulle Flight Data, and during climb advise Departure Control without delay.

SID	RWY	INITIAL CLIMB-OUT
ABB 8A, 8D BNE 8A, 8D CMB 8A, 8D	27	MIM CLIMB GRADIENT 5.5% UP TO FL150. Intercept CGN R-268, at D1.5 CGN turn RIGHT.
ABB 8G, 8K BNE 8G, 8K CMB 8G, 8K	09	MIM CLIMB GRADIENT 5.5% UP TO FL150. Intercept CGN R-088, at D8.4 CGN turn LEFT.
ABB 8H, 8L BNE 8H, 8L CMB 8H, 8L	10	MIM CLIMB GRADIENT 5.5% UP TO FL150. Intercept PGS R-088 to D8 PGS, turn LEFT.

Climb to first FL prescribed for each SID.

SID	RWY	ROUTING	CLIMB INSTRUCTION
ABB 8A, 8D (FOR DESTINATION WITHIN LONDON TMA)	27	Intercept BT R-331 to D18 BT, turn RIGHT, intercept ABB R-169 inbound to ABB VOR.	Climb to PROP: FL70 JET: FL100
ABB 8G, 8K (FOR DESTINATION WITHIN LONDON TMA)	09	Intercept ABB R-154 inbound to ABB VOR.	
ABB 8H, 8L (FOR DESTINATION WITHIN LONDON TMA)	10	Intercept ABB R-151 inbound to ABB VOR.	
BNE 8A, 8D	27	Intercept BT R-331 to D8.5 BT, turn RIGHT, 357° track to Vakso Int, turn LEFT, intercept BNE R-172 inbound to BNE VOR.	
BNE 8G, 8K	09	Intercept BNE R-163 inbound to BNE VOR.	
BNE 8H, 8L	10	Intercept BNE R-161 inbound to BNE VOR.	
CMB 8A, 8D	27	Intercept BT R-331 to D9 BT, turn RIGHT, intercept MTD R-199 inbound to MTD VOR, turn RIGHT, intercept MTD R-036 to CMB VORTAC.	
CMB 8G, 8K	09	360° track, at CGN 19 DME turn RIGHT, intercept CMB R-198 inbound to CMB VORTAC.	
CMB 8H, 8L	10	341° track, at D17 PGS turn RIGHT, intercept PGS R-018 to CMB VORTAC.	

7.3 - Determination of the TOC and TOD

7.3.1 - Determination of the TOC

Example 11

See the Paris Charles-de-Gaulle 20-3 SID chart.

An IFR flight is planned from Paris-Charles-de-Gaulle, runway 27, to London. The distance from Paris to the top of climb (TOC), determined using the climb graph, is 50 NM (see Chapter 033 03 "Fuel").

Identify the top of climb (TOC) and determine the distance from the top of climb (TOC) to ABB 116.6.

A) 74.5 NM B) 50 NM

C) 35.5 NM D) 24.5 NM

Answer

The two possible SIDs on departure from the Paris-CDG runway 27 are ABB 8A and ABB 8B; in fact both courses are identical.

The distance from the end of runway 27 to the ABB VOR is the sum of segments: 2 + 7 + 0,5 + 9 + 56 = 74.5 NM. As the distance from the end of runway 27 to the top of climb is 50 NM, the top of climb is located in the segment between point D18 BT and the ABB VOR. The distance from the top of climb to the ABB VOR is: 74.5 – 50 = 24.5 NM.

7.3.2 - Determination of the TOD

Example 12

An IFR flight must cruise at flight level 155 with a 260 kt TAS, the pilot plans a descent at 500 ft/min to reach the MAN VOR at 2,000 ft (1,030 hPa QNH) located 5 NM away from the destination airport. The TAS will remain constant during the descent, the wind is negligible and the temperature is ISA condition.

Determine the TOD position from which the crew must initiate the descent to the destination airport.

A) 121 NM B) 116 NM

C) 126 NM D) 135 NM

Answer

Let's consider 1 hPa ≈ 30 ft, the VOR altitude with regard to 1,013 hPa is:

VOR pressure alt. = VOR altitude at 1,030 + (1,013 – 1,030) x 30

= 2,000 – 510

= 1,490 ft

The difference of altitude between FL 155 and the VOR pressure altitude is: 15,500 – 1,490 = 14,010 ft

The descent time from FL 155 to the VOR is: 14,010 / 500 = 28 min.

The VOR distance from which the pilot initiates the descent is equal to TAS x descent time in hours; i.e. 260 x (28 / 60) = 121 NM.

The TOD distance at which the pilot must initiate his descent to the destination airport is 121 + 5 = 126 NM.

7.4 – Advantages and limitations of using GNSS/FMC equipment

When using GNSS/FMC equipment, advantages are numerous but there also some limitations related to this equipment.

a) Advantages:

- Automatic calculation and display of tracks and leg distances
- Additional route information in the database (minimum altitudes, approach procedures) compared to the charts
- Time and fuel estimated over waypoints
- Ability to adjust speed to arrive over a waypoint as a defined time
- Time and fuel revisions based on predicted and actual wind

- Automatic calculation and display of tracks and leg distances

The GNSS device is a useful tool for providing the distance to travel to waypoint or destination. Indeed, this device is a very precise indicator of Ground Speed (GS). This information may be presented to the pilot to provide the most accurate speed for navigational computation; in particular, the time to a given waypoint or destination.
Although the calculated tracks and distances can be a great help for pilot, they should always be checked with the chart and navigation log for possible mistakes.

- Additional route information in the database (minimum altitudes, approach procedures)

Today's GNSS devices contain extensive databases, which hold a large amount of data and information. In order to be able to use these databases the pilot must ensure that they are up-to-date and contain valid, current information. However, official charts and published information should always be used as a primary source of information.

- Time and fuel estimates over waypoints

Most of the modern GNSS receivers and systems contain a utility for fuel calculation. When using such a feature, always keep in mind that it serves for information purposes only! The device may not connect with the aircraft system (this usually does not apply to built-in systems) and its calculations are based on the inputs inserted into the device, manually, by the pilot. For calculating the trip fuel, current fuel on board and average fuel consumption usually has to be entered. The device then calculates fuel required for the legs of flight plan.

- Ability to adjust speed to arrive over a waypoint as a defined time

One of the various GNSS device's functions is to predict ETAs (Estimated Time of Arrival) at a given waypoint or at destination. Thus, this function can be used as a way of monitoring the flight progress and hence to adjust the speed for arriving at waypoints or destination at a given time.

- Time and fuel revisions based on predicted and actual wind

These revisions can be done by entering predicted and actual ground speed into the device's flight planning utility and fuel planning utility.

b) Limitations of usage GNSS/FMC equipment:

As for any other equipment installed on board, pilot must have a suitable backup plan prepared for the case of loss of GNSS receiver or position degradation when flying dependent on RNAV/RNP. Good practice is to always have conventional navigation aids prepared suitable to the stage of flight; thus, pilot will be always prepared for the loss or degradation of a GNSS position. Tuning in to conventional radio-navigational aids is a sign of good airmanship.

Besides, regarding the combination usage of GNSS/FMC, there are some limitations regarding the equipment:

- Pilot entered errors (flight levels, wind, temperature, fuel)
- The effect of other than predicted wind on fuel and time estimates
- The effect of aircraft non-standard configuration on FMS predictions

✓ Pilot entered errors (flight levels, wind, temperature, fuel)

The data entry errors are always a major safety hazard. All data entries in GNSS devices are designed to have selected data displayed before confirming their entry. The sign of good airmanship is to always verify data prior to entering them and double check them after entering.

✓ The effect of other than predicted wind on fuel and time estimates

The change of wind other than predicted wind has a great effect on fuel consumption and time estimates; thus, fuel reserve must be sufficient to account for a possible change in wind force. Normally, the contingency fuel reserve does take into account the change of meteorological conditions; still, when the unfavorable wind component is high, it is then necessary to monitor carefully the fuel consumption for the rest of the flight.

✓ The effect of aircraft non-standard configuration on FMS predictions

As specified in the previous paragraph, for calculating the trip fuel, the average fuel flow has to be entered into the equipment.

When a non-standard configuration occurs during a flight that have an impact on the aerodynamics of the aeroplane (missing part upon adjacent structure like fairings, panels…), this will result in higher fuel consumption and this overconsumption will not be taken automatically into account by the GNSS/FMC on fuel predictions as the performance data base of the FMS does not host these non-standard configurations. Thus, the pilot needs to correct the fuel flow and input the correct value associated to the non-standard configuration in the equipment.

7.5 - Navigation log

As an example, we consider a route from London Heathrow EGLL (N51 29 W000 28) to Paris CDG LFPG (N49 01 E02 33) with the following navigation information.

Charts

SID: London (chart 10-3J): departure from EGLL using the MID 3G SID to the MID VOR-DME.
En-route charts E(HI) 4 and E(LO) 2:
UA1 track from MID to WOR; BOGNA on E(LO) 2 chart;

ATS track from WOR to HARDY;
UA47 track from HARDY to UIR N50 21.1 E000 38.5;
UA475 track from DPE to SOKMU.
STAR: Paris Charles de Gaulle (chart 20-2A): arrival via STAR DPE 1E, 1W to Paris CDG.

Flight levels

FL 150 from MID to HARDY
FL 270 from HARDY to DPE

Winds

FL 150 300/80
FL 250 300/60

TAS

See the TAS specified in the navigation log.

The aircraft takeoffs from London at 0827 UTC.

Using the above-mentioned elements and chart extracts on the pages below, complete the navigation log provided on the next page and record the pertinent minimum and maximum altitudes specified on the London chart 10-3 and the E(LO) 2 chart.

From	To	Airways SID/STAR	FL	Wind (*magnetic*)	Track (*magnetic*)	Heading (*magnetic*)	TAS (*kt*)	Wind Corr. (*kt*)	GS (*kt*)	Dist (*NM*)	Time (*min*)	Estimated Time Arrival (ETA)
EGLL	D12LON		climb							14	5	08:30
D12LON	MID (TOC)		climb						320			
MID (TOC)			FL 150				340					
	HARDY		FL 150				340					
	UIR *N50 21.1 E000 38.5*		FL 270				380					
			FL 270				380					
	SOKMU		ATC						350			
	MERUE (TOD)		ATC						320			
MERUE (TOD)	LFPG		ATC							40	12	
								Total				

SID

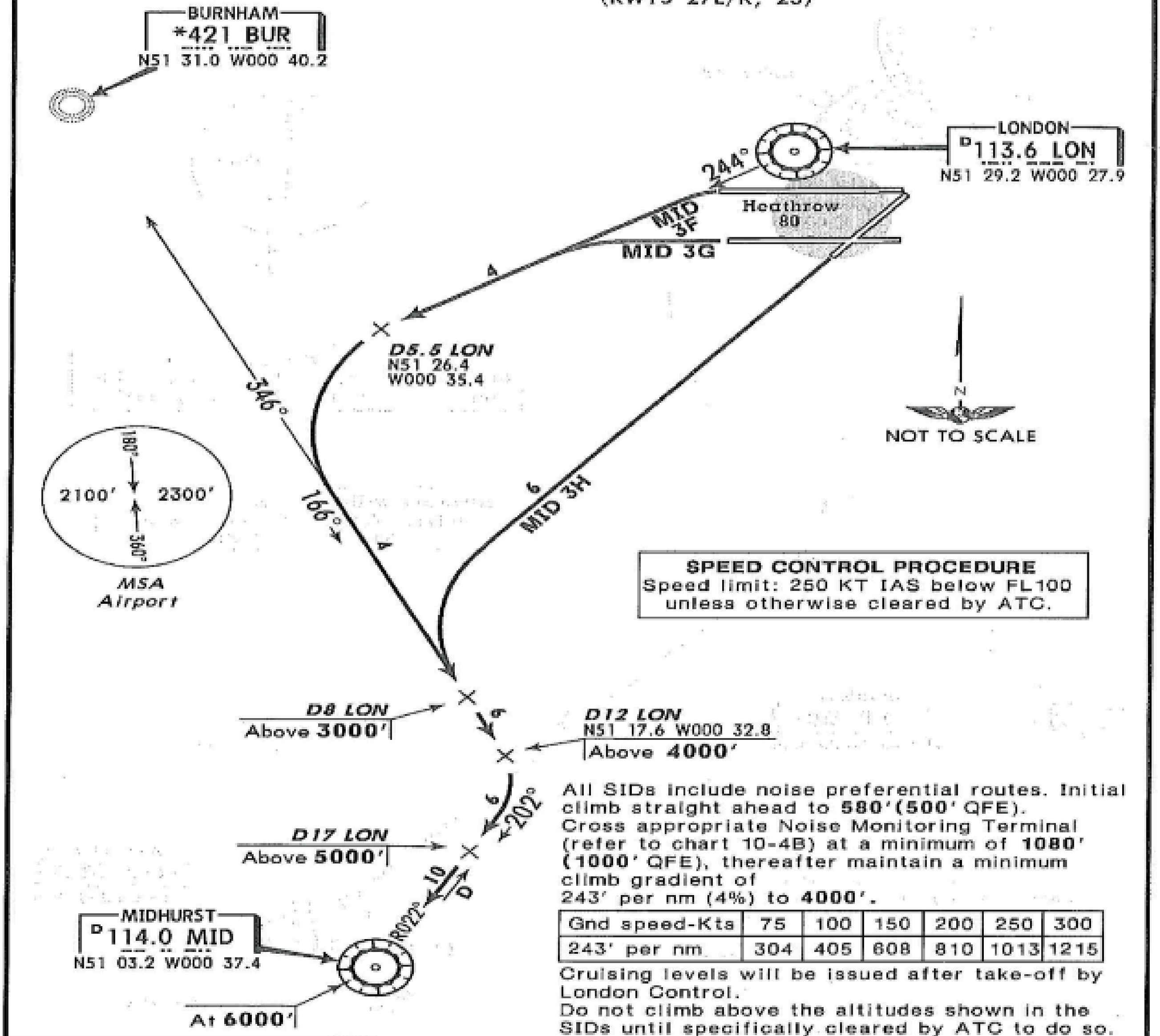
JEPPESEN 13 JUN 97 (10-3J)

LONDON, UK
HEATHROW

LONDON Control 120.47

TRANS LEVEL: BY ATC
TRANS ALT: 6000'

MIDHURST THREE FOXTROT (MID 3F)
MIDHURST THREE GOLF (MID 3G)
MIDHURST THREE HOTEL (MID 3H)
DEPARTURES
(RWYS 27L/R, 23)



SPEED CONTROL PROCEDURE
Speed limit: 250 KT IAS below FL100 unless otherwise cleared by ATC.

All SIDs include noise preferential routes. Initial climb straight ahead to **580'(500' QFE)**. Cross appropriate Noise Monitoring Terminal (refer to chart 10-4B) at a minimum of **1080' (1000' QFE)**, thereafter maintain a minimum climb gradient of 243' per nm (4%) to **4000'**.

Gnd speed-Kts	75	100	150	200	250	300
243' per nm	304	405	608	810	1013	1215

Cruising levels will be issued after take-off by London Control.
Do not climb above the altitudes shown in the SIDs until specifically cleared by ATC to do so.

SID	RWY	TAKE-OFF
MID 3F	27R	Straight ahead, turn LEFT, intercept LON R-244 to D5.5 LON, turn LEFT.
MID 3G	27L	Straight ahead, intercept LON R-244 to D5.5 LON, turn LEFT.
MID 3H	23	Straight ahead.

ROUTING	ALTITUDE
Intercept 166° bearing from BUR NDB to D12 LON, turn RIGHT, intercept MID R-022 inbound to MID VORDME.	Cross D8 LON above **3000'**, D12 LON above **4000'**, D17 LON (D10 MID) above **5000'**, MID VORDME at **6000'**.

E(HI) 4 chart

E(LO) 2 chart

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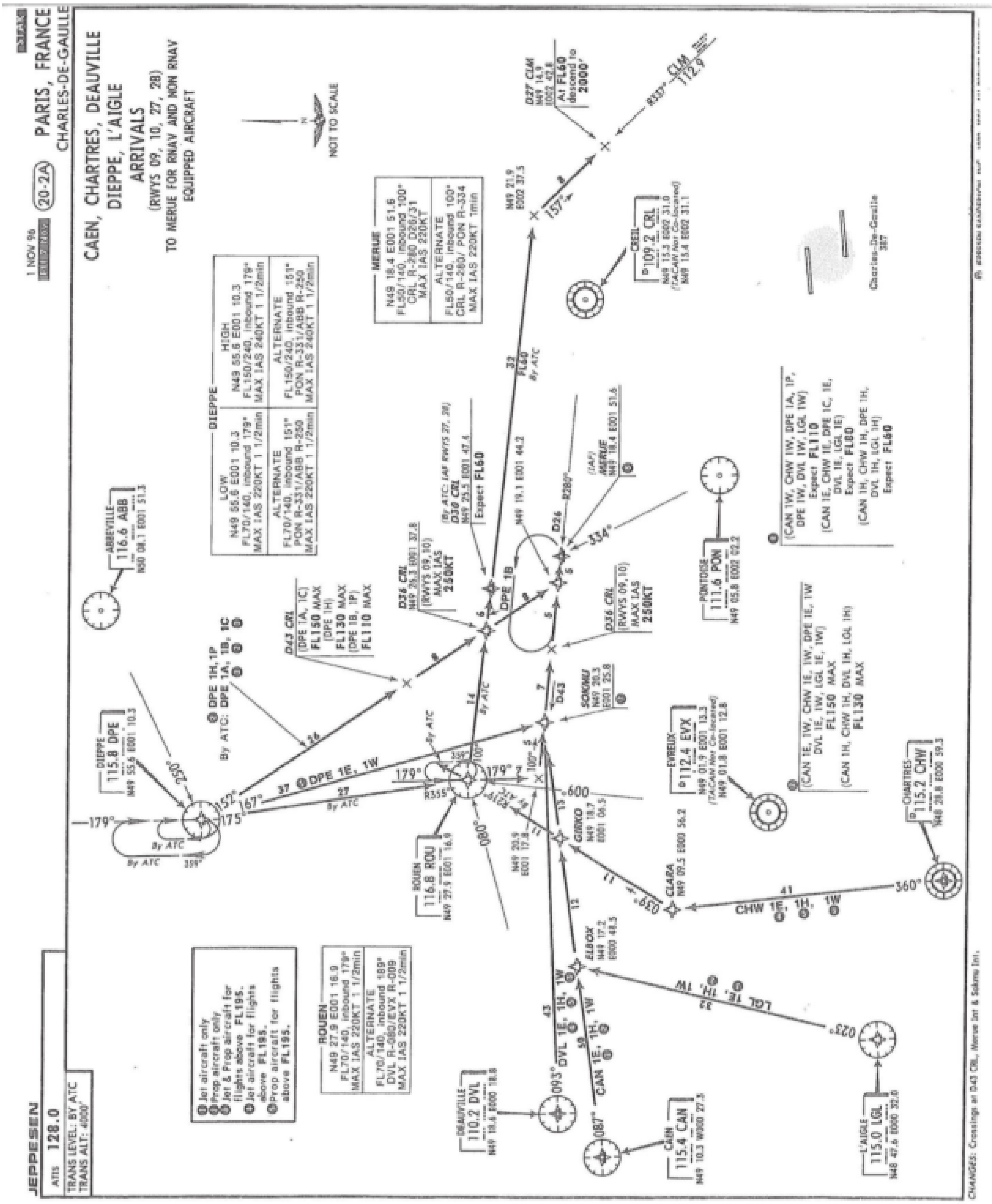
Enlargement of the E(LO) 2 chart extract for reading the MAA, MEA and MORA...


JEPPESEN
1 NOV 96
20-2A
PARIS, FRANCE
CHARLES-DE-GAULLE
CAEN, CHARTRES, DEAUVILLE
DIEPPE, L'AIGLE
ARRIVALS
(RWYS 09, 10, 27, 28)
TO MERUE FOR RNAV AND NON RNAV
EQUIPPED AIRCRAFT
NOT TO SCALE
ATIS 128.0
TRANS LEVEL: BY ATC
TRANS ALT: 4000'

Answer

From	To	Airways SID/STAR	FL	Wind *(magnetic)*	Track *(magnetic)*	Heading *(magnetic)*	TAS *(kt)*	Wind Corr. *(kt)*	GS *(kt)*	Dist *(NM)*	Time *(min)*	Estimated Time Arrival (ETA)
EGLL	D12LON	MID 3G	climb							14	5	08:30
D12LON	MID (TOC)	MID 3G	climb		202°				320	16	3	08:33
MID (TOC)	WOR (BOGNA)	UA1 *	FL 150	300/80	151°	157°	340	+68	408	25	3.5	08:36.5
WOR	HARDY	ATS	FL 150	300/80	121°	121°	340	+80	420	32	4.5	08:41
HARDY	UIR *N50 21.1 E000 38.5*	UA47*	FL 270	300/60	146°	150°	380	+50	430	9	1	08:42
UIR *N50 21.1 E000 38.5*	DPE	UA47	FL 270	300/60	146°	150°	380	+50	430	33	4.5	08:46.5
DPE	SOKMU	UA475	ATC		167°				350	38	6.5	08:53
SOKMU	MERUE (TOD)	STAR DPE 1W	ATC		100°				320	17	3	08:56
MERUE (TOD)	LFPG	1W	ATC							40	12	09:08
								Total		**224**	**43**	

** UA1 = A1 and UA47 = A47 on E(LO) 2 chart*

Determining the minimum altitudes of the route.

London chart 10-3

The MID 3G SID is located in the West sector of the airport. This chart indicates a 2,100 ft MSA.

E(LO) 2 chart

On this chart, we can record the minimum and maximum altitudes (if required) for each sector of the route:

- MID → BOGNA or WOR segment on the E(HI) 4 chart of airway A1:
  MEA = FL70
  MORA = 2,000a
  Grid MORA = 2_2 (2,200 ft), then 2_1 (2,100 ft)
  The flight level scheduled on this segment (FL 150) complies with the specified minimum altitudes.

- BOGNA → HARDY segment via the direct course (ATS)
  MAA = FL 150
  MEA = FL90
  MORA = 1800a
  Grid MORA = 2_1
  The flight level scheduled on this segment (FL 150) complies with the specified maximum and minimum altitudes.

- HARDY → WPT N50 21,1 E000 38,5 segment of airway A47
  MEA = FL70
  MORA = 2000a
  Grid MORA = 2_1
  The flight level scheduled on this segment (FL 270) complies with the specified minimum altitudes.

Note. *For this segment, it is specified that: "Only for arrivals Paris TMA, except Orly, Toussus-le-Noble and Villacoublay airports. FL70 2000a. " Therefore, to fly to the Paris TMA, the specified levels (FL 70 2000a) must be applied; otherwise, for arrivals to Orly, Toussus-le-Noble and Villacoublay, the levels of the previous segment are kept; i.e. FL 80, 2,000a.*

- HARDY → DPE segment of airway A47
  MEA = FL50
  MORA = 2400a
  Grid MORA = 2_1
  The flight level scheduled on this segment (FL 270) complies with the specified minimum altitudes.

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03

FUEL PLANNING

Fuel Planning

In the theoretical exam, the ATPL certificate requires candidates to be able to generate a fuel log during the flight preparation stage using the data published in the "Performance" chapters of the flight manual.

In this chapter, after addressing the general information and the regulatory requirements relating to fuel calculation, we shall proceed with the use of the various tables and graphs published in CAP 697 for the following three generic aircraft:

- the single engine piston aircraft, Beechcraft BE36, called SEP (Single Engine Piston);
- the twin-engined piston aircraft, Piper Seneca PA34, called MEP (Multi Engine Piston);
- the twin-jet engine, B737-400, called MRJT (Medium Range Jet Transport).

We shall also study the Airbus A310 performance data, which is included in the syllabus of the 033 ATPL certificate exam.

In order to set up a fuel log during the flight preparation stage, the pilot must use the performance data in the flight manual to be able to determine the following data:

- distance, time, consumption for climb;
- Top Of Climb (TOC) position;
- fuel flow and cruise true airspeed, in order to derive the distance consumption or the specific range;
- distance, time, consumption for cruise;
- Top Of Descent (TOD) position;
- distance, time, consumption for descent;

01 GENERAL

For correct use of data published in the "Performance" chapters of the flight manual to determine a fuel log during the flight preparation, the pilot must have a firm grasp of the definitions and use of the following parameters: fuel flow, endurance, specific range, distance consumption, air distance vs. ground distance, etc.

We shall go over all these basic notions described in book 031(A)-032 "Aircraft Performance" and unit conversion, included in the current 033 certificate syllabus.

1.1 - Unit conversion

Many tests include unit conversion. It is important to be familiar with the basic conversion factors for units commonly used in aviation.

Mass			Length			Volume		
1 kg	=	2.205 lb	1 m	=	3.28 ft	1 US gal	=	3.785 liters
1 lb	=	0.454 kg	1 ft	=	0.305 m	1 liter	=	0.264 US gal
			1 inch	=	2.54 cm			
			1 nautical mile	=	1,852 m			

Density:

Density is the fluid volume weight to water volume weight ratio. Density is a dimensionless figure and its value is expressed without any unit.

$$d = \frac{\rho \text{ fluid}}{\rho \text{ water}}$$

As the water volume weight is 1 kg/l in the international system, we can say that the density of a fluid is equal to the volume weight of this fluid.

Example, the fuel density is 0.79 ➔ $d_{fuel} = \rho_{fuel}$ = 0.79 kg/l ➔ the mass of one liter of this fuel weights 0.79 kg.

Example

The fuel flow (see definition in the following section) of a turboprop engine is 220 l/hr, with a 0.8 fuel density. If the density is 0.75, what is the new fuel flow?

A) 220 l/hr B) 200 l/hr C) 176 l/hr D) 235 l/hr

Answer

The fuel flow expressed in mass/hour (kg/hr, for instance) remains unchanged. But, if the fuel flow is expressed in volume/hour (l/hr, for instance) varies with the fuel density.
A 200 l/hr fuel flow with a 0.8 density gives the following value:
= 220 x 0.8 = 176 kg/hr
With 176 kg/hr and a 0.75 density, the fuel flow remains unchanged: 176 kg/hr. But, if it is expressed in l/hr, the new fuel flow is:
= 176 x 0.75 = 235 l/hr.
Answer **D**.

1.2 - Fuel flow, endurance, specific range, distance consumption

1.2.1 - Fuel flow and endurance

The fuel flow (FF) is the fuel burn per time unit usually expressed in kg/hour, liter/hour or USG/hour (GPH). In other words, it is the total fuel flow (example: FF = 2,000 kg/hr or 300 l/hr).

This value also depends on the flight regime (speed) and selected flight level. The regime for a minimum fuel flow is the holding regime.

$$FF = \frac{\text{fuel burn}}{\text{flight time}}$$

The endurance is the total time during which an aircraft can fly with an amount of fuel on board.

This value also depends on the fuel flow (speed, flight level, etc.) and the usable fuel on board, according to the following formula.

$$\text{Endurance} = \frac{\text{usable fuel}}{\text{FF}}$$

Example

The flight is planned over a 440 NM distance. The wind data according to the altitude are:
FL 50: – 30 kts;
FL 100: – 50 kts;
FL 180: – 70 kts;
The flight manual provides the following performance data:

Flight level	40	80	120	160	200
TAS (kts)	190	198	204	212	220
Fuel flow (l/hr)	210	202	182	170	156

What is the level allowing the best performance in range?
A) FL 050
B) FL 050 or FL 100, optional
C) FL 180
D) FL 100

Answer
Let's compute the consumption for the three proposed levels.
• FL 50. By interpolation, the result is:
TAS = 192 kt ⇨ ground speed = 192 – 30 = 162 kt ⇨ flight time to cover 440 NM:
440 / 162 = 2.7 hr.
With a 208 l/hr fuel flow and a 2.7 hr flight time, the fuel bum is: 208 x 2.7 = 561 l.
• FL 100. By interpolation, the result is:
TAS = 201 kt ⇨ ground speed = 201 – 50 = 151 kt ⇨ flight time to cover 440 NM:
440 / 151 = 2.9 hr.
With a 192 l/hr fuel flow and a 2.9 hr flight time, the fuel bum is: 192 x 2.9 = 557 l.
• FL 180. By interpolation, the result is:
TAS = 216 kt ⇨ ground speed = 216 – 70 = 146 kt ⇨ flight time to cover 440 NM:
440 / 146 = 3 hr.
With a 163 l/hr fuel flow and a 3 hr flight time, the fuel burn is: 163 x 3 = 489 l.
The flight level to be selected is **FL 180**, as fuel consumption will be the lowest to cover 440 NM.
Answer **C**.

1.2.2 - Specific Range and Fuel Consumption

- The Specific Range (SR) or **Fuel Mileage** (FM) is the ratio:

$$SR = \frac{\text{ground distance}}{\text{fuel burn}}$$

or

$$SR = \frac{\mathbf{GS}}{\mathbf{FF}}$$

FF = total fuel flow and GS = ground speed

The specific range is the ground distance that can be covered per fuel burn off unit. It is usually expressed in NM/kg or NM/t.
Example: SR = 30 NM/t ⇨ with 1 ton of fuel, the aircraft can cover 30 NM.

NB. By "pure" definition, the SR is expressed by the TAS/FF ratio. However, when computing fuel in operation, wind obviously must be taken into account. Thus here TAS (true airspeed) must be replaced with the ground speed.

- The Aircraft's Specific Fuel Consumption (SFC) is the opposite of the specific range. It corresponds to the fuel burn per distance unit, and is usually expressed in kg/NM or t/NM.

$$SFC = \frac{1}{SR} = \frac{\mathbf{FF}}{TAS}$$

1.2.3 - Computing the fuel burn

According to flight parameters (true airspeed, wind, altitude, outside air temperature and flight regime) and performance data published or calculated using the flight manual (FF, SR and FC), we can calculate the fuel burn by applying the following formulas:

- Knowing the fuel flow (FF) and the estimated flight time:
  Fuel burn = FF x estimated flight time.
- Knowing the Specific Range (SR) and the ground distance to be covered:
  Fuel burn = ground distance / SR
- Knowing the Fuel Consumption (FC) and the ground distance to be covered:
  Fuel burn = ground distance / DC

Example
With a 50 NM ground distance to be covered to reach the destination airport, what is the fuel amount required to cover this distance for a piston engine aircraft with a 92 lb/hr average fuel flow and a 230 kt ground speed?
A) 20 lb
B) 35 lb
C) 40 lb
D) 55 lb

Answer
First compute the specific range:
SR = 230 / 92 = 2.5 NM/lb
To cover 50 nm, you must plan:
Fuel burn = ground distance / SR
= 50 / 2.5
= 20 lb of fuel
Answer **A**.

*NB. In addition to the trip fuel required to cover 50 NM, the flight management regulation requires flight crews to take into account final reserve fuel, corresponding to 45 min of flight for a piston engine aircraft. Logically, the fuel load should be equal to 20 + 69 (final reserve fuel = 92 x 45/60), i.e. 89 lb. We shall discuss this subject further and go into the flight management rule in Chapter 033-06.*C – Air distance / Ground distance

1.3 – Air distance / Ground distance

Most graphs published in CAP 697 refer to distances expressed in nautical air miles (NAM). They show measurements of the air distance (D_{AIR}) travelled by an aircraft. That is, the distance covered at true airspeed (TAS).

In windy conditions, ground distance (D_{GROUND}) is referred to; this corresponds to the distance covered by an aircraft at true airspeed. That is the distance covered at ground speed (GS).

- In zero wind conditions, the air distance is equal to the ground distance.
- In headwind conditions, the air distance covered by the aircraft will be longer than the ground distance.
- In tailwind conditions, the air distance covered by the aircraft will be shorter than the ground distance.

The relationship between the air distance (D_{AIR}) and the ground distance (D_{GROUND}) can be expressed by applying the following formula:

$$\frac{D_{GROUND}}{GS} = \frac{D_{AIR}}{TAS}$$

Example
An aircraft covers 50 NAM at a 152 kt TAS. If the effective wind component is 15 kt tailwind, what is the covered ground distance?

Answer
TAS = 152 kt
GS = 152 + 15 = 167 kt
By applying the above formula, we obtain:
$D_{GROUND} = D_{AIR}$ x GS / TAS = 50 x 167 / 152 = **54.9 NM**.

02 FUEL REQUIREMENT FOR COMMERCIAL FLIGHTS

2.1 - Fuel regulation

The regulated fuel required to ensure a safe flight is the sum of the amounts planned to complete the various phases of the flight, taking into account:

- aircraft performance characteristics;
- estimated operational masses;
- weather and environment (restrictions and specific procedures imposed by the air traffic services, extended holding time on arrival, etc.) estimated for the time of flight operation.

2.1.1 - Regulatory fuel requirements

For a standard trip, the regulated fuel is the sum of the following fuel amounts.

Taxi	
Trip fuel	
Reserves fuel	Contingency fuel
	Alternate fuel
	Final reserve fuel
Additional fuel	
Extra fuel	

For easy understanding of the regulation text on fuel policy, it is not necessary to reproduce the whole text, but we shall just explain the main requirements concerning the minimum fuel to be on board to operate a commercial flight.

a) Taxi fuel

Fuel amount required for engine start-up, auxiliary power unit (APU) consumption on ground, and taxiing to brake release point.

b) Trip fuel

Fuel amount required from brake release on the departure airport to touch-down on the destination aerodrome, taking all predictable enroute conditions into account. It is the sum of the following amounts:

- fuel consumption for take-off and climb to the initial cruising altitude or level, taking the planned standard instrument departure (SID) into account;
- fuel from top of climb (TOC) to top of descent (TOD), taking any step climb and descent into account;
- fuel from top of descent to the initial approach fix (IAF), taking the expected arrival procedure into account; and
- fuel required for approach and landing at the destination airport.

c) Reserves fuel

There are three types of reserves fuel: contingency fuel, alternate fuel, final reserve fuel.

Contingency fuel

During the flight preparation stage, it is not possible to estimate all of the factors that may impact fuel consumption to the destination airport. The contingency fuel is loaded onboard to compensate for such elements as:

- aircraft consumption differences compared to the manufacturer data;
- differences with respect to planned weather conditions (wind, temperature…);
- differences with respect to planned routes and altitudes or levels.

The contingency fuel corresponds to the following amounts at brake release:

- 5 % of the planned trip fuel or, in case of inflight replanning, 5 % of the planned consumption for the remainder of the flight; or,
- 3 % of the planned trip fuel or, in case of inflight replanning, 3 % of the planned trip fuel for the remainder of the trip provided an enroute alternate airport is available; or,
- an amount corresponding to 20 minutes of the planned trip consumption for this flight. For this purpose, the operator must define a fuel consumption monitoring programme for individual aircraft and incorporate this data into the computation of the fuel; or,
- a fuel amount based on an authority-approved statistical method ensuring an appropriate statistical coverage of the deviation between the planned and actual trip fuel.

Under no circumstances can the contingency fuel be less than a fuel amount corresponding to a 5-minutes holding at 1,500 ft above the destination airport, in standard conditions.

NB. *In the exam tests, if no information is specified, the contingency fuel is equal to an amount of fuel corresponding to 5 % of the trip fuel, or 5 minute holding at 1,500 ft, whichever is the higher.*

Alternate fuel

Fuel amount required from missed approach on the destination airport from the DH (Decision Height) or MDA (Minimum Descent Altitude) to touch-down at the alternate airport, taking all the enroute predictable conditions into account, i.e.: weather conditions, the missed approach flight path, the air traffic procedures during the cruise phase, the planned arrival procedure and the approach and landing procedure on the alternate aircraft, etc.

Final reserve fuel

Fuel amount computed under the following conditions:

- for piston engines aircraft: it is the fuel amount required to fly for a 45 minutes; or
- for turbine engines aircraft: it is the amount required to fly for 30 minutes at holding speed at 1,500 ft above the alternate airport and calculated with the estimated mass at the alternate airport or to the destination airport, when no destination alternate airport is required.

d) Additional fuel

This fuel amount should allow for:

- a 15-minutes holding 1,500 t above the destination airport, in standard conditions, when the flight is an IFR flight with no alternate airport to destination;
- and following the possible failure of an engine or pressurization system; assuming that the failure occurs at the most critical enroute point for an aircraft to:
  - descend and continue the flight to an appropriate airport;
  - and then, hold during 15 minutes, 1,500 ft above the airport, in standard conditions;
  - and perform approach and landing.

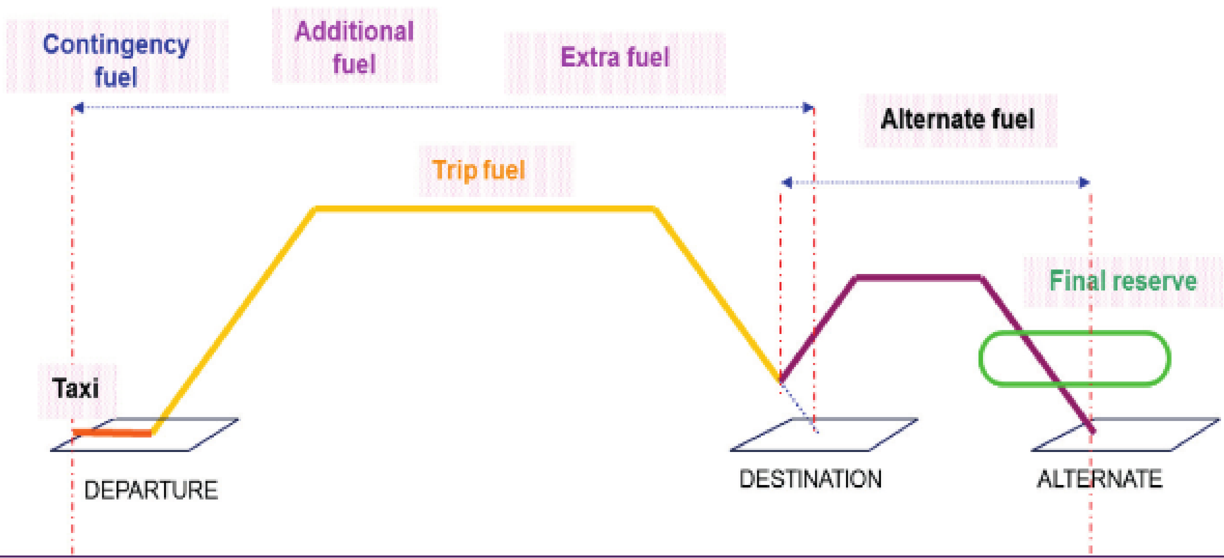
It should be noted that the additional fuel is required only when the above amount (trip + reserves fuel) does not allow for such failure to be addressed.

e) Extra fuel

This is the fuel amount decided by the pilot in command, in addition to the minimum regulatory fuel amount.

2.1.2 - Summary of the fuel regulatory requirements

In order to simplify and summarize the fuel regulatory requirements, the figure below illustrates all the required fuel amounts associated with the various flight phases of a standard trip.



Regulated fuel = Taxi fuel+ Trip fuel + reserves fuel (contingency; alternate; final) + additional fuel (+ extra fuel)

2.1.3 - Examples of fuel computation

a) Example of taxi fuel computing

The taxi fuel is specified in the flight manual as:

- a fixed value (e.g. 10 lb fuel for the SEP for taxi and engine start-up);
- a fuel flow (e.g. 11 kg/min for the B737. This value corresponds to an average taxi value to which you must add the 115 kg/hr value for the APU operation).

b) Example of trip fuel computing

The next sections will detail trip fuel computing, using data published in the flight manual for each one of the four generic aircraft of the syllabus.

c) Example of final reserve fuel computing

Let's take the example of the final reserve fuel computing for the MRJT (Medium Range Jet Transport).
The holding table published for the B737-400 allows the final reserve fuel to be determined depending on the planned landing weight at the alternate airport.

The following two key points should be noted:

- this is the fuel flow data for a racetrack holding; if holding is in a straight line, these values can be reduced by 5 %;
- the fuel flow values indicated in the table are total consumption values, not the fuel flow per engine.

Example

Available data:

- planned landing weight at destination: 48,000 kg;

Press Alt. ft	Weight x 1,000 kg														
	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38
	FUEL FLOW in kg per hour														
37,000					2,740	2,540	2,400	2,260	2,160	2,080	1,980	1,900	1,800	1,740	1,680
35,000		3,020	2,820	2,660	2,520	2,420	2,320	2,220	2,140	2,060	1,960	1,880	1,800	1,720	1,660
30,000	2,840	2,740	2,660	2,560	2,480	2,400	2,300	2,220	2,140	2,060	1,960	1,880	1,800	1,740	1,680
25,000	2,840	2,760	2,660	2,580	2,500	2,420	2,320	2,240	2,160	2,080	2,000	1,920	1,840	1,780	1,720
20,000	2,840	2,760	2,680	2,580	2,500	2,420	2,340	2,260	2,180	2,100	2,020	1,940	1,860	1,800	1,760
15,000	2,880	2,800	2,700	2,620	2,540	2,460	2,380	2,300	2,220	2,140	2,060	1,980	1,920	1,860	1,800
10,000	2,920	2,820	2,740	2,660	2,580	2,500	2,420	2,340	2,260	2,180	2,100	2,020	1,980	1,920	1,880
5,000	2,960	2,860	2,780	2,700	2,620	2,540	2,460	2,380	2,300	2,220	2,140	2,080	2,020	1,960	1,920
1,500	3,000	2,900	2,820	2,740	2,660	2,580	2,520	2,440	2,360	2,280	2,220	2,140	2,080	2,020	1,980

45

2180

Figure 4.4 Holding Fuel Flow – Flaps Retracted

- planned landing weight at alternate: 45,000 kg.

Assuming a 30-minute racetrack holding pattern, what is the final reserve fuel for a twin jet aircraft?

A) 2,180 kg
B) 1,090 kg
C) 2,140 kg
D) 1,070 kg

Answer

The final reserve fuel for a turbine engine aircraft corresponds to the fuel amount required for a 30-minutes holding pattern at 1,500 ft, at the estimated weight at the alternate airport (not the planned weight at destination).

Reading the pressure altitude 1,500 ft, the holding table gives the following fuel flow values:

- weight 44 t ⇨ 2,140 kg/hr;
- weight 46 t ⇨ 2,200 kg/hr.

With a 45 t estimated weight at alternate, the resulting total fuel flow is 2,180 kg/hr.

The final reserve fuel corresponding to the fuel required for a 30-minutes holding pattern is 2,180 / 2 = 1,090 kg.

Answer B.

d) Example of alternate fuel computing (MRJT)

The following graph, provided by the manufacturer, allows the alternate fuel to be determined. It is relatively easy to use and will be detailed in the section related to the MRJT fuel computing in the chapter.

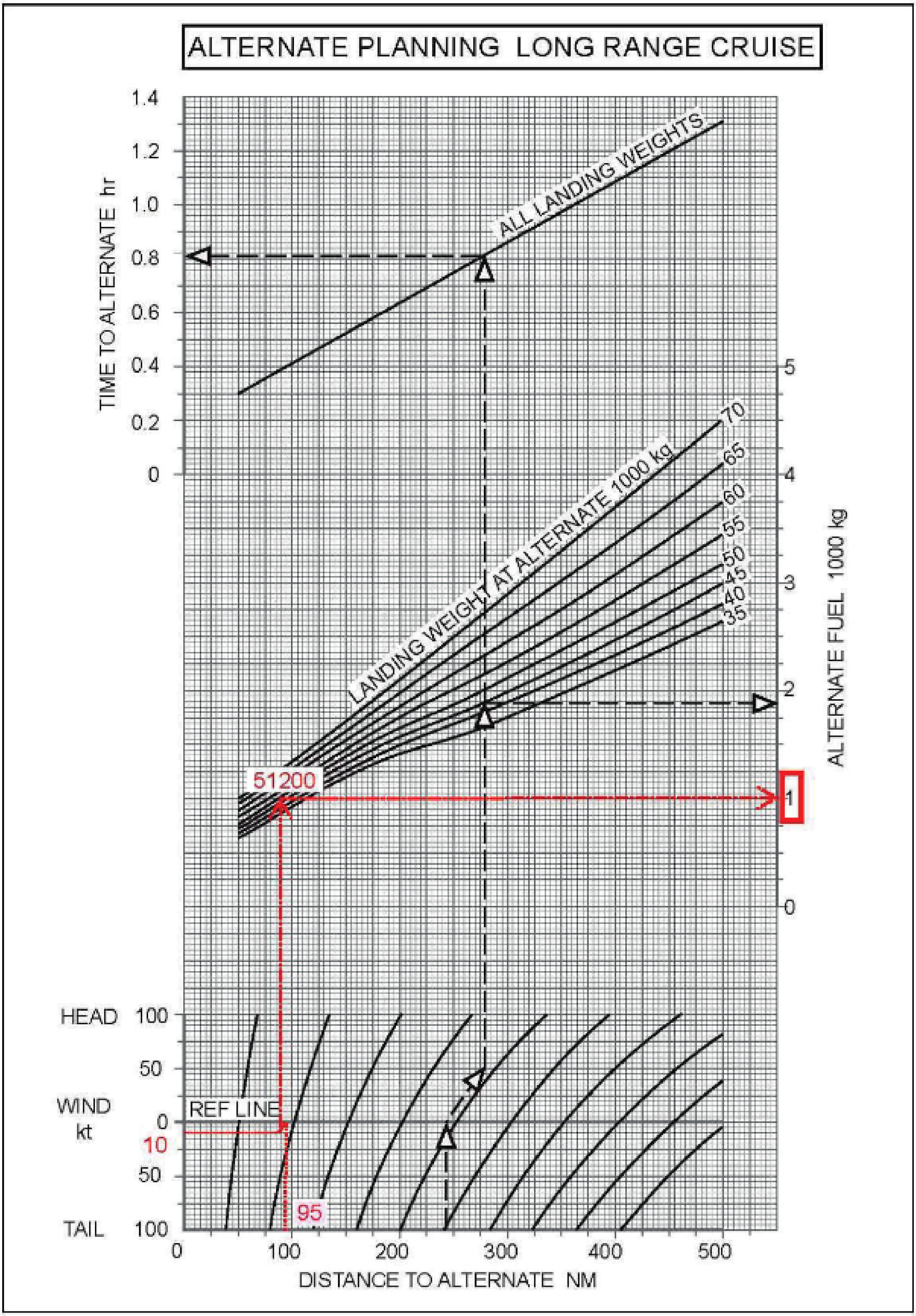


Figure 4.3.6 Simplified Flight Planning – Alternate Distances to 500 NM

Example

See the graph fig. 4.3.6.
Using the following data, determine the alternate fuel:
Dry Operating Mass: 35,500 kg;
traffic load: 14,500 kg;
reserve fuel: 1,200 kg;
alternate distance from the destination airport: 95 NM;
tailwind: 10 kt.
A) 1,000 kg B) 1,300 kg C) 800 kg D) 600 kg

Answer

Before completing the graph to determine the alternate fuel, the planned landing weight should first be computed.
Landing weight = Dry Operating Mass + traffic load + reserve fuel
= 35,000 + 14,500 + 1,200
= 51,200 kg
Using the graph, the alternate fuel is equal to 1,000 kg (see correction on the graph).
Answer **A**.

e) Example of total fuel load computing

The following data are given for a turbine engine aircraft:

- taxi fuel: 600 kg;
- fuel flow at cruising speed: 10,000 kg/hr;
- holding fuel flow: 8,000 kg/hr;
- alternate fuel (with additional fuel): 10,200 kg;
- estimated flight time: 6 hours;
- planned visibility at the destination airport: 2,000 m.

What is the minimum amount of fuel to be loaded at the departure parking?
A) 80,500 kg
B) 79,200 kg
C) 77,800 kg
D) 76,100 kg

Answer

Taxi fuel: 600 kg.
Trip fuel: 10,000 x 6 hr = 60,000 kg
Contingency fuel: highest value between 5 % of trip fuel (60,000 x 5 % = 3,000 kg) and 5-minutes holding at 1,500 ft (8,000 x 5 / 60 = 666 kg). Thus, select 3,000 kg as the contingency fuel.
Alternate fuel (with additional fuel): 10,200 kg.
Final reserve fuel (30 minute holding at 1,500 ft): 8,000 / 2 = 4,000 kg.
Minimum fuel on parking = taxi fuel + trip fuel + contingency fuel
+ alternate fuel (with additional fuel) + final reserve fuel
= 600 + 60,000 + 3,000 + 10,200 + 4,000
= 77,800 kg.

Answer **C**.

2.2 - Computing fuel for SEP (Single Engine Piston)

To illustrate the preparation of a fuel log for SEP 1 (BE36), we shall now study the following graphs and tables published in the flight manual of this aircraft:

- take-off/climb graph (fig 2.1 in CAP 697);
- cruise tables (fig 2.2.1, 2.2.2, 2.2.3 et 2.3.1 in CAP 697);
- range graph (fig 2.4 in CAP 697);
- endurance graph (fig 2.5 in CAP 697).

2.2.1 - Take-off/climb graph

This graph (see next page) allows determination of the time, fuel, and distance covered from brake release to the selected cruising altitude.
The graph usage method is clearly explained by the example provided in the graph. However, the following points should be noted.

- If the elevation of the departure airport is sea level, the results (time, fuel, distance) are read directly on the graph at once.
- If the elevation of the departure airport is not sea level, results are obtained in two steps:
  - determine the distance, time and consumption (DTC) with the departure airport elevation and the outside air temperature noted at this altitude;
  - determine the distance, time and consumption with the selected cruising altitude and the outside air temperature noted at this altitude.

By working out the difference between the results obtained in both steps above, the distance, time and fuel from the departure airport to the selected cruising altitude is obtained.
The distance read on the graph is an air distance. Thus, to obtain the ground distance, proceed as follows:

- divide the air distance by time to determine the true airspeed;
- compute the ground speed from the average wind component during climb;
- apply the D_{AIR} / D_{GROUND} formula to determine the ground distance.

Example

Take-off mass: 3,500 lb; departure airport pressure altitude: 2,500 ft and a + 10°C outside air temperature; first cruise level: FL 140, temperature: – 5°C; average climb wind component: + 25 kt (tailwind).

Determine the time, fuel, air distance and ground distance to climb from brake release point.

A) 22 min; 6.7 gal; 45 NM; 53.4 NM B) 24 min; 7,7 gal; 47 NM; 56 NM

C) 16.5 min; 4.9 gal; 34.5 NM; 48.6 NM D) 23 min; 7.7 gal, 50 NM; 59,1 NM

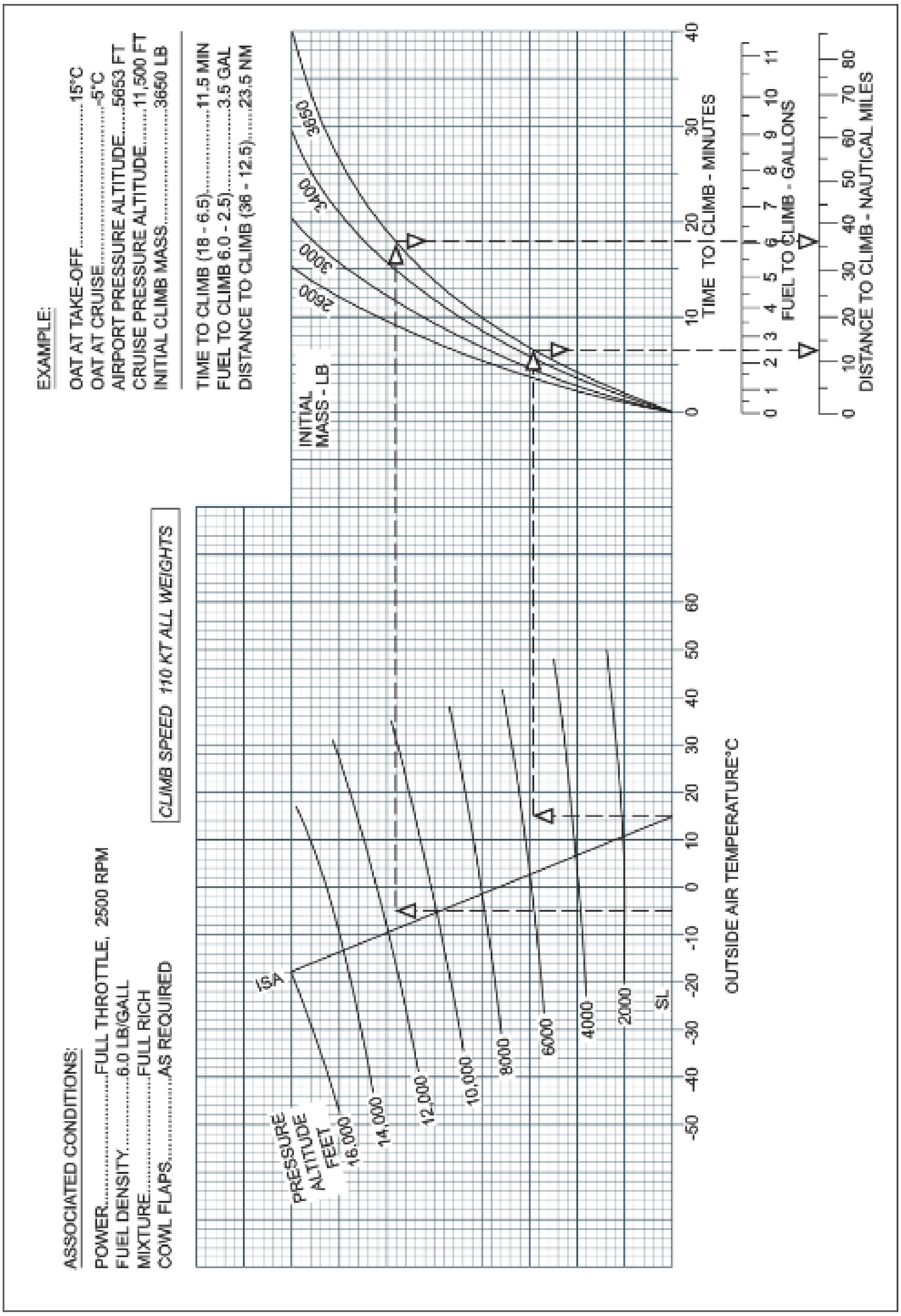


Figure 2.1 Time, Fuel and Distance to Climb

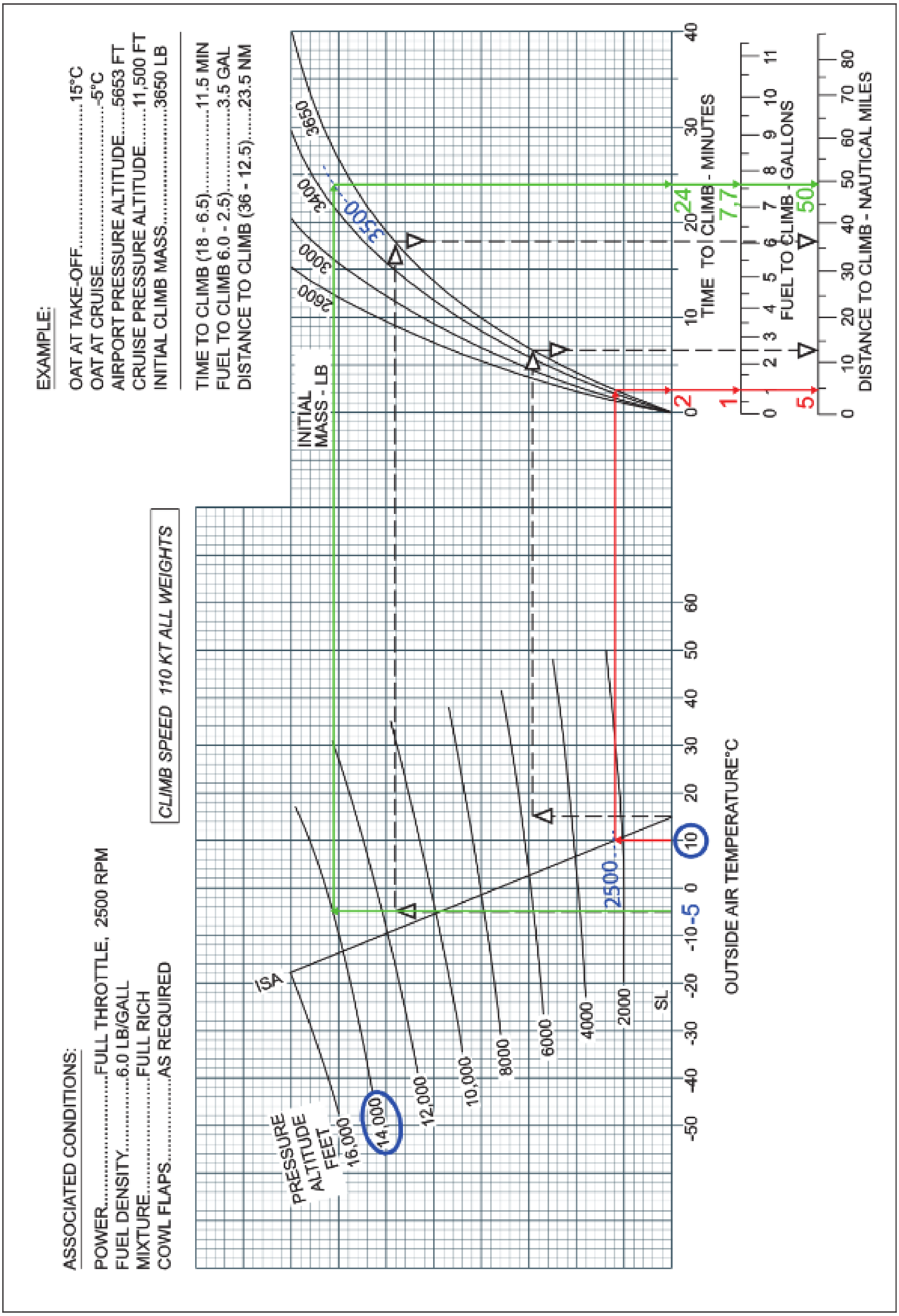


Figure 2.1 Time, Fuel and Distance to Climb

Answer
Refer to the previous document.

a) The time, fuel and air distance are determined in two steps.
• With a departure airport at 2,500 ft and a 10°C outside air temperature, the time, fuel and distance are 2 min, 1 US gal and 5 NM, respectively (see red lines).
• With a cruise altitude at 14,000 ft and a - 5°C outside air temperature, the time, fuel and distance are de 24 min, 7.7 US gal and 50 NM, respectively (see green lines).
The time to climb from the departure airport to FL 140 is: 24 – 2 = **22 min.**
The fuel to climb from the departure airport to FL 140 is: 7.7 – 1 = **6.7 US gal**.
The air distance to climb from the departure airport to FL 140 is: 50 – 5 = **45 NM**.

b) Computing the ground distance
True airspeed (TAS) = air distance / time (in hour) = 45 /(22 / 60) = 122.7 kt
Ground speed (GS) = TAS ± wind = 122.7 + 25 = 145.7 kt.
Ground distance (D_{GROUND}) = D_{AIR} x GS / TAS = 45 x 145.7 / 122.7 = **53.4 NM**.

Answer **A.**

2.2.2 - Cruise tables

The SEP 1 cruise tables published in CAP 697 are in tabular form with different displays (power, lean mixture).

Table 2.2.1: 25 in.Hg (or full throttle) @ 2 500 RPM.
Table 2.2.2: 25 in.Hg (or full throttle) @ 2 100 RPM.
Table 2.2.3: 23 in.Hg (or full throttle) @ 2 300 RPM.
Table 2.3.1: 21 in.Hg (or full throttle) @ 2 100 RPM.

As an example, we only publish tables 2.2.1 and 2.2.2. Other tables are identical.
These tables provide the true airspeed and fuel flow depending on the outside air temperature, pressure altitude and cruise power.
In practice, the power level to be displayed depends on the targeted parameters, i.e. speed, fuel economy, range and endurance.

For a pertinent comparison of the different display options, it is useful to compute the specific range (SR) which represents the distance covered per fuel consumption unit.

Example
Use tables 2.2.1 and 2.2.2 below, and compare the results in terms of fuel flow in lb/hour, true airspeed in kts and specific range in NM/lb.

Available data:
- lean mixture:
- FL 100,
- outside air temperature: + 5°C.

Table 2.2.1 25.0 in. Hg (or full throttle) @ 2,500 rpm

Off-peak EGT Cruise lean mixture @ cruise weight 3,400 lb

ISA Dev.	Press. Alt.	IOAT		Man. Press.	Fuel Flow		Airspeed	
°C	Feet	°C	°F	In. Hg	PPH	GPH	KIAS	KTAS
-20	0	-3	27	25.0	86.3	14.4	168	159
	2,000	-6	20	25.0	89.3	14.9	168	164
	4,000	-10	13	25.0	92.3	15.4	168	169
	6,000	-14	6	24.1	89.8	15.0	164	170
	8,000	-18	-1	22.3	82.6	13.8	157	168
	10,000	-22	-8	20.6	76.0	12.7	150	165
	12,000	-26	-15	19.1	70.2	11.7	143	162
	14,000	-30	-23	17.7	65.5	10.9	135	158
	16,000	-35	-30	16.3	60.8	10.1	126	152
0	0	17	63	25.0	82.9	13.8	163	160
	2,000	14	56	25.0	85.6	14.3	163	165
	4,000	10	50	25.0	88.5	14.8	163	170
	6,000	6	42	24.1	86.1	14.4	159	171
	8,000	2	35	22.3	79.3	13.2	152	169
	10,000	-2	28	20.6	73.3	12.2	145	166
	12,000	-6	21	19.1	67.8	11.3	137	162
	14,000	-10	13	17.7	63.5	10.6	129	157
	16,000	-15	6	16.3	59.1	9.9	120	150
+20	0	37	99	25.0	79.5	13.3	158	161
	2,000	34	92	25.0	82.1	13.7	158	166
	4,000	30	86	25.0	84.7	14.1	158	171
	6,000	26	79	24.1	82.5	13.8	154	172
	8,000	22	71	22.3	76.2	12.7	147	169
	10,000	18	64	20.6	70.5	11.8	140	165
	12,000	14	57	19.1	65.5	10.9	132	161
	14,000	10	49	17.7	61.5	10.3	123	155
	16,000	5	42	16.3	57.5	9.6	113	146

Figure 2.2 Recommended Cruise Power Settings

NOTE 1: Full-throttle manifold pressure settings are approximate.

NOTE 2: Shaded areas represent operation with full throttle.

NOTE 3: Fuel flows are to be used for flight planning. Lean using the EGT.

Table 2.2.2 25.0 in. Hg (or full throttle) @ 2,100 rpm

Off-peak EGT Cruise lean mixture @ cruise weight 3,400 lb

ISA Dev.	Press. Alt.	IOAT		Man. Press.	Fuel Flow		Airspeed	
°C	Feet	°C	°F	In. Hg	PPH	GPH	KIAS	KTAS
-20	0	-3	26	25.0	63.8	10.6	148	140
	2,000	-7	19	25.0	66.4	11.1	149	145
	4,000	-11	12	25.0	68.9	11.5	149	150
	6,000	-15	5	24.3	68.3	11.4	147	152
	8,000	-19	-2	22.5	63.9	10.7	139	148
	10,000	-23	-9	20.8	60.1	10.0	132	144
	12,000	-27	-17	19.3	56.7	9.5	123	139
	14,000	-31	-24	17.9	54.5	9.1	113	132
	16,000	-35	-32	16.5	52.2	8.7	95	114
0	0	17	62	25.0	61.9	10.3	143	140
	2,000	13	55	25.0	64.2	10.7	143	145
	4,000	9	48	25.0	66.6	11.1	144	150
	6,000	5	41	24.3	66.1	11.0	141	152
	8,000	1	34	22.5	61.9	10.3	134	148
	10,000	-3	27	20.8	58.5	9.8	126	143
	12,000	-7	19	19.3	55.6	9.3	116	136
	14,000	-11	12	17.9	53.5	8.9	103	125
	16,000	-	-	-	-	-	-	-
+20	0	37	98	25.0	60.1	10.0	138	140
	2,000	33	91	25.0	62.1	10.4	138	145
	4,000	29	84	25.0	64.4	10.7	139	150
	6,000	25	77	24.3	63.9	10.7	136	151
	8,000	21	70	22.5	60.2	10.0	128	147
	10,000	17	63	20.8	56.8	9.5	119	141
	12,000	13	55	19.3	54.5	9.1	108	131
	14,000	-	-	-	-	-	-	-
	16,000	-	-	-	-	-	-	-

Figure 2.2 Recommended Cruise Power Settings (continued)

NOTE 1: Full-throttle manifold pressure settings are approximate.

NOTE 2: Shaded areas represent operation with full throttle.

NOTE 3: Fuel flows are to be used for flight planning. Lean using the EGT.

Answer

- Computing the ΔISA:

ISA at FL 100 = 15 – 2 x 10 = – 5°C.
ΔISA = OAT – ISA = 5 – (– 5) = 10°C.

- Computing the TAS, fuel flow (FF) and specific range (SR).

To compute the fuel flow and true airspeed at flight level 100 and ISA + 10, perform an interpolation between ISA and ISA + 20 to obtain:

Table	RPM	FF (lb/h)	TAS (kt)	SR (NM/lb)
2.2.1	2,500	71.9	166	2.3
2.2.2	2,100	57.65	142	2.46

This comparison shows that the 2,100 RPM cruise offers better fuel economy with a higher SR. However, the true airspeed is noticeably lower, thus extending the flight time.

2.2.3 - Range graph

The range graph (see next page) allows determination of the distance covered during the climb and cruise phases.

The distance (or range) computed with the graph also includes the fuel for:

- taxi;
- engines run up;
- 45-minutes reserve fuel.

The range varies according to the power setting. For each power setting, range decreases with altitude, then increases at the altitude for which full throttle is reached.

The graph also allows determines true airspeed, depending on the altitude and power setting.

Example

See the graph on next page.

What is the maximum possible distance with a 2,300 RPM full throttle power setting?
Indicate the altitude to obtain maximum power.
A) 1,010 NM; 12,500 ft
B) 907 NM; 13,200 ft
C) 1,010 NM; 13,200 ft
D) 907 NM; 12,500 ft

Answer on the graph on next pages.

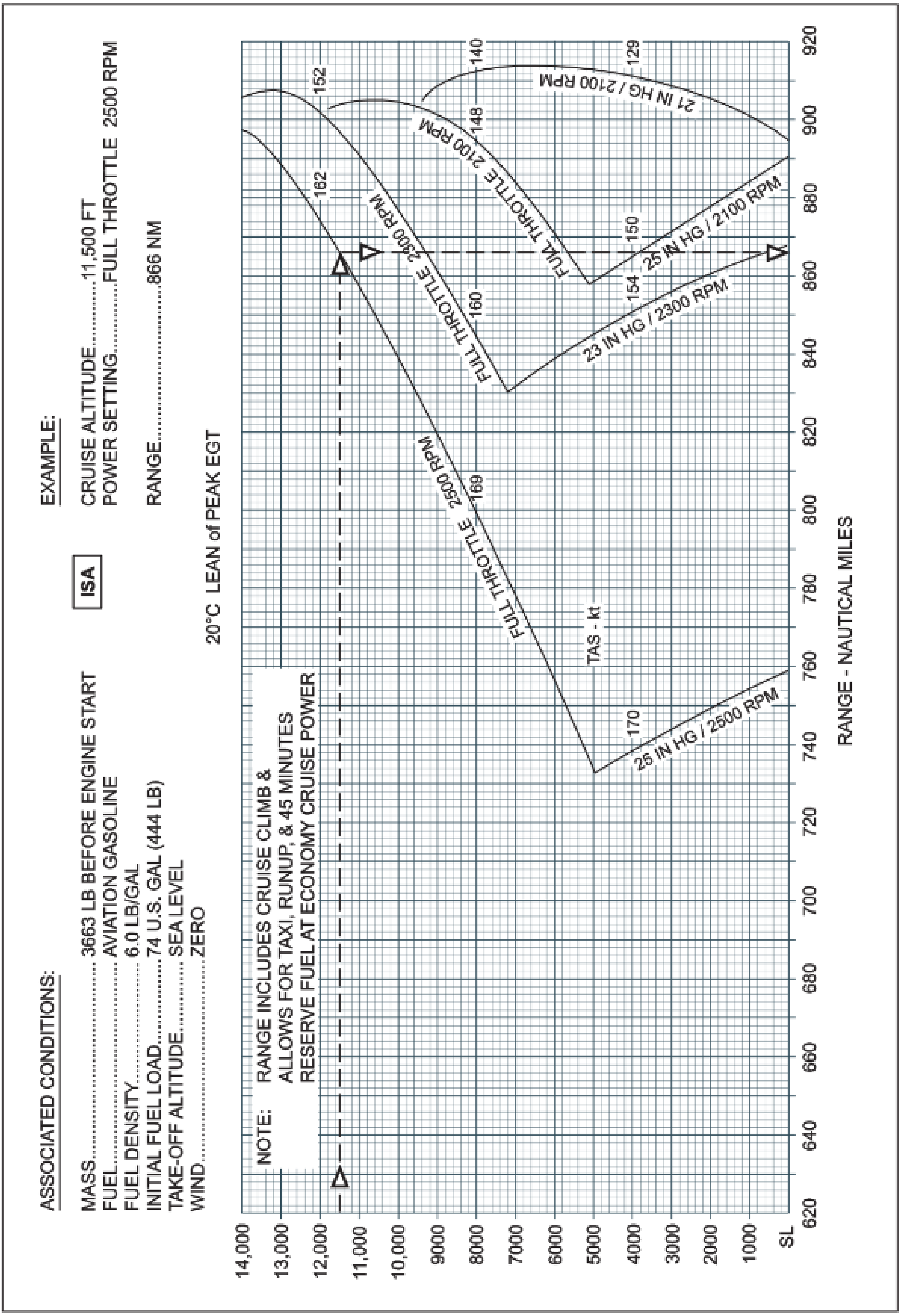


Figure 2.4 Range

Answer

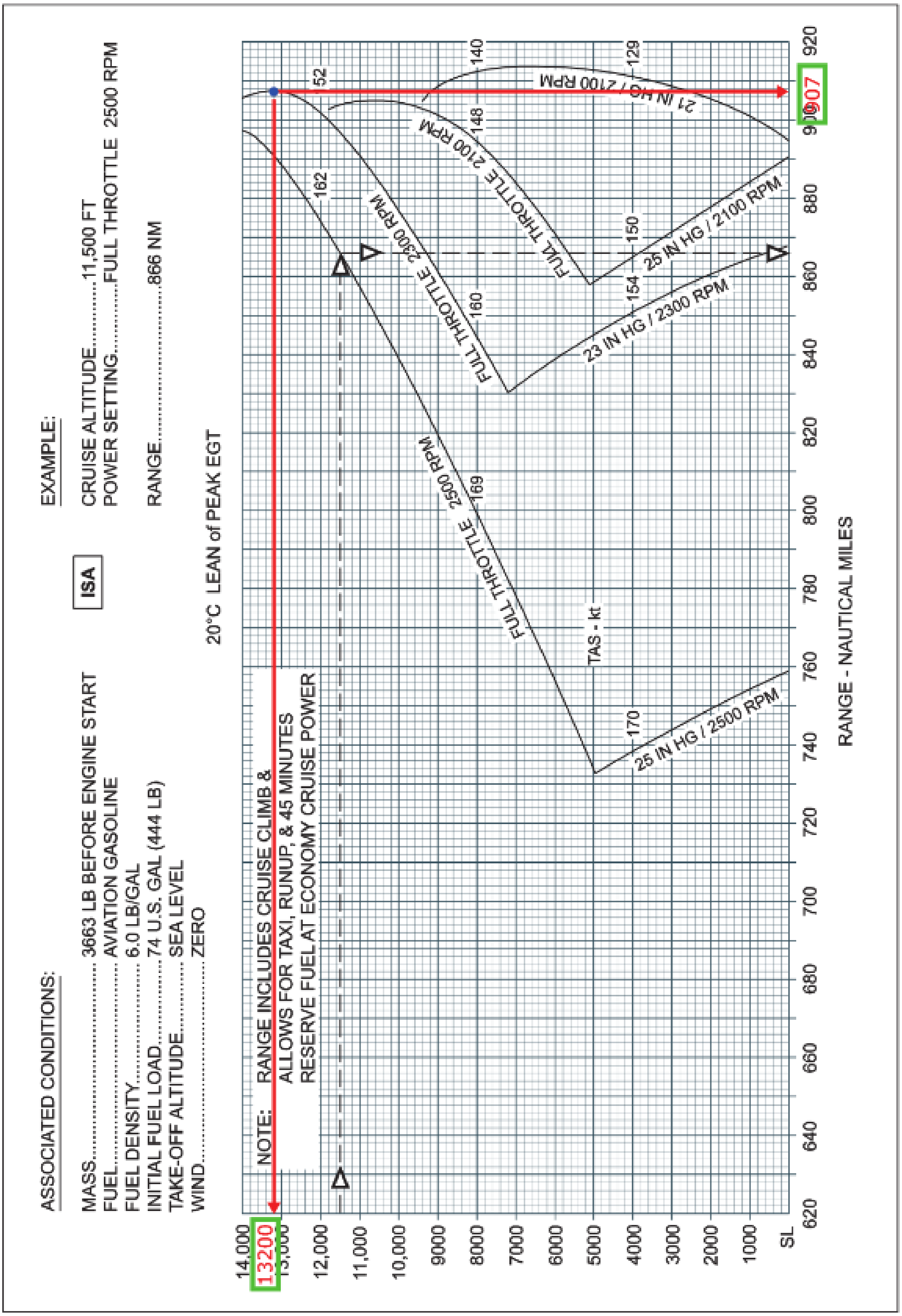


Figure 2.4 Range

On the "Full Throttle – 2 300 RPM" graph, identify the point indicating the maximum distance. From this point, plot a horizontal line to find the altitude to obtain the maximum distance.
Maximum distance = 907 NM.
Altitude = 13,200 ft.
Answer B.

NB. The range obtained with the graph is an air distance. A head or tailwind component may significantly affect distance computing.

2.2.4 - Endurance graph

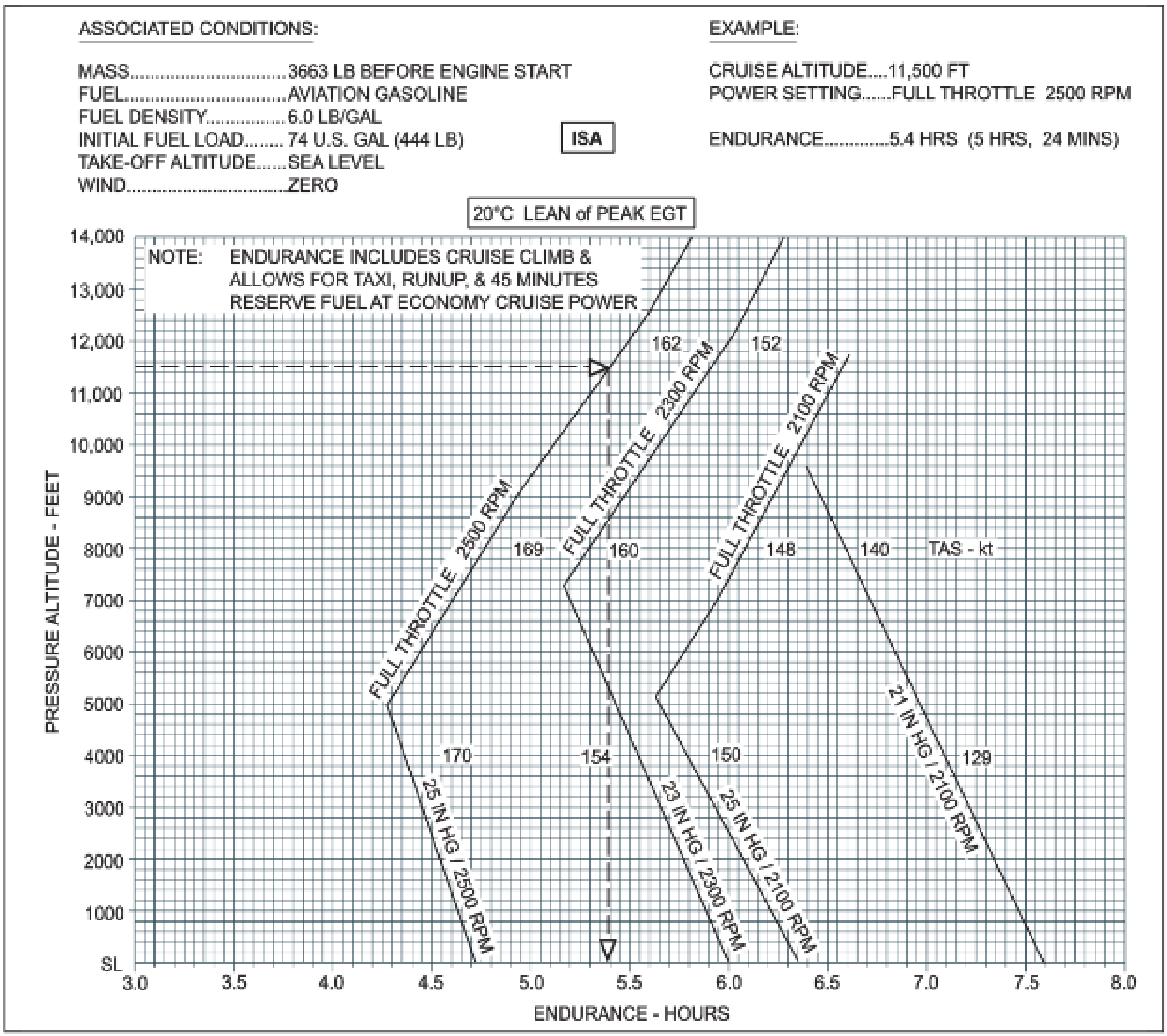
The graph below allows determination of the endurance of an aircraft. The method for this graph is the same as for the range graph.

NB. Endurance is not affected by the wind.

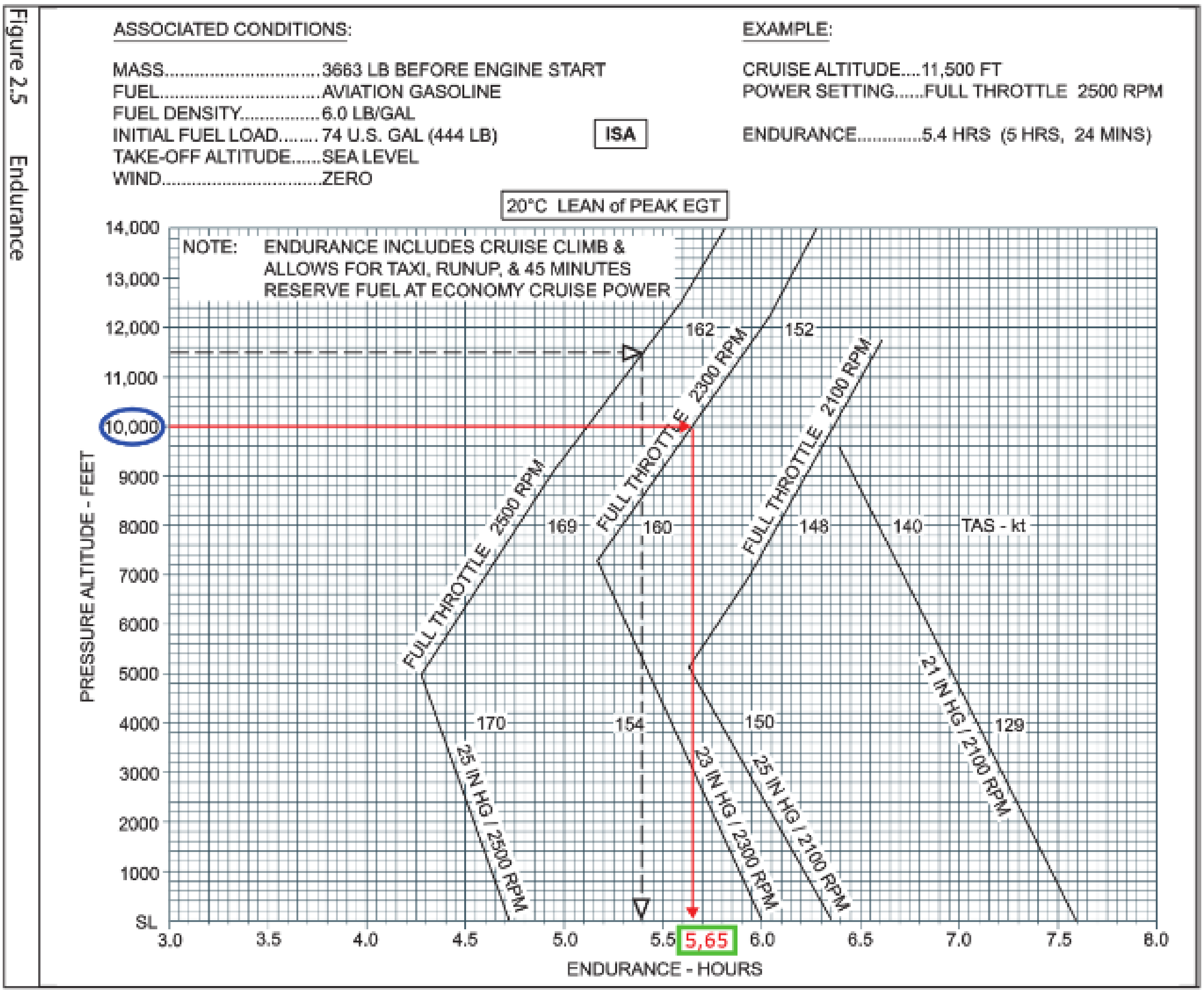
Example

Determine the endurance with a full throttle 2,300 RPM power setting and a 10,000 ft altitude.

Figure 2.5 Endurance



Answer



Endurance = 5.65 hrs, i.e. 5 hrs 39 min.

2.3 - Computing the fuel for MEP (Multi Engine Piston)

The graphs and tables published in the flight manual of the twin piston engine generic aircraft (Piper Seneca) are the same as for the SEP previously described.

Fuel Planning

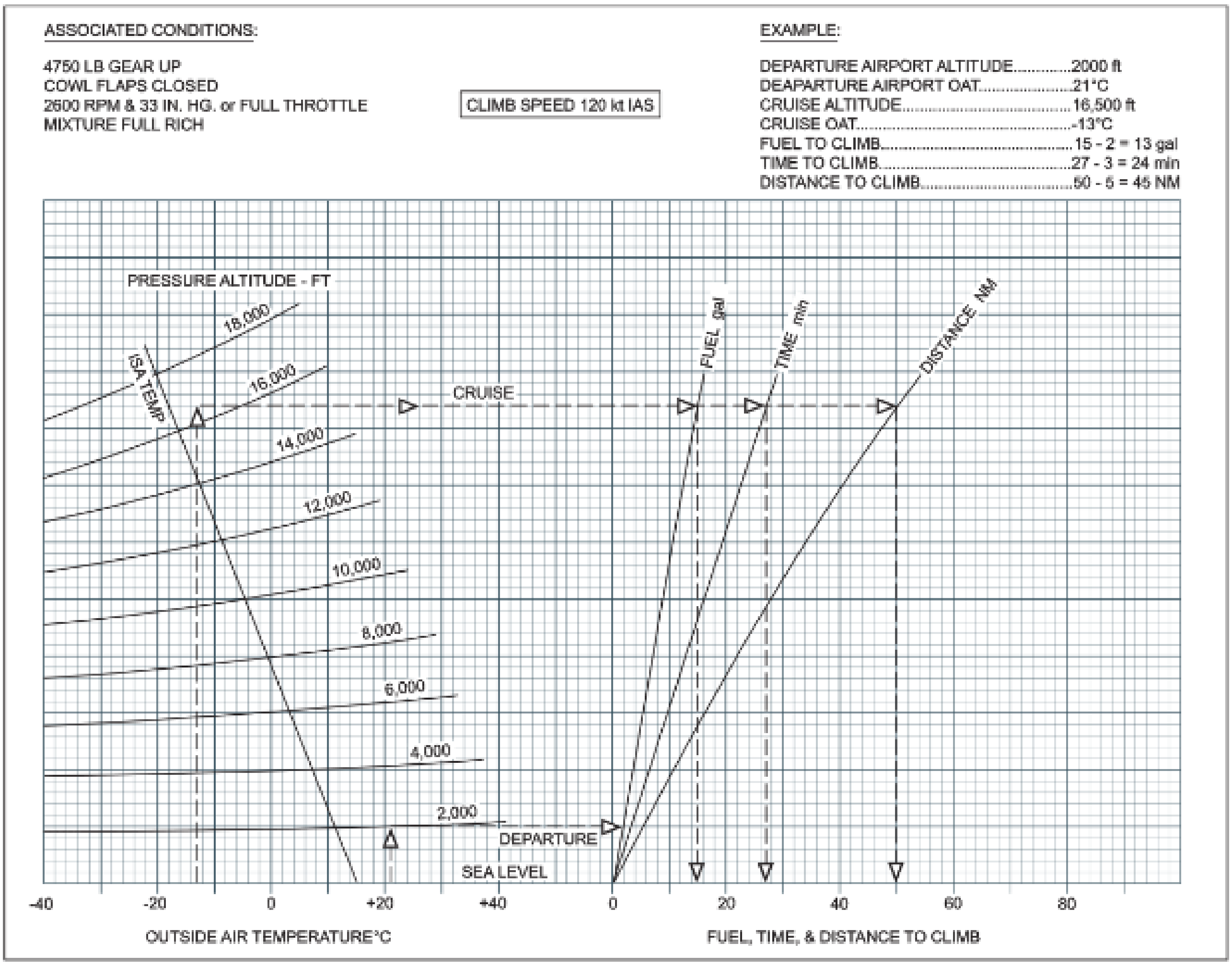
This data should allow determination of the fuel required for the following phases: take-off and climb (fig 3.1 in CAP 697); cruise (fig 3.3 in CAP 697); descent (fig 3.6 in CAP 697).
Other information is available to determine the range and endurance with:

- range graph (fig 3.2 in CAP 697);
- endurance graph (fig 3.5 in CAP 697).

2.3.1 - Take-off/climb graph

The processing of this graph is the same as for the SEP.

Figure 3.1 Climb



Example

Available data:

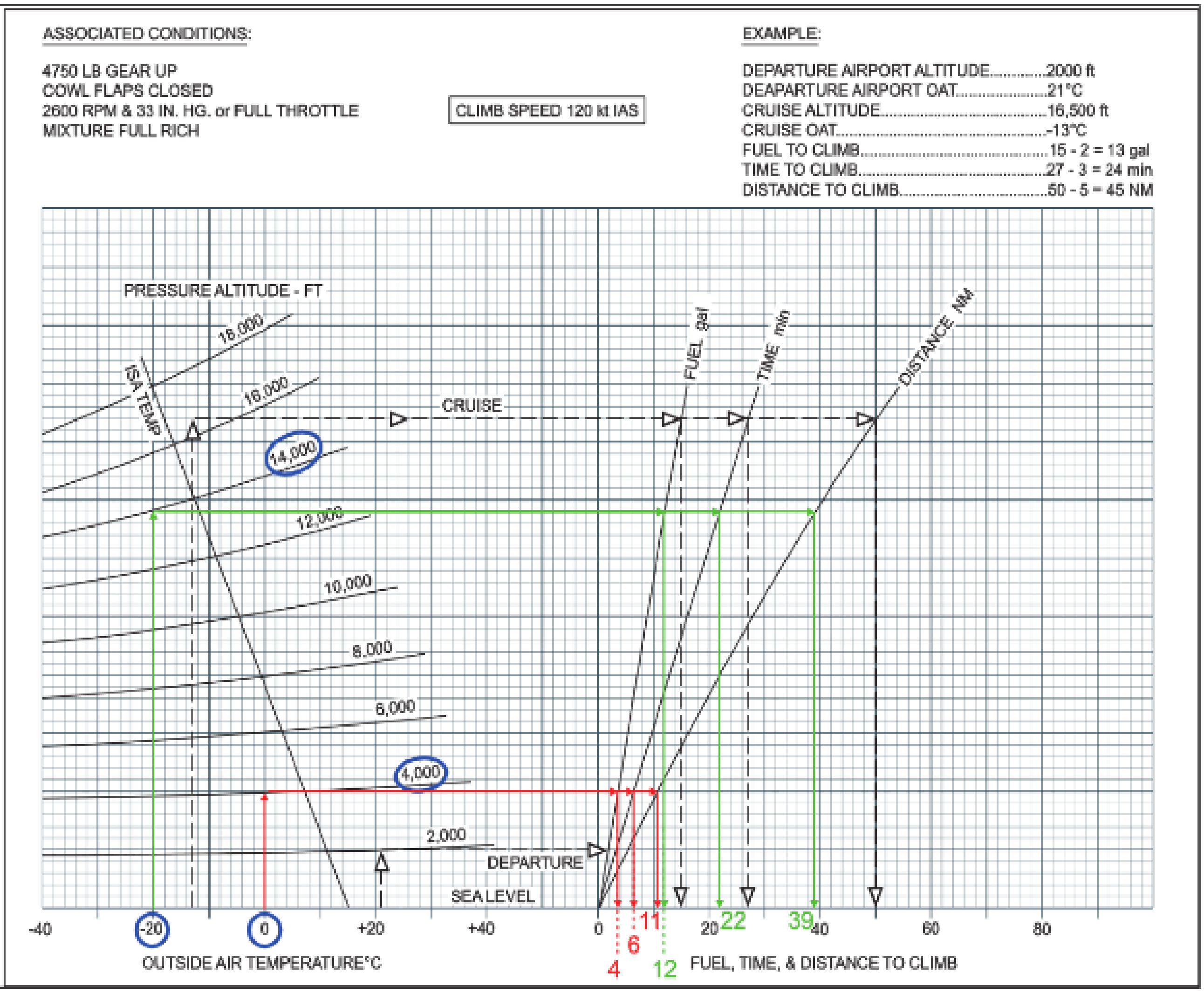
- departure airport pressure altitude: 4,000 ft, with a 0°C outside air temperature;
- target cruise level: FL 140, temperature: – 20°C;
- average climb wind component: – 40 kt (headwind)

Determine the time, fuel, air distance and ground distance to climb from the brake release point.

A) 22 min; 6.7 gal; 35 NM; 29.4 NM
B) 24 min; 7,7 gal; 27 NM; 21 NM
C) 16 min; 8.0 gal; 28 NM; 17.3 NM
D) 23 min; 7.7 gal, 30 NM; 25.1 NM

Answer

Figure 3.1 Climb



a) The time, fuel and air distance are determined in two steps.

• With a departure airport at 4,000 ft and a 0°C outside air temperature, the time, fuel and distance are 6 min, 4 US gal and 11 NM, respectively (see red lines).

• With a cruise altitude at 14,000 ft and a – 20°C outside air temperature, the time, fuel and distance are 22 min, 12 US gal and 39 NM, respectively (see green lines).

The time to climb from the departure airport to FL 140 is: 22 – 6 = **16 min.**
The fuel to climb from the departure airport to FL 140 is: 12 – 4 = **8 US gal**.
The distance to climb from the departure airport to FL 140 is: 39 – 11 = **28 NM.**

b) Determining the ground distance.
True airspeed (TAS) = air distance / time (in hour) = 28 /(16 / 60) = 105 kt.
Ground speed (GS) = TAS ± wind = 105 – 40 = 65 kt.
Ground distance (D_{GROUND}) = D_{AIR} x GS / TAS = 28 x 65 / 105 = **17.3 NM.**

Answer **C.**

2.3.2 - Cruise table

POWER		75%		65%			55%						45%					
FUEL FLOW		29.0 GPH		23.3 GPH			18.7 GPH						16.0 GPH					
RPM		2,500	2,600	2,400	2,500	2,600	2,100	2,200	2,300	2,400	2,500	2,600	2,100	2,200	2,300	2,400	2,500	2,600
PRESS ALT (ft)	ISA 0°C	MANIFOLD ABSOLUTE PRESSURE (Hg in) (MAP)																
0	15	34.0	33.0	33.8	32.0	31.0	31.2	30.3	29.4	28.2	27.2	26.3	27.1	26.4	25.5	24.3	23.3	22.5
2,000	11	33.8	32.7	33.2	31.7	30.7	30.5	29.7	28.8	27.8	26.8	26.0	26.4	25.8	24.6	23.7	22.8	22.1
4,000	7	33.6	32.4	32.8	31.5	30.5	30.0	29.2	28.3	27.4	26.4	25.6	25.8	25.0	24.0	23.2	22.3	21.8
6,000	3	33.4	32.2	32.5	31.2	30.3	29.7	28.8	28.0	27.0	26.2	25.3	25.3	24.5	23.5	22.8	21.9	21.5
8,000	-1	33.1	32.0	32.3	31.0	30.1	29.4	28.4	27.7	26.8	25.7	25.0	24.8	24.0	23.0	22.4	21.6	21.2
10,000	-5	33.0	31.9	32.0	30.9	30.0	-	28.3	27.5	26.5	25.5	24.7	24.4	23.7	22.8	22.0	21.4	21.0
12,000	-9	32.5	31.8	31.8	30.7	29.8	-	28.3	27.2	26.3	25.3	24.6	24.0	23.3	22.5	21.7	21.2	20.9
14,000	-13	-	31.7	-	30.5	29.7	-	-	27.1	26.1	25.2	24.4	-	23.0	22.3	21.4	21.1	20.8
16,000	-17	-	31.6	-	30.4	29.5	-	-	-	25.9	25.0	24.3	-	-	22.0	21.3	21.0	20.6
18,000	-21	-	-	-	-	29.4	-	-	-	-	25.0	24.2	-	-	-	21.2	20.9	20.5
20,000	-25	-	-	-	-	29.3	-	-	-	-	-	24.2	-	-	-	21.2	20.8	20.4
22,000	-28	-	-	-	-	-	-	-	-	-	-	24.1	-	-	-	-	-	20.4
MAX EGT		1,525°F		1,650°F														
24,000	-33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.4
25,000	-34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.4

Figure 3.3 Power Setting Table

The cruise power settings are expressed in percent of power, depending on the cruise modes:

- 75 % (high speed cruise);
- 65 % (economy cruise);
- 55 % and 45 % (long range cruise).

a) Complete the table with the selected power percent to obtain the fuel flow.
Example: with the economy cruise power (65 %), the fuel flow is 23.3 US gal/hr.

b) Each power percent column is subdivided to allow selection of the manifold absolute pressure and the RPM depending on the pressure altitude in standard atmosphere.
Example: the high speed cruise power (75 %) and a 29 US gal/hr fuel flow are obtained at FL 60, with:

- a 33.4 in.Hg @ 2 500 RPM manifold pressure;
- or a 32.2 in.Hg @ 2 600 RPM manifold pressure.

Determining the true airspeed

Opposite the SEP table, the true airspeed is not indicated in the cruise table.
Use the graph below to determine the true airspeed depending on the cruise altitude, outside air temperature at this level and power percent.

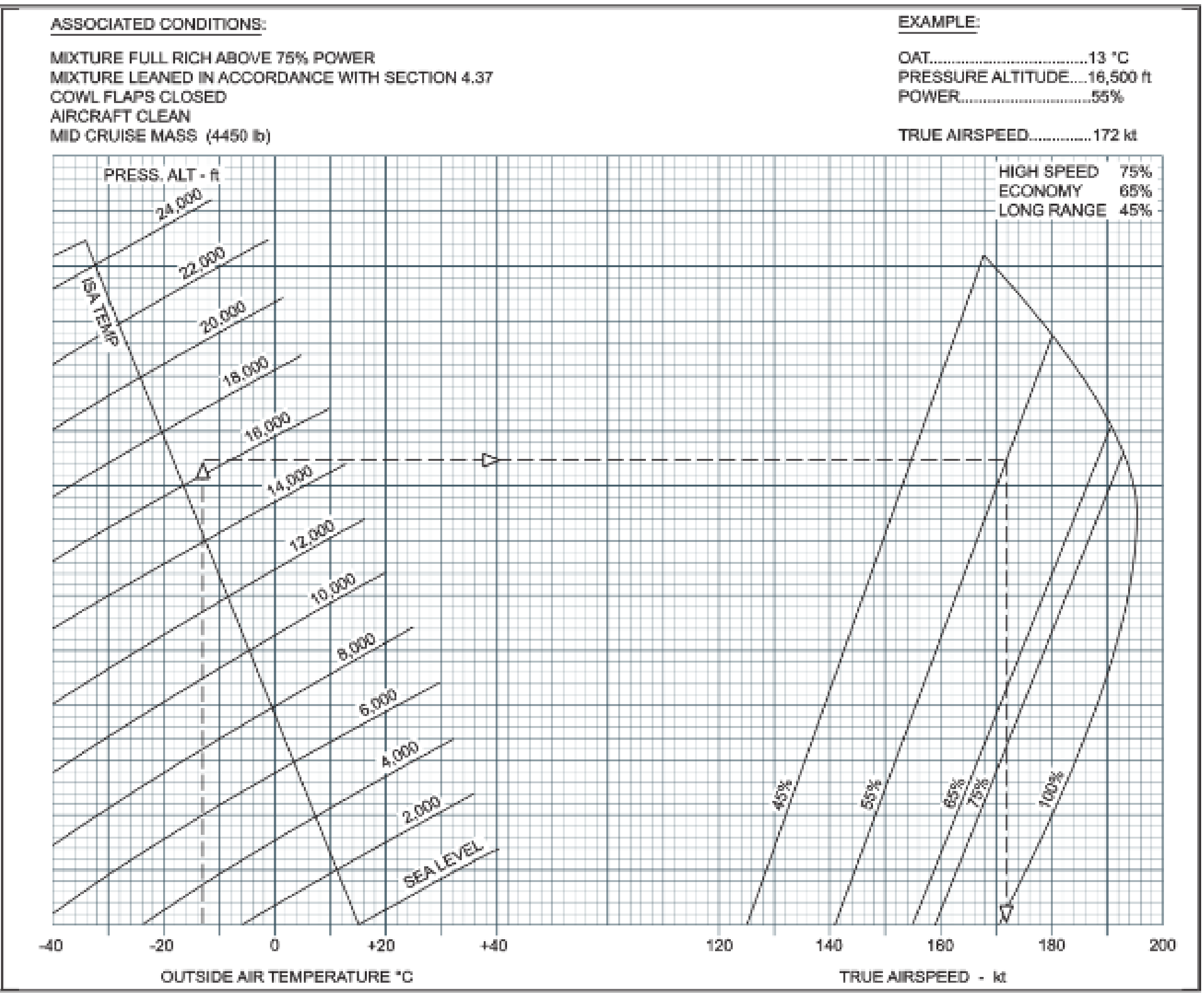
This graph is easy to use.

2.3.3 - Endurance graph

This is different from the graph for a single piston engine aircraft, for which the fuel consumption for descent is considered to be close to the cruise consumption.

As the engine power and fuel consumption of the piston twin engine are higher, the difference between the descent and cruise consumption is greater.

Figure 3.4 Speed v Power



Therefore, it is necessary to publish a specific descent graph for this type of aircraft.
The use of the descent graph is the same as for climb.

Example

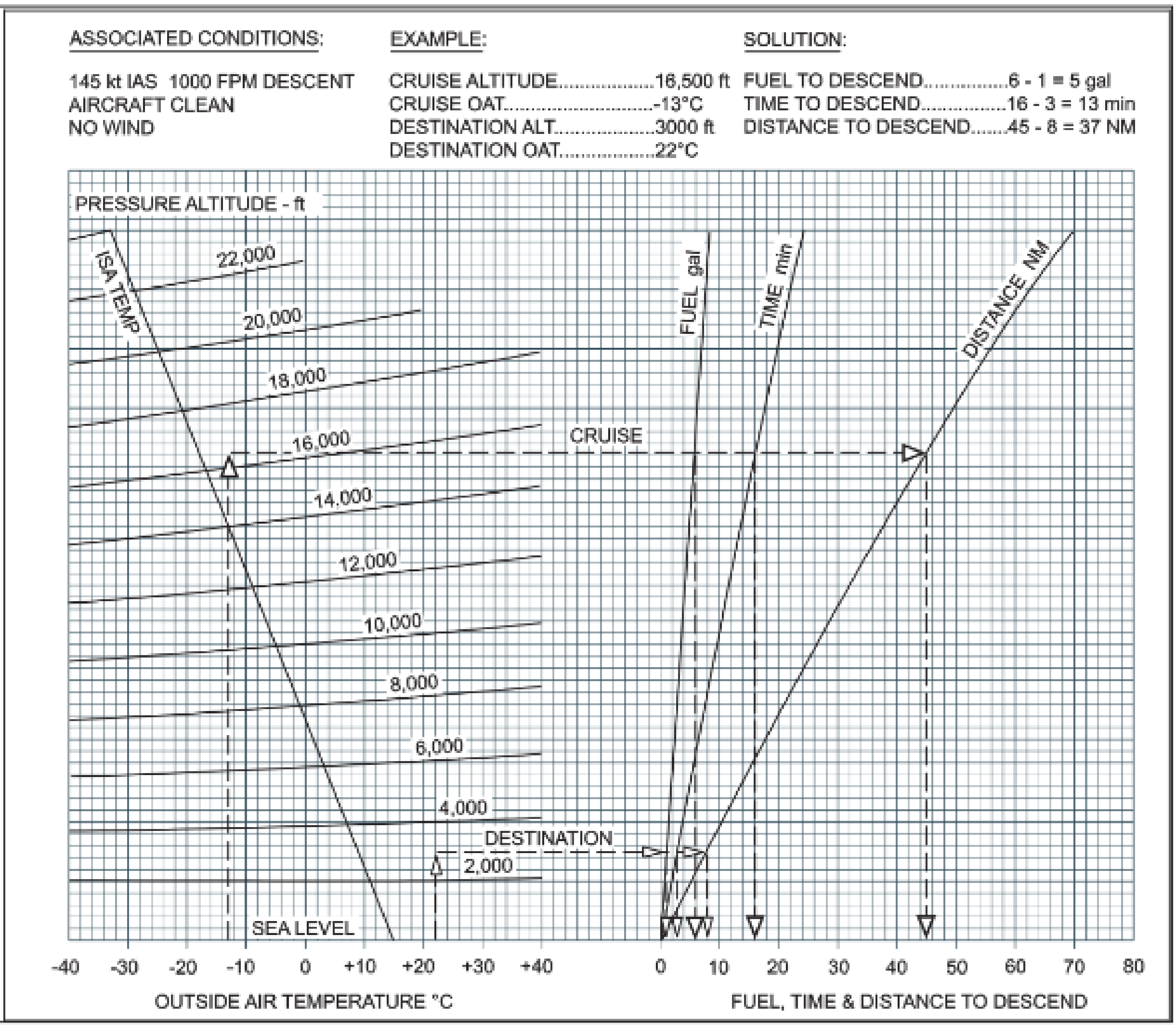
Given:

- descent is initiated at flight level 120, with a – 20°C outside air temperature;
- the pressure altitude of the arrival airport is 4,000 ft and the outside air temperature is 0°C;
- the average wind component in descent is – 20 kt (headwind).

Determine the time, fuel, air distance and ground distance to descend.

A) 12 min; 3.7 gal; 29 NM; 23.4 NM
B) 8 min; 2 gal; 22 NM; 19.3 NM
C) 10.5 min; 2.9 gal; 24.5 NM; 21.6 NM
D) 15 min; 4.7 gal; 50 NM; 47.1 NM

Figure 3.6 Fuel, Time and Distance to Descend



Answer on next page.

Answer

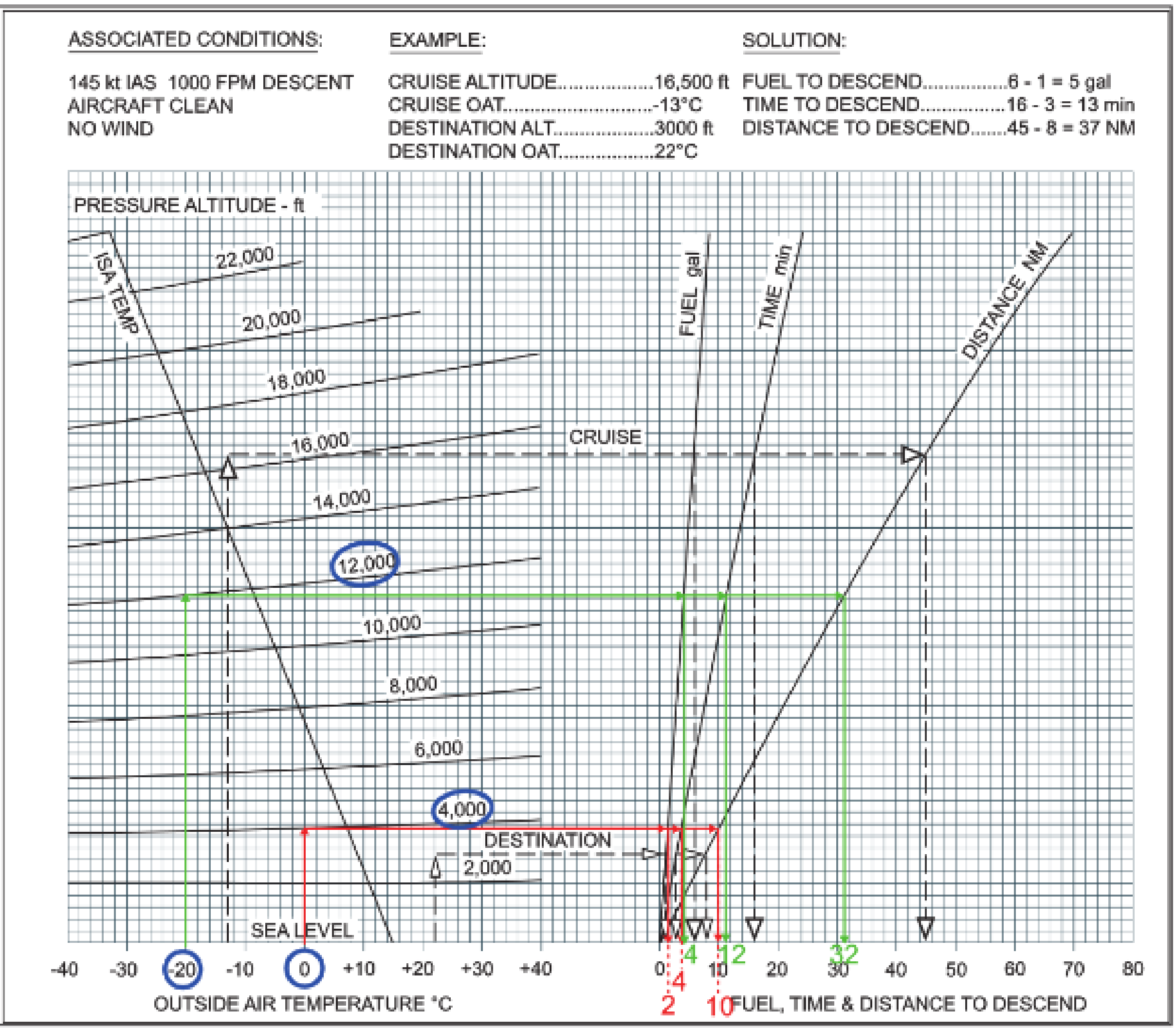


Figure 3.6 Fuel, Time and Distance to Descend

a) The time, fuel and air distance are determined in two steps.

• At FL 120 and with a – 20°C outside air temperature, the time, fuel and distance are 12 min, 4 US gal and 32 NM, respectively (see green lines).

• With an arrival airport at 4,000 ft and a 0°C outside air temperature, the time, fuel and distance are 4 min, 2 US gal and 10 NM, respectively (see red lines).

The time to descend from FL 120 to the airport is: 12 – 4 = **8 min.**

The fuel to descend from FL 120 to the airport is: 4 – 2 = **2 US gal**.

The distance to descend from FL 120 to the airport is: 32 – 10 = **22 NM**.

b) Determining the ground distance.

True airspeed (TAS) = air distance / time (in hour) = 22 /(8 / 60) = 165 kt.

Ground speed (GS) = TAS ± wind = 165 – 20 = 145 kt.

Ground distance (D_{GROUND}) = D_{AIR} x GS / TAS = 22 x 145 / 165 = **19.3 NM**.

Answer **B**.

2.3.4 - Range and endurance graphs

These two graphs allow determination of range (air distance) and endurance, with the following two assumptions:

- range and endurance with 45-minutes reserve, at 45 % power setting;
- range and endurance with no reserve.

Besides, the two graphs are set at the maximum structural take-off mass, with a standard climb and descent and a 4.2 US gal fixed value is taken into account for start-up, taxi and take-off.

Note. *The range graph was determined for standard conditions. Thus, for non-standard conditions, a ± 1 NM correction shall be applied for 1°C ΔISA (see box in the left top corner of the graph).*

Example

Using the following two graphs, determine the range and endurance, with an economy power and at level 100 in ISA conditions.

Answer

See corrections with both graphs on next pages.

	With reserve	With no reserve
Range:	760 NM	850 NM
Endurance:	4.5 hr (4 hrs 30 min)	5 hrs

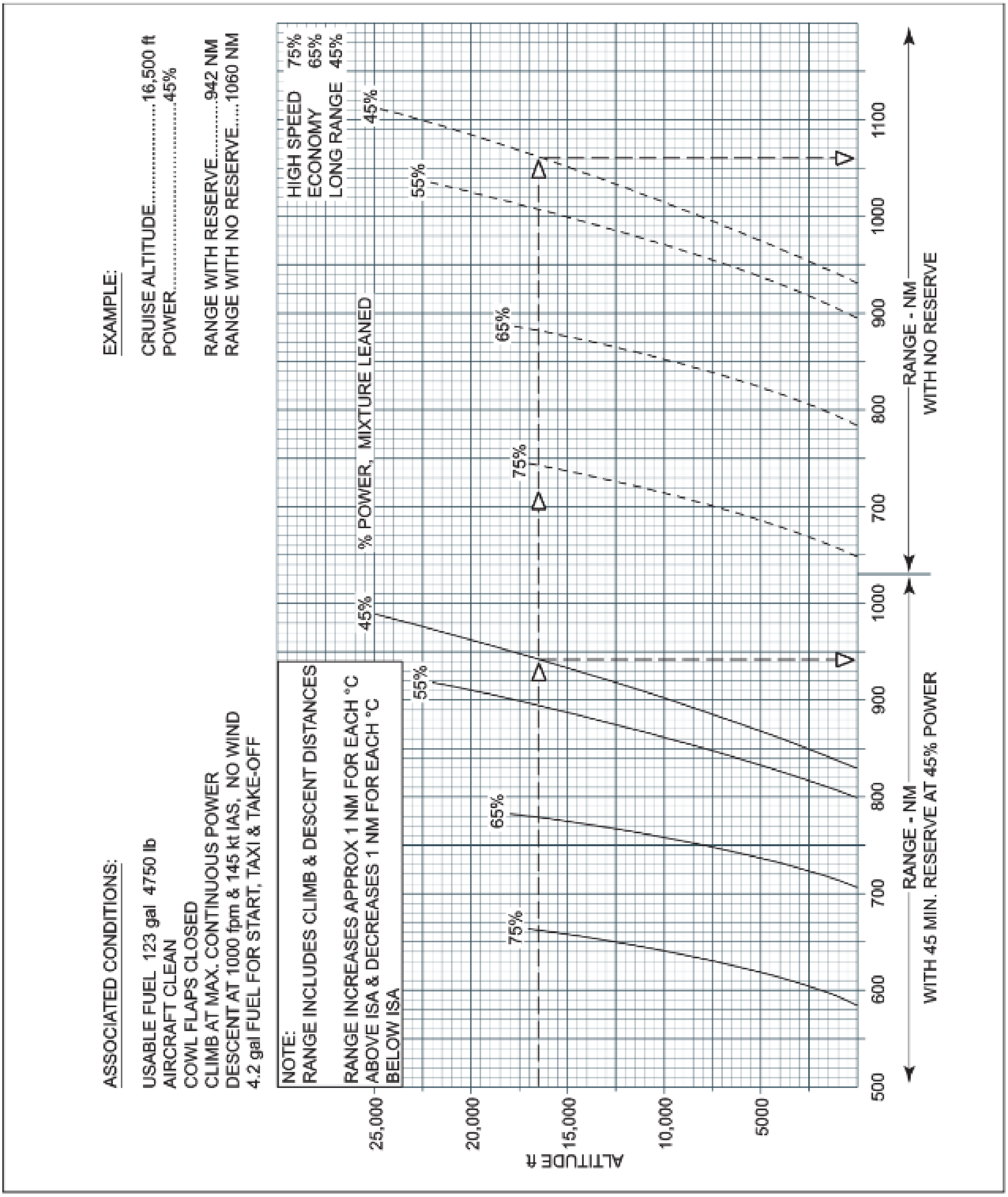


Figure 3.2 Range

Range graph.

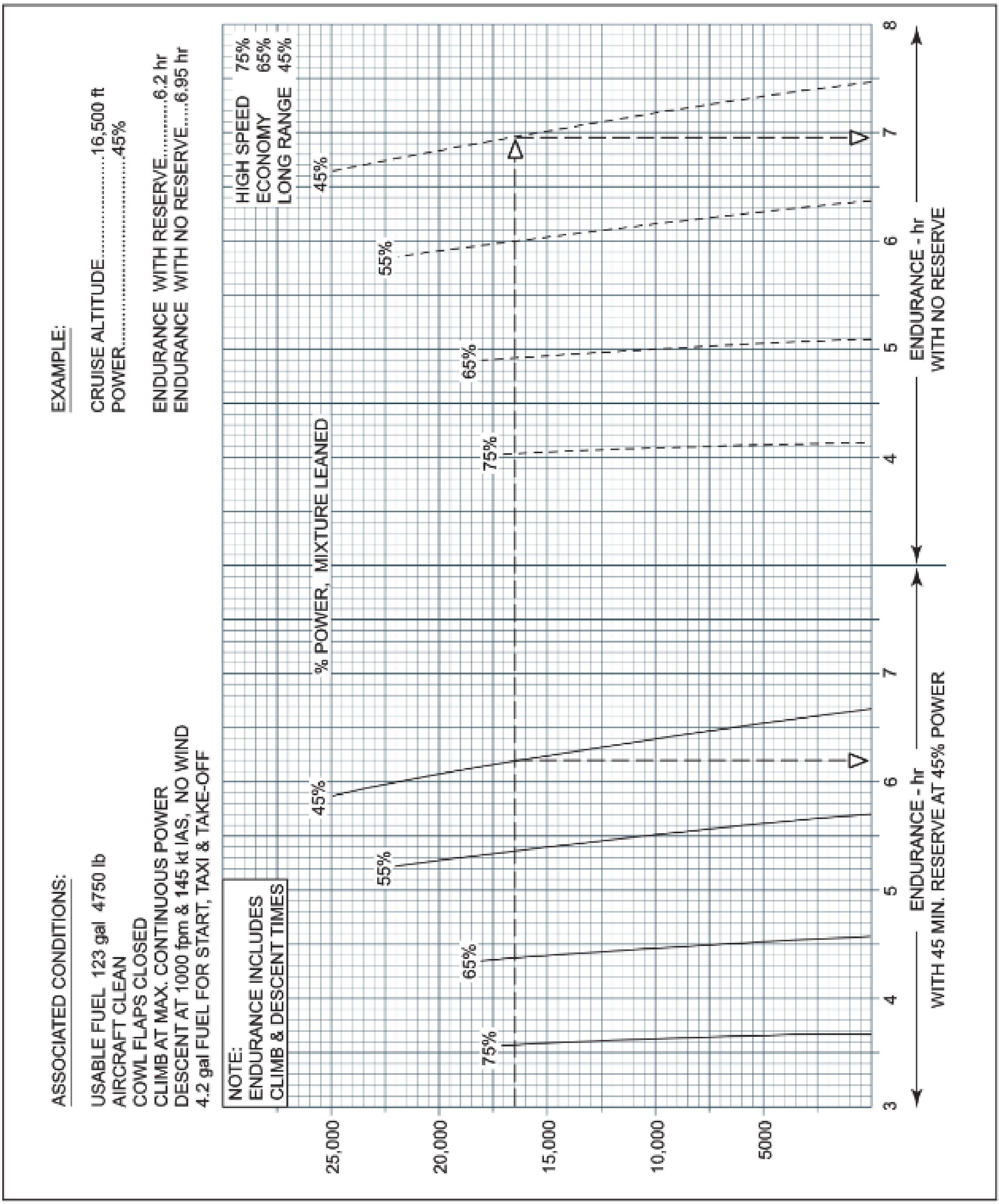


Figure 3.5 Endurance

Endurance graph.

Figure 3.2 Range

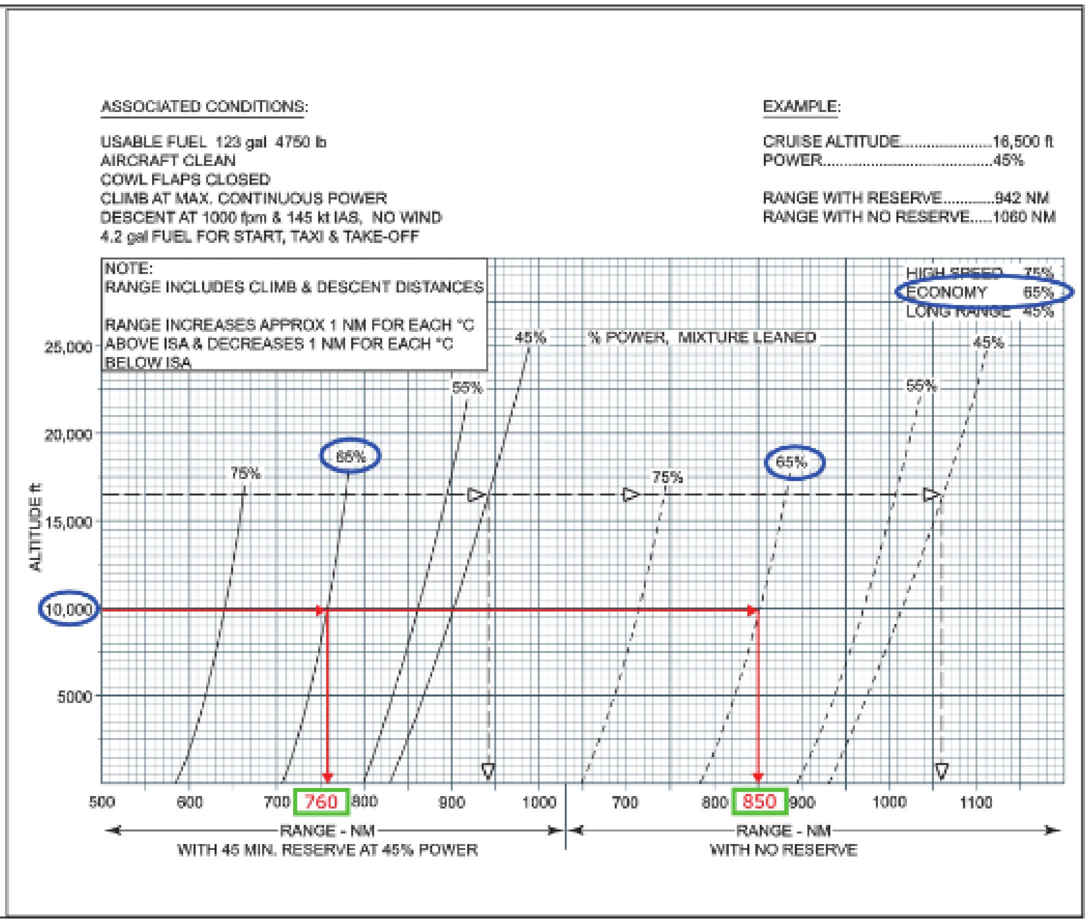
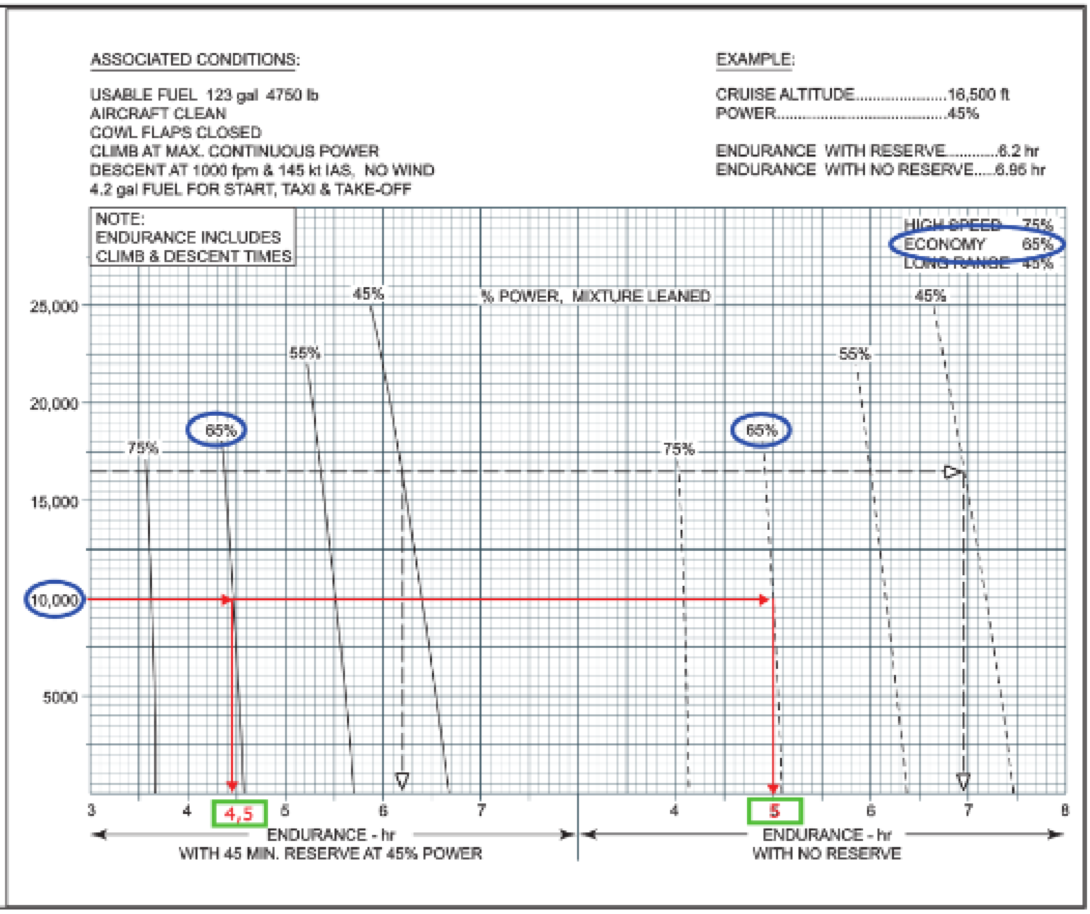


Figure 3.5 Endurance



2.4 - Computing the fuel for Boeing 737-400 (MRJT)

Using the information published in CAP 697 for this aircraft, we shall perform the following computations:

- optimum altitude and short range cruise altitude;
- trip fuel for a standard trip. Two different techniques may be applied. We shall focus on the following two methods:
  - method 1: use of the "Simplified Flight Planning" graphs. This data allows quick determination of the trip fuel and estimated flight time for a specified trip, from brake release to landing, through the three main flight phases: climb (direct departure procedure), cruise and descent (direct approach procedure);
  - method 2: use of performance tables and the "cruise integrated range" tables. This analytical method determines the trip fuel more accurately by computing the fuel consumption for each flight phases: climb, cruise and descent.

2.4.1 - Optimum altitude and short range cruise altitude

a) Optimum altitude

For a specified speed or Mach, the optimum altitude is the altitude for which the specific range is maximum. In other words, the altitude to obtain minimum cruise fuel burn.

The graph shown in CAP 697 (fig. 4.1) allows the optimum altitudes to be computed according to the following speed laws:
Mach long range or M.74;
M.78.

This graph is easy to use.

Let's consider the example specified on the chart: with a 56.8 t cruise weight or a brake release weight approximately equal to 58.5 t, and an M.74 or long range cruise Mach, reading the graph indicates a 33.500 ft optimum altitude

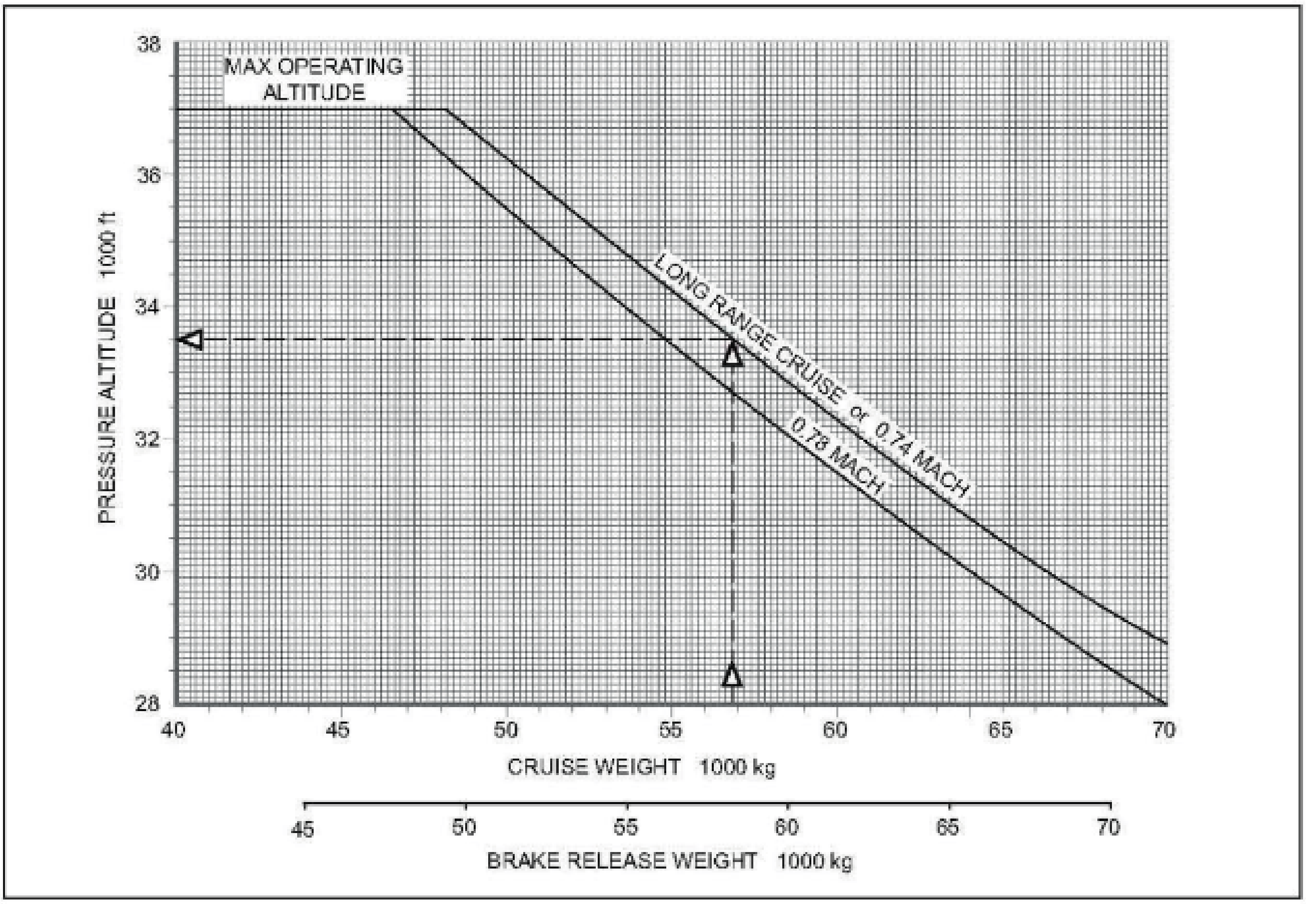


Figure 4.1 Optimum Altitude

This graph also shows that the optimum altitude increases as the weight decreases according to the amount of cruise fuel burn.

The ideal cruise would be a climb cruise, following the optimum altitude as the weight decreases due to fuel burn.

However, for air traffic management; climb cruise is not allowed by the ATC. You must therefore plan to perform a step climb technique, at altitudes as close as possible to the optimum altitude as the aircraft weight decreases.

Thus, when deviating from the optimum altitude, whether above or below, the specific range decreases; this negatively affects the fuel consumption.

The table below indicates the fuel penalty depending on the altitude deviation from the optimum altitude computed for the different cruise Mach numbers.

Off-Optimum Condition	Fuel Mileage Penalty %	
	LRC or Mach 0.74	Mach 0.78
2,000 ft above	-1	-1
Optimum	0	0
2,000 ft below	-1	-2
4,000 ft below	-4	-4
8,000 ft below	-10	-11
12,000 ft below	-15	-20

Table 4.1 Off-Optimum Fuel Penalty

b) Short range cruise altitude

For short range flights (distance < 250 NM), the aircraft cannot reach its optimum cruise altitude published in the previous graph before initiating the descent.

The graph below determines the highest altitude according to the distance to be flown, allowing a minimum cruise time at least equal to one minute.

Complete the graph with the trip ground distance and ISA deviation, and the take-off weight to read the optimum altitude for a short range cruise.

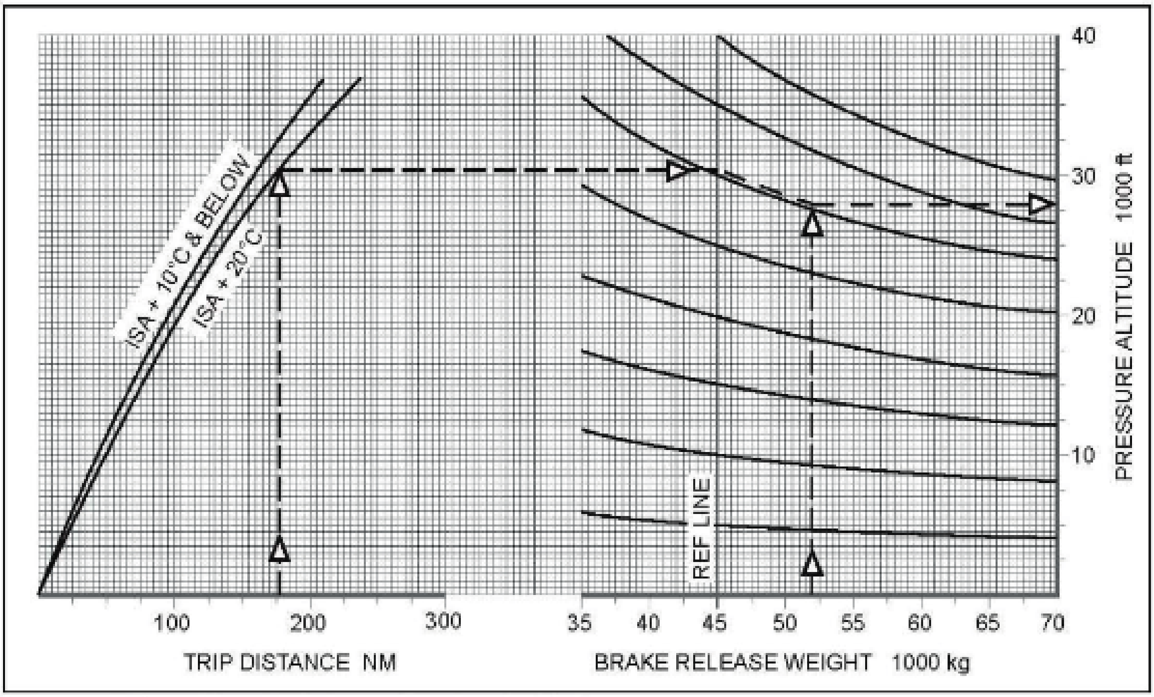


Figure 4.2 Short Distance Cruise Altitude

Example

The example is shown on the graph.
Trip ground distance: 175 NM.
Temperature: ISA + 20°C.
Brake release weight: 52,000 kg.
What is the short range cruise altitude?
A) 28,000 ft
B) 29,000 ft
C) 30,000 ft
D) 31,000 ft

Answer

The short range cruise altitude is 28,000 ft.
It should be noted that, for the same flight conditions, this altitude is much lower than the optimum altitude obtained with the graph in the previous section.

2.4.2 - Method 1: Computing the trip fuel for a standard trip with the "Simplified Flight Planning" graphs

The graphs are referenced with according to the following cruise speed regimes:

- long range cruise;
- M.74 cruise;
- M.78 cruise;
- 300 kt IAS cruise;
- cruise with step climbs: this graph allows optimization of the fuel by framing the optimum altitude in ± 2 000 ft successive steps. The cruise regime used for this chart is the long range or M.74;
- alternate cruise to long range: this graph includes the missed approach procedure, followed by a climb, then a long range cruise and a descent using direct approach. It determines the amount of alternate fuel.

It should be noted that the trip fuel obtained from these graphs does not include:

- taxi fuel (11 kg/min) and the APU operation on the ground (115 kg/hr);
- fuel penalties depending on the deviation from the optimum altitude;
- fuel increase due to bleeds: high flow packs (+ 1 % of the cruise consumption), anti-icing operation (engine anti-icing: 70 kg/hr and total anti-icing: 180 kg/hr);
- holding fuel.

The layout and use of these graphs are similar to the previous graphs.
The use of these graphs will be explained with two examples:

- example 1: computing the trip fuel and flight time;
- example 2: computing the maximum ground distance for a specified fuel amount.

Example 1

Refer to graph 4.3.1c in CAP 697: Long range cruise.
For a 2,400 NM ground flight, the following data is available:
tailwind: 25 kt;
temperature: ISA – 10°C;
cruise altitude: 31,000 ft;
planned landing weight: 52,000 kg.
What are the trip fuel and flight time?
A) 14,200 kg; 5 hrs 30 min
B) 16,200 kg; 5 hrs 45 min
C) 13,600 kg; 6 hrs 30 min
D) 12,000 kg; 5 hrs 15 min
Note. *The trip distances are always expressed in ground nautical miles.*

Answer
See correction on next page.
The graph is designed for the following speed laws:
climb at 280 kt/M.74;
cruise at long range speed;
descent at M.74/250 kt.

In such conditions, the trip fuel and flight time are 14,200 kg and 5 hrs 30 min, respectively. See correction on the graph below.
Answer **A**.

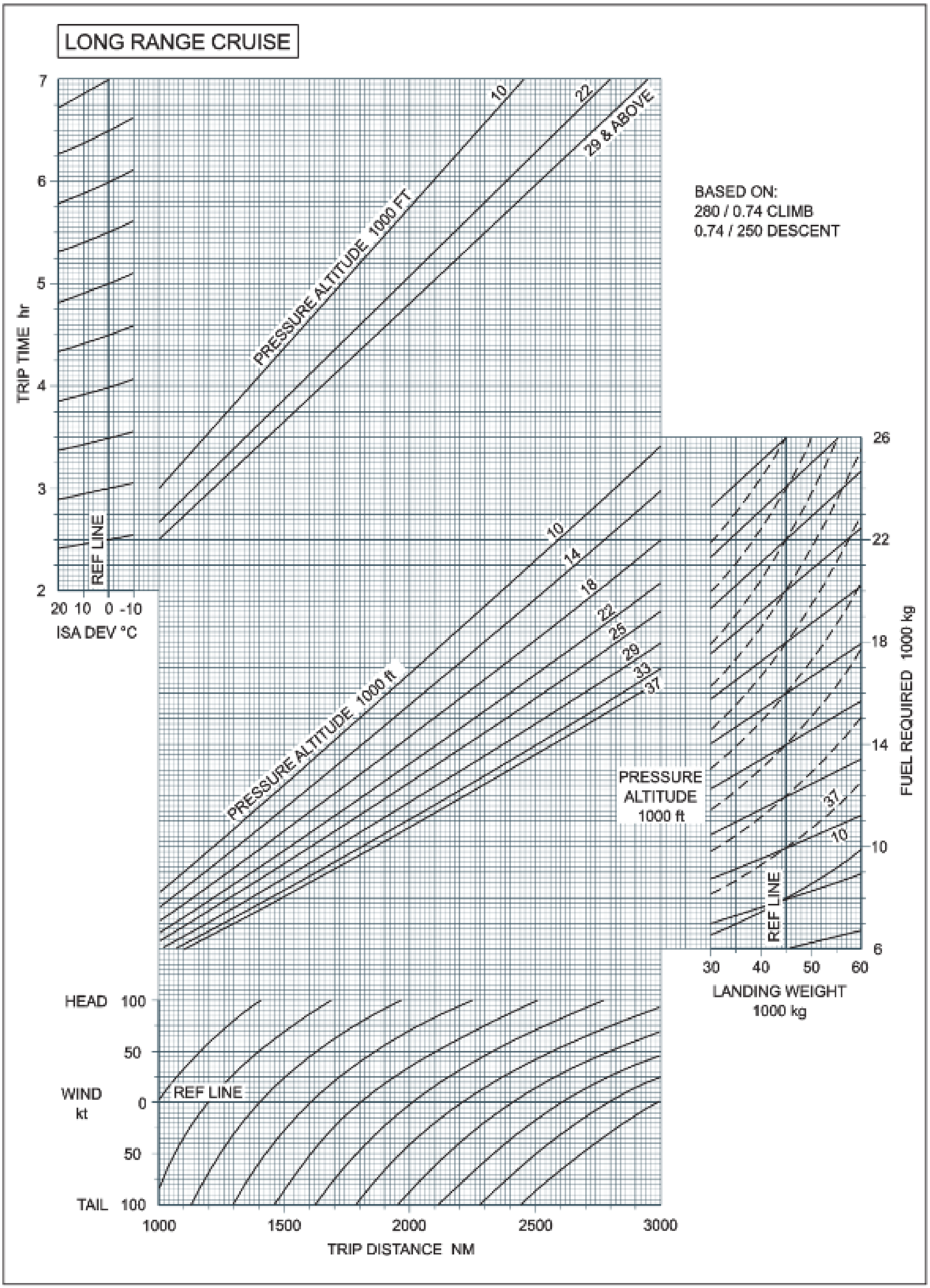


Figure 4.3.1 c Simplified Flight Planning – Trip Distances 1,000 NM to 3,000 NM

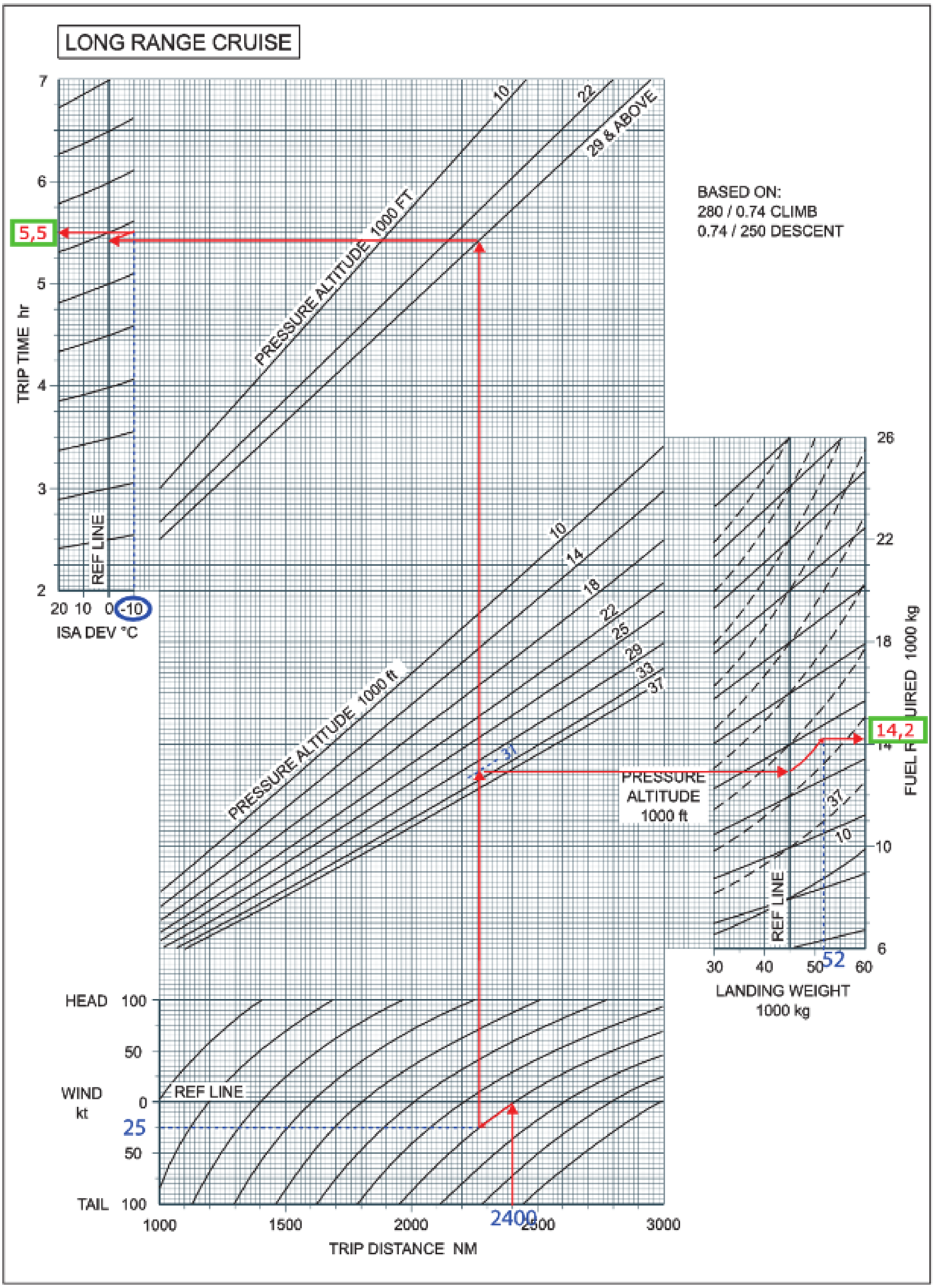


Figure 4.3.1 c Simplified Flight Planning – Trip Distances 1,000 NM to 3,000 NM

Example 2

The "Simplified Flight Planning" graphs may be used to determine the maximum ground distance that can be covered according to the fuel amount on board. We shall explain this computing case.

See the graph below. Under the following conditions:

- tailwind: 10 kt
- temperature: ISA + 10°C;
- brake release weight: 63,000 kg;
- available trip fuel: 20,000 kg.

What is the maximum range?

A) 3,500 NM B) 3,640 NM

C) 3,740 NM D) 3,250 NM

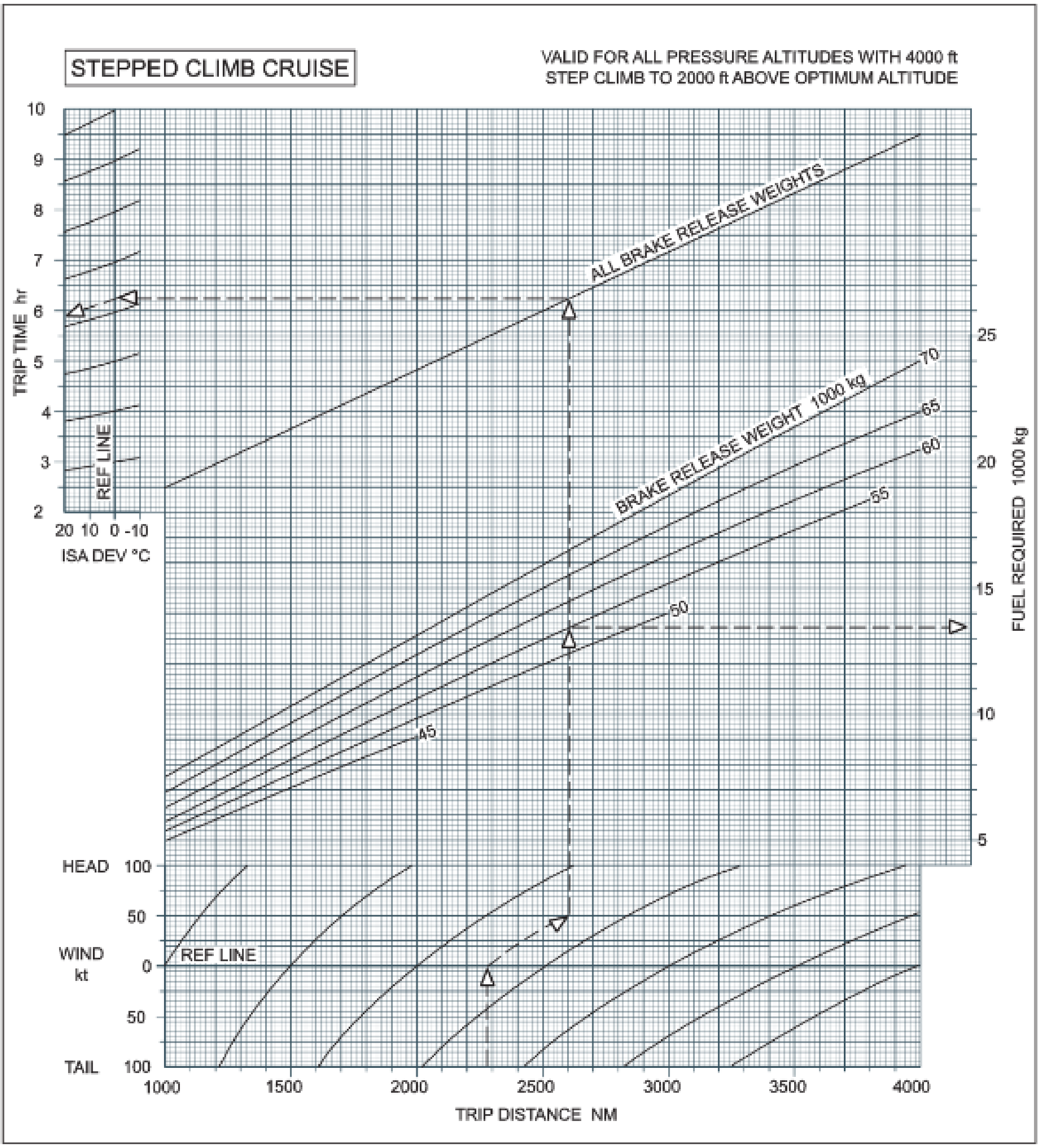


Figure 4.3.5 Simplified Flight Planning – Trip Distances 1,000 NM to 4,000 NM

Answer

The maximum range is 3,740 NM.

Answer **C**.

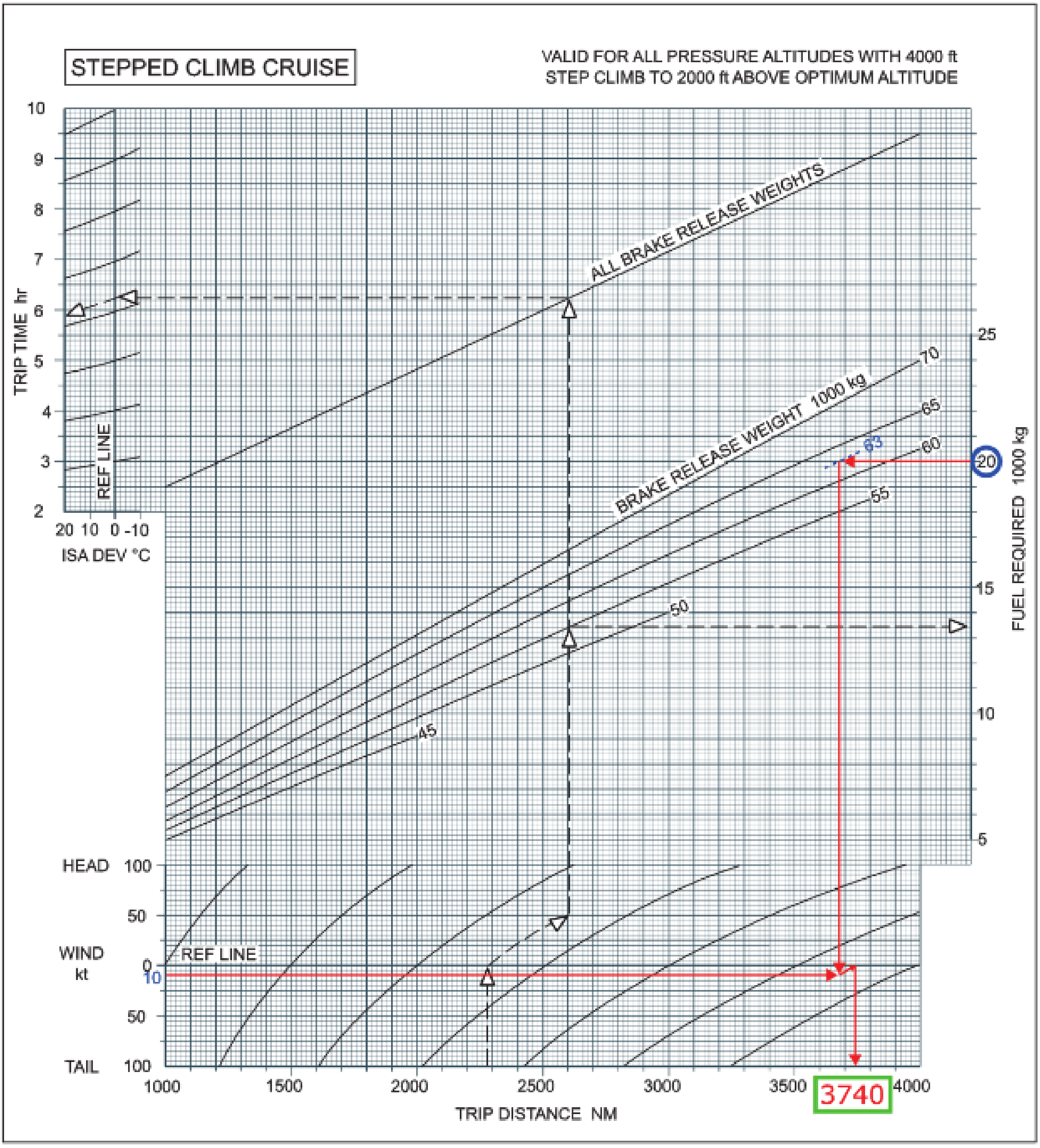


Figure 4.3.5 Simplified Flight Planning – Trip Distances 1,000 NM to 4,000 NM

2.4.3 - Analytical method: performance tables and "cruise integrated range" tables.

As compared with the previous method, using the timetables and "cruise integrated range" tables allows for fuel to be computed more accurately for each flight phase of a route: climb, cruise, descent, and holding.

a) Climb

The B737 climb timetables are based on a 280 kt/M.74 speed; they are given for different temperatures and provide the following information:

- the climb time;
- the climb fuel: the trip fuel values are given for an airport located at sea level; for airports above sea level, the trip fuel corrections mentioned at the bottom of each table should be applied.
- the air distance;

  Note. To obtain the ground distance, apply the following formula: $D_{GROUND} = D_{AIR} \times GS / TAS$.
- the average climb ground speed.

Example

See table 4.5.1 "Enroute Climb 280/.74"

Available data:

brake release weight: 58,000 kg;

temperature: ISA + 15°C.

What is the fuel required to climb from a 4,000 ft elevation airport to FL 300?

A) 1,350 kg B) 1,400 kg

C) 1,450 kg D) 1,250 kg

Answer

This climb table is valid for a temperature from ISA + 6°C to ISA + 15°C.

Computation includes two steps.

At 58,000 kg and at FL 300, reading this table shows a 1,350 kg climb consumption from a 0 ft altitude.

For a 4,000 ft elevation airport, taking the correction specified in the title block at the bottom of the table into account, the corrected consumption is:

1,350 – 100 = 1,250 kg.

ISA +6°C TO +15°C

Press. Alt. ft	Units Min/kg NAM/Kt	BRAKE RELEASE WEIGHT KG										
		68000	66000	64000	62000	60000	58000	56000	52000	48000	44000	40000
37000	Time/Fuel				33/2350	27/2000	24/1850	22/1700	18/1500	16/1300	14/1150	12/1000
	Dist/TAS				212/409	169/404	147/402	132/400	111/397	95/396	82/394	72/393
36000	Time/Fuel			30/2250	26/2000	23/1650	21/1700	20/1600	17/1400	15/1250	13/1100	12/1000
	Dist/TAS			189/405	161/402	143/400	130/398	119/397	102/395	89/393	77/392	68/391
35000	Time/Fuel	35/2600	29/2250	26/2050	23/1900	21/1750	20/1650	19/1550	16/1350	14/1200	13/1100	11/950
	Dist/TAS	224/407	180/402	157/399	141/397	129/396	119/395	110/394	95/392	83/391	73/390	64/389
34000	Time/Fuel	28/2250	25/2050	23/1900	21/1800	20/1650	19/1550	18/1500	16/1300	14/1200	12/1050	11/950
	Dist/TAS	173/400	154/397	140/395	128/394	118/393	110/392	102/391	89/389	78/388	69/387	61/386
33000	Time/Fuel	25/2100	23/1950	21/1800	20/1700	19/1600	18/1500	17/1450	15/1300	13/1150	12/1050	10/900
	Dist/TAS	151/394	139/393	127/391	118/390	109/389	102/388	95/389	84/386	74/385	65/385	58/384
32000	Time/Fuel	23/1950	21/1850	20/1750	19/1650	18/1550	17/1450	16/1400	14/1250	13/1100	11/1000	10/900
	Dist/TAS	136/390	128/389	117/388	109/387	102/386	95/385	89/384	78/383	70/383	62/382	55/381
31000	Time/Fuel	22/1850	20/1750	19/1650	18/1550	17/1500	16/1400	15/1350	13/1200	12/1100	11/1000	10/900
	Dist/TAS	125/386	116/385	108/384	101/383	95/382	89/382	84/381	74/380	66/380	59/379	52/378
30000	Time/Fuel	20/1800	19/1700	18/1600	17/1500	16/14[illegible]	15/1350	14/1300	13/1150	12/1050	10/950	9/850
	Dist/TAS	115/382	108/381	101/380	95/379	89/379	84/378	77/378	70/377	62/376	56/376	49/375
29000	Time/Fuel	19/1700	18/1600	17/1550	16/1450	15/1400	14/1300	14/1250	12/1150	11/1000	10/900	9/850
	Dist/TAS	105/376	98/376	92/375	87/374	82/374	77/374	73/373	65/373	58/372	52/372	46/371
28000	Time/Fuel	17/1600	17/1550	16/1450	15/1400	14/1300	13/1250	13/1200	12/1100	10/1000	9/900	8/800
	Dist/TAS	95/371	90/371	84/370	80/370	75/369	71/369	67/369	60/368	54/368	48/367	42/367
27000	Time/Fuel	16/1550	15/1450	15/1400	14/1350	13/1250	13/1200	12/1150	11/1050	10/950	9/850	8/750
	Dist/TAS	87/366	82/366	77/366	73/365	69/365	66/365	62/364	56/364	50/363	44/363	39/363
26000	Time/Fuel	15/1450	15/1400	14/1350	13/1250	13/1200	12/1150	11/1100	10/1000	9/900	8/800	8/750
	Dist/TAS	80/362	75/362	71/361	67/361	64/361	60/360	57/360	51/360	46/359	41/359	37/359
25000	Time/Fuel	14/1400	14/1350	13/1250	12/1200	12/1150	11/1100	11/1050	10/950	9/850	8/800	7/700
	Dist/TAS	73/356	69/357	65/357	62/'357	59/367	56/356	53/356	47/356	43/356	38/355	34/355
24000	Time/Fuel	13/1350	13/1250	12/1200	12/1150	11/1100	11/1050	10/1000	9/900	8/850	8/750	7/700
	Dist/TAS	67/354	63/353	60/353	57/353	54/353	51/353	49/352	44/352	39/352	35/352	32/351
23000	Time/Fuel	13/1250	12/1200	11/1150	11/1100	10/1050	10/1000	10/950	9/900	8/800	7/750	7/650
	Dist/TAS	61/350	58/350	55/349	53/349	50/349	47/349	45/349	41/348	37/348	33/348	29/348
22000	Time/Fuel	12/1200	11/1150	11/1100	10/1050	10/1000	9/950	9/950	8/850	8/750	7/700	6/650
	Dist/TAS	56/346	54/346	51/346	48/346	46/345	44/345	42/345	37/345	34/345	30/345	27/344
21000	Time/Fuel	11/1150	11/1100	10/1050	10/1000	9/950	9/950	9/900	8/800	7/750	6/700	6/600
	Dist/TAS	52/343	49/342	47/342	44/342	42/342	40/342	38/342	35/342	31/341	28/341	25/341
20000	Time/Fuel	10/1100	10/1050	10/1000	9/950	9/950	8/900	8/850	7/800	7/700	6/650	6/600
	Dist/TAS	47/339	45/339	43/339	41/339	39/339	37/338	35/338	32/338	29/338	26/338	23/338
19000	Time/Fuel	10/1050	9/1000	9/950	9/950	8/900	8/850	8/800	7/750	6/700	6/600	5/550
	Dist/TAS	43/336	41/336	39/335	37/335	36/335	34/335	32/335	29/335	26/335	24/335	21/335
18000	Time/Fuel	9/1000	9/950	8/900	8/900	8/850	7/800	7/800	7/700	6/650	6/600	5/550
	Dist/TAS	39/332	38/332	36/332	34/332	33/332	31/332	30/332	27/332	24/332	22/332	19/332
17000	Time/Fuel	9/950	8/900	8/900	8/850	7/800	7/750	7/750	6/700	6/600	5/550	5/500
	Dist/TAS	36/329	34/329	33/329	31/329	30/329	28/329	27/329	24/329	22/329	20/329	18/329
16000	Time/Fuel	8/900	8/850	7/850	7/800	7/750	7/750	6/700	6/650	5/600	5/550	4/500
	Dist/TAS	33/326	31/326	30/326	28/326	27/326	26/326	25/326	22/326	20/326	18/326	16/326
15000	Time/Fuel	8/850	7/800	7/800	7/750	6/750	6/700	6/650	5/600	5/550	5/500	4/450
	Dist/TAS	29/323	28/323	27/323	26/323	24/323	23/323	22/323	20/323	18/323	16/323	15/323
14000	Time/Fuel	7/800	7/800	7/750	6/700	6/700	6/650	6/650	5/600	5/550	4/500	4/450
	Dist/TAS	26/321	25/321	24/321	23/320	22/320	21/320	20/320	18/320	17/320	15/320	13/320
13000	Time/Fuel	7/750	6/750	6/700	6/700	6/650	5/650	5/600	5/550	4/500	4/450	4/450
	Dist/TAS	24/318	23/318	22/318	21/318	20/318	19/318	18/318	16/318	15/318	13/318	12/318
12000	Time/Fuel	6/700	6/700	6/650	5/650	5/600	5/600	5/550	5/500	4/500	4/450	4/400
	Dist/TAS	21/315	20/315	19/315	18/315	18/315	17/315	16/315	15/315	13/315	12/315	11/315
11000	Time/Fuel	6/650	5/650	5/600	5/600	5/600	5/550	5/550	4/500	4/450	4/400	3/400
	Dist/TAS	19/313	18/313	17/313	16/313	16/313	15/312	14/312	13/312	12/312	11/312	9/312
10000	Time/Fuel	5/600	5/600	5/600	5/550	5/550	4/500	4/500	4/450	4/450	3/400	3/350
	Dist/TAS	16/310	16/310	15/310	14/310	14/310	13/310	12/310	11/310	10/310	9/310	8/310
8000	Time/Fuel	4/550	4/500	4/500	4/500	4/450	4/450	4/450	3/400	3/350	3/350	3/300
	Dist/TAS	12/305	11/305	11/305	10/305	10/305	10/305	9/305	8/305	8/305	7/305	6/305
6000	Time/Fuel	4/450	4/450	3/400	3/400	3/400	3/400	3/350	3/350	3/300	2/300	2/250
	Dist/TAS	8/301	8/301	7/301	7/301	7/301	6/301	6/301	6/301	5/301	5/301	4/301
1500	Time/Fuel	2/250	2/250	2/250	2/250	2/250	2/250	2/250	2/200	2/200	2/200	1/150

Fuel Adjustment for high elevation airports	Airport Elevation	2000	4000	6000	8000	10000	12000
Effect on time and distance is negligible	Fuel Adjustment	-50	-100	-200	-250	-300	-400

Figure 4.5.1 En-route Climb 280/.74 (continued)

b) Cruise: "Cruise integrated range" tables

The cruise tables are published in "Cruise integrated range" tables, computed for a specified cruise speed and flight level (see next page). They allow quick determination of the cruise fuel consumption for a specified cruise air distance.

These tables are relatively easy to use: the difference of two weights published in the table corresponds to a consumed fuel amount and the difference of two distances associated to these two weights correspond to the range for this fuel weight.

Remember that these tables only allow determination of the cruise fuel. To obtain the trip fuel, it would be necessary to add the fuel amount required for climb, descent, as well as departure and arrival procedures.

Two important remarks relating to the use of the "Cruise integrated range" tables.

- The distance to be used in these tables is the air distance. It is thus necessary to convert the ground distance into air distance before completing these tables. For this purpose, you can use either the ground distance/air distance conversion graph provided by the manufacturer, or the conversion formula $D_{AIR} = D_{GROUND} \times (TAS / GS)$.
  Warning: In the second case, you may often be required to correct the TAS according to the outside air temperature difference with respect the ISA. The correction values are shown at the bottom of the table.

- The trip fuel published in the table is computed in ISA conditions. If there is a temperature difference, a correction should be applied according to the information at the bottom of the table.

All Engines Maximum Cruise Thrust Limits A/C Auto

PRESSURE ALTITUDE 31,000 ft LONG RANGE CRUISE

GROSS		0	100	200	300	400	500	600	700	800	900
WT. kg	TAS	CRUISE DISTANCE NAUTICAL AIR MILES									
35000	391	0	22	44	66	88	110	132	154	176	199
36000	395	221	242	264	286	308	330	352	374	395	417
37000	399	439	461	482	504	525	547	569	590	612	633
38000	403	655	676	698	719	740	762	783	804	825	847
39000	406	868	889	910	931	952	973	995	1016	1037	1058
40000	410	1079	1100	1120	1141	1162	1183	1204	1225	1245	1266
41000	414	1287	1308	1328	1349	1369	1390	1410	1431	1452	1472
42000	417	1493	1513	1533	1554	1574	1594	1615	1635	1655	1676
43000	420	1696	1716	1736	1756	1776	1796	1816	1837	1857	1877
44000	423	1897	1917	1936	1956	1976	1996	2016	2036	2056	2076
45000	425	2095	2115	2135	2154	2174	2194	2213	2233	2252	2272
46000	428	2292	2311	2331	2350	2369	2389	2408	2428	2447	2466
47000	430	2486	2505	2524	2543	2563	2582	2601	2620	2639	2658
48000	432	2678	2697	2716	2735	2754	2772	2791	2810	2829	2848
49000	433	2867	2886	2905	2924	2942	2961	2980	2998	3017	3036
50000	435	3055	3073	3092	3110	3129	3147	3166	3184	3203	3221
51000	436	3240	3258	3276	3295	3313	3331	3350	3368	3386	3405
52000	437	3423	3441	3459	3477	3495	3513	3531	3550	3568	3586
53000	437	3604	3622	3640	3657	3675	3693	3711	3729	3747	3765
54000	437	3783	3800	3818	3836	3853	3871	3889	3906	3924	3942
55000	437	3959	3977	3994	4012	4029	4047	4064	4082	4099	4117
56000	437	4134	4152	4169	4186	4203	4221	4238	4255	4272	4290
57000	437	4307	4324	4341	4358	4375	4392	4409	4426	4443	4461
58000	437	4478	4494	4511	4528	4545	4562	4579	4596	4612	4629
59000	437	4646	4663	4679	4696	4713	4729	4746	4763	4779	4796
60000	437	4813	4829	4845	4862	4878	4895	4911	4928	4944	4960
61000	437	4977	4993	5009	5025	5042	5058	5074	5090	5107	5123
62000	437	5139	5155	5171	5187	5203	5219	5235	5251	5267	5283
63000	437	5299	5315	5331	5346	5362	5378	5394	5410	5425	5441
64000	437	5457	5473	5488	5504	5519	5535	5550	5566	5582	5597
65000	437	5613	5628	5643	5659	5674	5690	5705	5720	5736	5751
66000	437	5766	5782	5797	5812	5827	5842	5857	5873	5888	5903
67000	437	5981	5933	5948	5963	5978	5993	6008	6023	6037	6052

NOTE 1: OPTIMUM WEIGHT FOR PRESSURE ALTITUDE IS 63,500 kg

A) THRUST LIMITED WEIGHT FOR ISA +10 AND COLDER EXCEEDS STRUCTURAL LIMIT
B) THRUST LIMITED WEIGHT FOR ISA +15 EXCEEDS STRUCTURAL LIMIT
C) THRUST LIMITED WEIGHT FOR ISA +20 EXCEEDS STRUCTURAL LIMIT

NOTE 2: ADJUSTMENTS FOR OPERATION AT NON-STANDARD TEMPERATURES

A) INCREASE FUEL REQUIRED BY 0.6 PERCENT PER 10 DEGREES C ABOVE ISA
B) DECREASE FUEL REQUIRED BY 0.6 PERCENT PER 10 DEGREES C BELOW ISA
C) INCREASE TAS BY 1 KNOT PER DEGREE C ABOVE ISA
D) DECREASE TAS BY 1 KNOT PER DEGREE C BELOW ISA

Figure 4.5.3.1 Long Range Cruise – Pressure Altitude 31,000 ft

Ground distance to air distance conversion graph.

As already specified, this graph is designed to convert the ground distance into air distance. It is jointly used with the "Cruise integrated range" tables.
It is relatively easy to use.

Example

See the graph on the next page.

True airspeed = 450 kt.
Ground distance = 500 NM.
Effective wind = 50 kt, headwind.
What is the corresponding air distance?

A) 504 NM B) 562 NM
C) 450 NM D) 615 NM

Answer
See correction on the graph.
The corresponding air distance is 560 NM (approx.).
Answer B.

The answer may also be obtained with the formula $D_{AIR} = D_{GROUND} \times (TAS / GS)$.
With GS = 450 + 50 = 400 kt
$D_{AIR} = 500 \times (450 / 400) = 562$ NM.

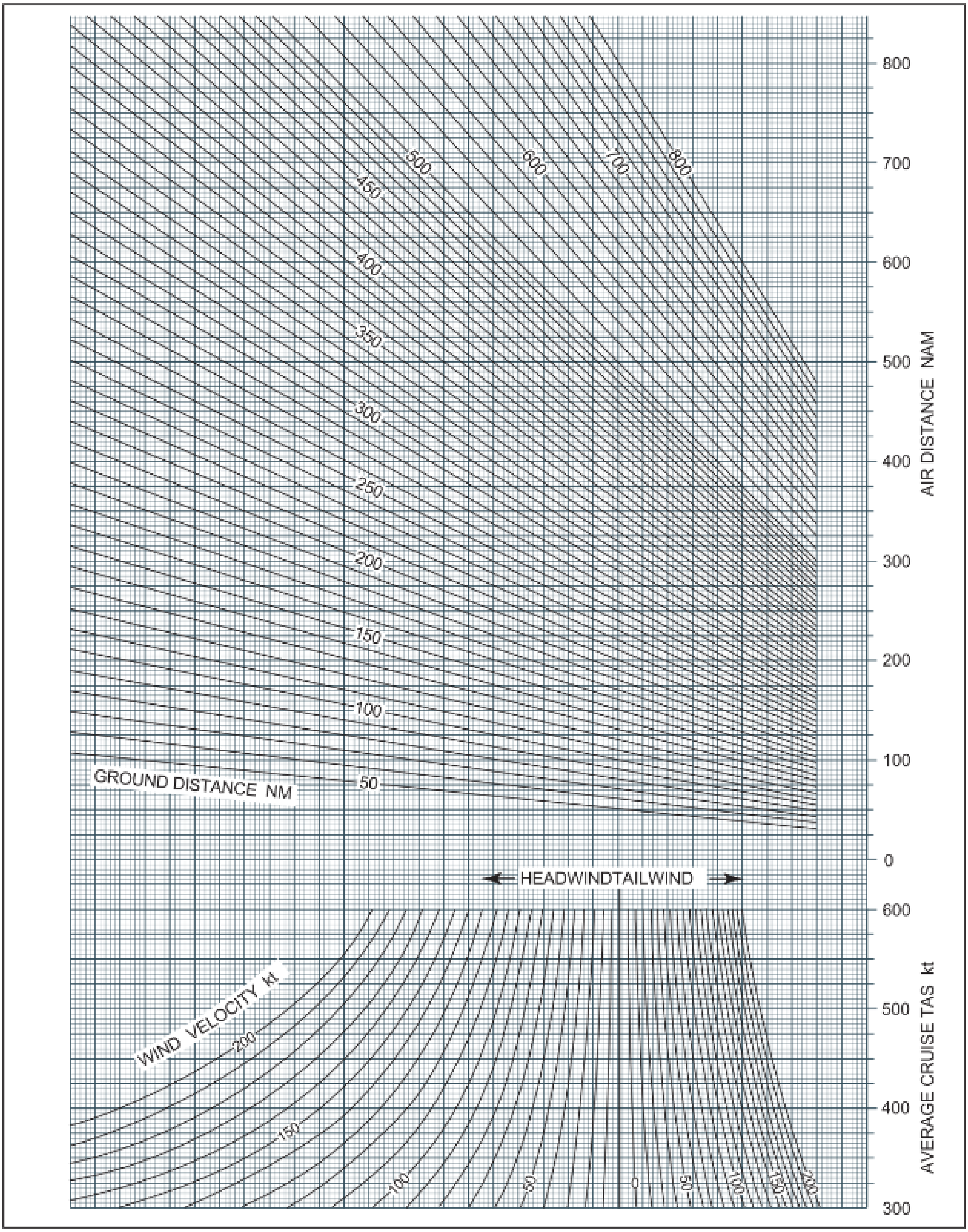


Figure 4.5.2 Wind Range Correction Graph

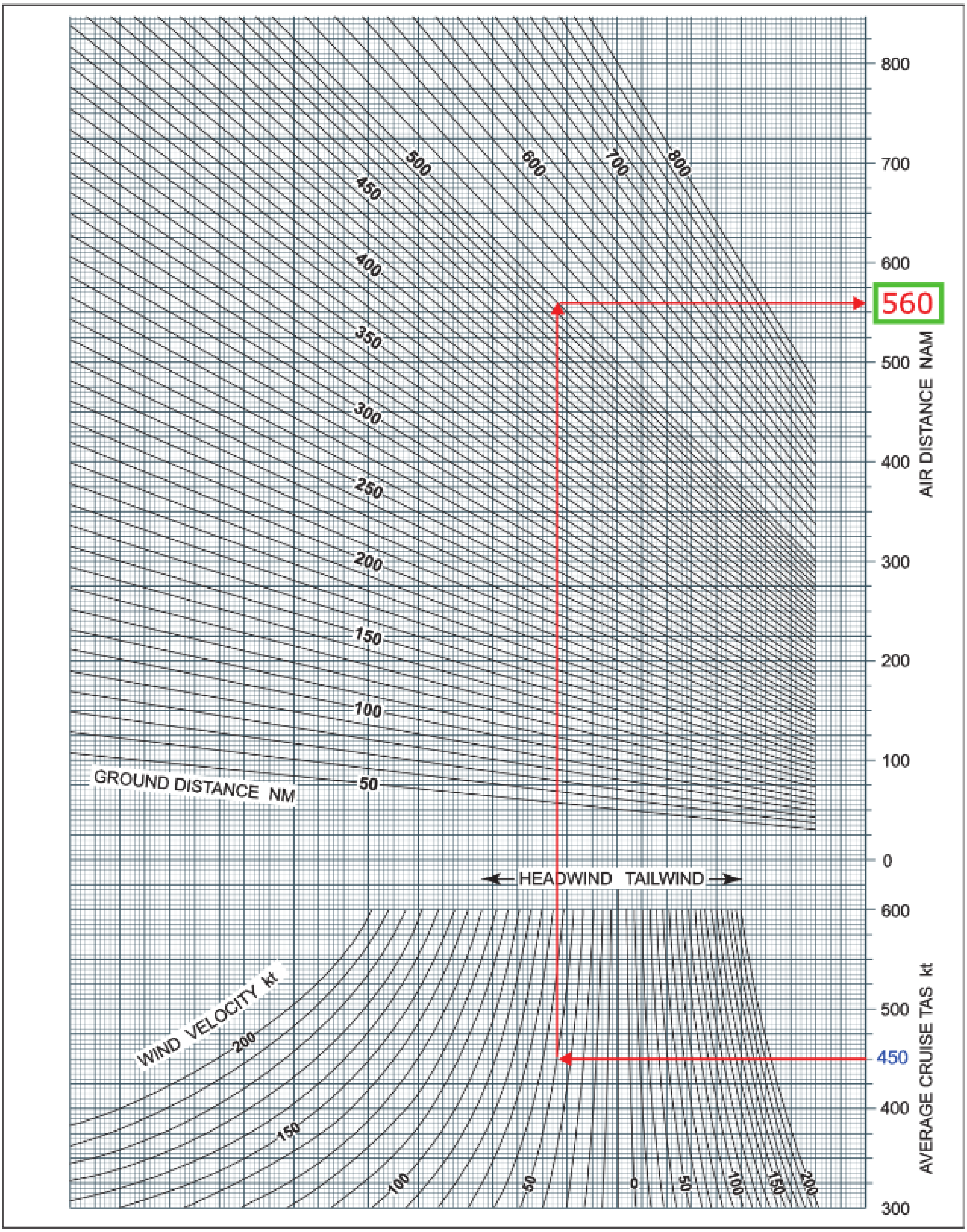


Figure 4.5. 2 Wind Range Correction Graph

B737 "Cruise integrated range" tables

The use of these graphs will be explained with the following example.

Example

See table 4.5.3.3 "Mach 0.78 Cruise – Pressure Altitude 30 000 ft" (see next page).
Available data:
A-B ground distance: 1,200 NM;
cruise Mach 0.78 at FL 300;
temperature: ISA – 14°C;
tailwind: 40 kt;
weight at A: 50,200 kg.
What is the cruise fuel required to cover the A-B segment?

A) 5,850 kg	B) 6,150 kg
C) 7,300 kg	D) 7,050 kg

Answer
See correction on next page.

a) Step 1: compute the air distance to cover between A and B.
The TAS is always specified in the "Cruise integrated range" table, either in the table heading for fixed Mach, or in the second column for long range Mach.
TAS (ISA) = 460 kt.
The correction at the bottom of the table (note 2) allows determination of the TAS at ISA – 14°C:
TAS (ISA – 14°C) = 460 – 14 = 446 kt.
Graph 4.5.2, "Wind Range Correction" allows the 1,200 NM ground distance to be converted into air distance. However, it is easier to obtain the result by directly applying the following formula:
$D_{AIR} = D_{GROUND}$ x (TAS / GS), with GS = 446 + 40 = 486 kt
D_{AIR} = 1,200 x (446 / 486) = 1,101 NM.

b) Step 2: read the "Cruise integrated range" table.
The table is computed for 100 kg weight steps. To increase the result accuracy, a linear interpolation can be performed between the two consecutive weight values.

	Weight (kg)	Air Miles(NM)
At segment start (point A)	50,200	2,800
Air distance to cover between A and B		1,101

End of segment (point B)	44,000	1,699

The fuel required in ISA conditions is 50,200 – 44,000 = 6,200 kg.

c) Step 3: fuel required corrected by the standard temperature difference.
The fuel required above is given in standard conditions. It must be corrected according if there is a temperature difference with respect to standard conditions. The temperature correction is specified at the bottom of the table (note 2). It is – 0.60 % for 10°C ΔISA.

At ISA – 14, the fuel correction is – 0,84 %, i.e. – 6,200 kg x 84 % = – 52 kg.
Required fuel = 6,200 – 52 = 6,148 kg.

Answer B.

All Engines Maximum Cruise Thrust Limits A/C Auto

PRESSURE ALTITUDE 30,000 ft MACH 0.78 CRUISE TAS 460 kt

GROSS WT. kg	0	100	200	300	400	500	600	700	800	900
	CRUISE DISTANCE NAUTICAL AIR MILES									
35000	0	19	38	57	77	96	115	135	154	173
36000	193	212	231	250	269	289	308	327	346	366
37000	385	404	423	442	461	480	499	519	538	557
38000	576	595	614	633	652	671	690	709	728	747
39000	766	785	804	823	842	860	879	898	917	936
40000	955	974	993	1011	1030	1049	1068	1086	1105	1124
41000	1143	1161	1180	1199	1217	1236	1255	1273	1292	1311
42000	1329	1348	1366	1385	1403	1422	1440	1459	1477	1496
43000	1514	1533	1551	1569	1588	1606	1624	1643	1661	1679
44000	1698	1716	1734	1752	1771	1789	1807	1825	1844	1862
45000	1880	1898	1916	1934	1952	1970	1988	2006	2024	2042
46000	2061	2078	2096	2114	2132	2150	2168	2186	2204	2222
47000	2239	2257	2275	2293	2310	2328	2346	2363	2381	2399
48000	2417	2434	2452	2469	2487	2504	2522	2539	2557	2574
49000	2592	2609	2627	2644	2661	2679	2696	2713	2731	2748
50000	2765	2783	2800	2817	2834	2851	2868	2886	2903	2920
51000	2937	2954	2971	2988	3005	3022	3039	3056	3073	3090
52000	3107	3123	3140	3157	3174	3191	3207	3224	3241	3258
53000	3274	3291	3308	3324	3341	3357	3374	3390	3407	3423
54000	3440	3456	3473	3489	3506	3522	3538	3555	3571	3587
55000	3604	3626	3636	3652	3668	3684	3701	3717	3733	3749
56000	3765	3781	3797	3813	3829	3845	3861	3877	3893	3909
57000	3925	3940	3956	3972	3988	4003	4019	4035	4050	4066
58000	4082	4097	4113	4128	4144	4160	4175	4191	4206	4222
59000	4237	4252	4268	4283	4298	4314	4329	4344	4360	4375
60000	4390	4405	4421	4436	4451	4466	4481	4496	4511	4526
61000	4541	4556	4571	4586	4601	4616	4631	4646	4661	4676
62000	4691	4705	4720	4735	4749	4764	4779	4794	4808	4823
63000	4838	4852	4867	4881	4896	4910	4925	4939	4954	4968
64000	4983	4997	5011	5025	5040	5054	5068	5083	5097	5111
65000	5125	5140	5154	5168	5182	5196	5210	5224	5238	5252
66000	5266	5280	5294	5308	5322	5335	5349	5363	5377	5391
67000	5405	5418	5432	5446	5459	5473	5487	5500	5514	5528

NOTE 1: OPTIMUM WEIGHT FOR PRESSURE ALTITUDE IS 64,200 kg
A) THRUST LIMITED WEIGHT FOR ISA +10 AND COLDER EXCEEDS STRUCTURAL LIMIT
B) THRUST LIMITED WEIGHT FOR ISA +15 EXCEEDS STRUCTURAL LIMIT
C) THRUST LIMITED WEIGHT FOR ISA +20 EXCEEDS STRUCTURAL LIMIT

NOTE 2: ADJUSTMENTS FOR OPERATION AT NON-STANDARD TEMPERATURES
A) INCREASE FUEL REQUIRED BY 0.6 PERCENT PER 10 DEGREES C ABOVE ISA
B) DECREASE FUEL REQUIRED BY 0.6 PERCENT PER 10 DEGREES C BELOW ISA
C) INCREASE TAS BY 1 KNOT PER DEGREE C ABOVE ISA
D) DECREASE TAS BY 1 KNOT PER DEGREE C BELOW ISA

Figure 4.5.3.3 Mach 0.78 Cruise – Pressure Altitude 30,000 ft

All Engines   Maximum Cruise Thrust Limits   A/C Auto

PRESSURE ALTITUDE 30,000 ft   MACH 0.78 CRUISE   TAS 460 kt

GROSS WT. kg	0	100	200	300	400	500	600	700	800	900
	CRUISE DISTANCE NAUTICAL AIR MILES									
35000	0	19	38	57	77	96	115	135	154	173
36000	193	212	231	250	269	289	308	327	346	366
37000	385	404	423	442	461	480	499	519	538	557
38000	576	595	614	633	652	671	690	709	728	747
39000	766	785	804	823	842	860	879	898	917	936
40000	955	974	993	1011	1030	1049	1068	1086	1105	1124
41000	1143	1161	1180	1199	1217	1236	1255	1273	1292	1311
42000	1329	1348	1366	1385	1403	1422	1440	1459	1477	1496
43000	1514	1533	1551	1569	1588	1606	1624	1643	1661	1679
44000	1698	1716	1734	1752	1771	1789	1807	1825	1844	1862
45000	1880	1898	1916	1934	1952	1970	1988	2006	2024	2042
46000	2061	2078	2096	2114	2132	2150	2168	2186	2204	2222
47000	2239	2257	2275	2293	2310	2328	2346	2363	2381	2399
48000	2417	2434	2452	2469	2487	2504	2522	2539	2557	2574
49000	2592	2609	2627	2644	2661	2679	2696	2713	2731	2748
50000	2765	2783	2800	2817	2834	2851	2868	2886	2903	2920
51000	2937	2954	2971	2988	3005	3022	3039	3056	3073	3090
52000	3107	3123	3140	3157	3174	3191	3207	3224	3241	3258
53000	3274	3291	3308	3324	3341	3357	3374	3390	3407	3423
54000	3440	3456	3473	3489	3506	3522	3538	3555	3571	3587
55000	3604	3626	3636	3652	3668	3684	3701	3717	3733	3749
56000	3765	3781	3797	3813	3829	3845	3861	3877	3893	3909
57000	3925	3940	3956	3972	3988	4003	4019	4035	4050	4066
58000	4082	4097	4113	4128	4144	4160	4175	4191	4206	4222
59000	4237	4252	4268	4283	4298	4314	4329	4344	4360	4375
60000	4390	4405	4421	4436	4451	4466	4481	4496	4511	4526
61000	4541	4556	4571	4586	4601	4616	4631	4646	4661	4676
62000	4691	4705	4720	4735	4749	4764	4779	4794	4808	4823
63000	4838	4852	4867	4881	4896	4910	4925	4939	4954	4968
64000	4983	4997	5011	5025	5040	5054	5068	5083	5097	5111
65000	5125	5140	5154	5168	5182	5196	5210	5224	5238	5252
66000	5266	5280	5294	5308	5322	5335	5349	5363	5377	5391
67000	5405	5418	5432	5446	5459	5473	5487	5500	5514	5528

NOTE 1: OPTIMUM WEIGHT FOR PRESSURE ALTITUDE IS 64,200 kg
A) THRUST LIMITED WEIGHT FOR ISA +10 AND COLDER EXCEEDS STRUCTURAL LIMIT
B) THRUST LIMITED WEIGHT FOR ISA +15 EXCEEDS STRUCTURAL LIMIT
C) THRUST LIMITED WEIGHT FOR ISA +20 EXCEEDS STRUCTURAL LIMIT

NOTE 2: ADJUSTMENTS FOR OPERATION AT NON-STANDARD TEMPERATURES
A) INCREASE FUEL REQUIRED BY 0.6 PERCENT PER 10 DEGREES C ABOVE ISA
B) DECREASE FUEL REQUIRED BY 0.6 PERCENT PER 10 DEGREES C BELOW ISA
C) INCREASE TAS BY 1 KNOT PER DEGREE C ABOVE ISA
D) DECREASE TAS BY 1 KNOT PER DEGREE C BELOW ISA

Figure 4.5.3.3 Mach 0.78 Cruise – Pressure Altitude 30,000 ft

c) Descent

The B737-400 descent tables are designed for the following speed laws:

- M.74/250 kt IAS: economy descent;
- M.70/280/250 kt IAS: turbulence descent.

The table data includes a direct approach procedure with a 2-minutes and 100 kg fuel fixed values. These tables allow determination of the time, consumption and air distance travelled during descent from the cruise level. They are easy to use.

The only point to emphasize concerns computation of the ground distance travelled. If the ground distance is requested instead of the air distance, the following formula should be applied: $D_{GROUND} = D_{AIR} \times (GS / TAS)$.

In this case, the true airspeed is computed with an average altitude, taking the temperature difference with respect to ISA into account.

Example

See the graph below.

Landing weight = 45,000 kg; cruise altitude = 30,000 ft; effective wind = 5kt headwind; temperature = ISA; descent regime: M.74/250 kt.

What are the time, consumption and ground distance to descend?

A) 25 min; 302 kg; 98 NM; 79 NM B) 19.5 min; 277.5 kg; 90 NM; 75 NM

C) 32 min; 325 kg; 102 NM; 87 NM D) 17.5 min; 265 kg; 85 NM; 71 NM

0.74 M/250 KIAS (Economy) Descent

PRESS. ALT. ft	TIME min	FUEL kg	AIR DISTANCE TRAVELLED NM				
			LANDING WEIGHT kg				
			35,000	45,000	55,000	65,000	75,000
37,000	23	295	98	109	114	114	110
35,000	22	290	94	105	110	110	106
33,000	21	285	89	99	103	103	101
31,000	20	280	83	93	97	98	95
29,000	19	275	78	87	91	91	89
27,000	19	270	73	81	85	85	83
25,000	18	260	68	75	79	79	77
23,000	16	255	63	69	72	73	71
21,000	15	245	58	64	66	67	66
19,000	14	235	53	58	60	61	60
17,000	13	225	48	52	54	55	54
15,000	12	215	43	46	48	49	48
10,000	9	185	30	32	33	34	33
5,000	6	140	18	18	18	18	18
3,700	5	130	14	14	14	14	14

0.74 M/250 KIAS (Economy) Descent

PRESS. ALT. ft	TIME min	FUEL kg	AIR DISTANCE TRAVELLED NM				
			LANDING WEIGHT kg				
			35,000	45,000	55,000	65,000	75,000
37,000	23	295	98	109	114	114	110
35,000	22	290	94	105	110	110	106
33,000	21	285	89	99	103	103	101
31,000	20	280	83	93	97	98	95
	19,5	277,5		90			
29,000	19	275	78	87	91	91	89
27,000	19	270	73	81	85	85	83
25,000	18	260	68	75	79	79	77
23,000	16	255	63	69	72	73	71
21,000	15	245	58	64	66	67	66
19,000	14	235	53	58	60	61	60
17,000	13	225	48	52	54	55	54
15,000	12	215	43	46	48	49	48
10,000	9	185	30	32	33	34	33
5,000	6	140	18	18	18	18	18
3,700	5	130	14	14	14	14	14

Answer

• Reading of the above table gives the following answers:
time = 19.5 minutes;
consumption = 277.5 kg;
air distance = 90 NM.

• Computing the ground distance to descend
$D_{GROUND} = D_{AIR}$ (GS / TAS).
The average altitude for computing the TAS is 15,000 ft.
So, using the computer, TAS (250 kt IAS at 15,000 ft and ISA) = 315 kt
GS = 315 + 50 = 265 kt
D_{GROUND} = (90 x 265) / 315 = 75 NM

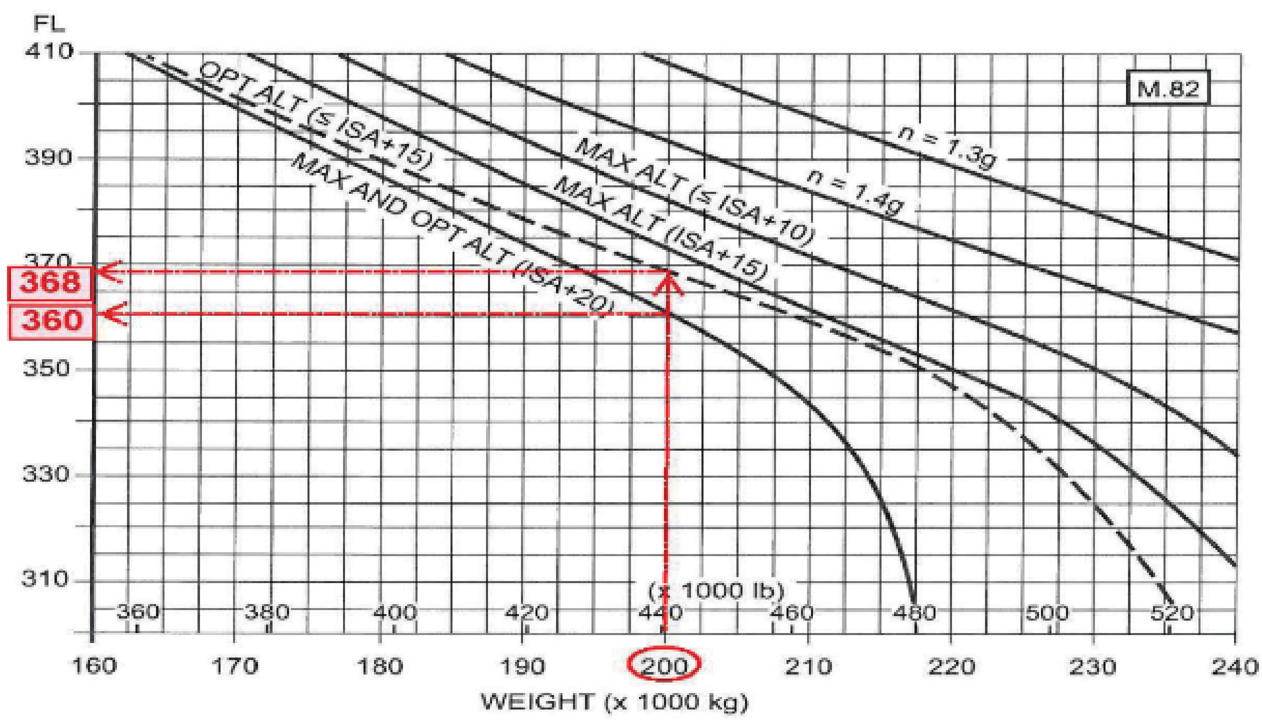
Answer B.

2.5 - Computing the fuel for A310

In comparison with fuel computation for the B737, we will discuss the different computing parameters for the A310:

- determining the optimum altitude;
- computing the trip fuel for a standard trip:
  method 1: using the "Flight Planning From Brake Release To Landing" tables;
  method 2: using the "Cruise integrated range" and climb and descent tables.

2.5.1 - Optimum altitude



The "Optimum altitude" graphs are designed for different speed laws (long range cruise, M.80, M.82, etc.).
The above graph is computed for M.82. It allows determination of the optimum altitude, but also maximum altitudes obtained with the maximum cruise thrust at different temperatures, as well as the 1.3 g and 1.4 g maneuver limits.

The example shown on the graph indicates, for a 200 t:

- a 36,800 ft optimum altitude for a temperature ≤ ISA + 15°C;
- a 36,000 ft optimum altitude for ISA + 20°C.

NB. In principle, the optimum altitude hardly varies according to the temperature (see book 032 Performance). In this case, the maximum cruise altitude at ISA + 20°C is below the optimum altitude. It is thus physically impossible to reach: the optimum altitude is then limited by the ISA + 20°C maximum cruise altitude.

2.5.2 - Method 1: Computing the trip fuel for a standard trip with the "Flight Planning From Brake Release To Landing" tables

a) Ground distance to air distance conversion table

This table is relatively easy to use. It is based on the following formula: $D_{AIR} = D_{GROUND} \times (TAS / GS)$.

Example: Ground distance to air distance conversion table for M.82, on the next page page.

b) "Flight Planning From Brake Release To Landing" tables

The "Flight Planning From Brake Release To Landing" tables allow quick determination of the trip fuel and estimated flight time to cover a specified air distance.

They are designed with the following computation criteria:

- climb (250 kt/300 kt/M.80); cruise (M.80 or M.82 or M.84 or LR); descent (cruise Mach/300 kt/250 kt);
- standard condition (ISA);
- reference landing weight: 140,000 kg;
- CG = 37 %;
- normal air conditioning;
- anti-icing OFF.

Thus, when the computing conditions differ from those in the above computing criteria, the appropriate fuel corrections should be applied:

- the landing weight and bleed corrections are shown in the tables;
- for temperature correction, apply the following rule for each degree above standard temperature (correction formula provided for the exam in an appendix): 0.010 (kg/°C/NM) x Δ ISA (°C) x air distance (NM).

The use of these graphs will be explained with the following example.

Example
See tables on next pages.
Ground distance travelled: 2,000 NM; cruise flight level: FL 300; cruise speed: M.82 (true air speed = 470 kt); headwind: 30 kt; planned landing weight at destination: 160,000 kg; temperature: ISA; CG: 37 %; total anti-icing ON; air conditioning "HI".

The fuel required to perform this flight is:
A) 27,950 kg
B) 28,450 kg
C) 29,650 kg
D) 25,920 kg

GROUND DIST (NM)	AIR DISTANCE (NM)						
	TAIL WIND		WIND COMPONENT (KTS)			HEAD WIND	
	+150	+100	+50	0	-50	-100	-150
10	8	8	9	10	11	13	15
20	15	17	18	20	22	25	29
30	23	25	27	30	34	38	44
40	30	33	36	40	45	51	59
50	38	41	45	50	56	63	73
100	76	83	90	100	112	127	146
200	152	165	181	200	224	254	293
300	228	248	271	300	335	381	439
400	304	330	362	400	447	507	586
500	380	413	452	500	559	634	732
1000	759	825	904	1000	1118	1268	1465
1500	1139	1238	1357	1500	1677	1903	2197
2000	1518	1651	1809	2000	2237	2537	2930
2500	1898	2063	2261	2500	2796	3171	3662
3000	2277	2476	2713	3000	3355	3805	4395
3500	2657	2889	3165	3500	3914	4439	5127
4000	3036	3302	3617	4000	4473	5073	5860
4500	3416	3714	4070	4500	5032	5708	6592
5000	3795	4127	4522	5000	5591	6342	7324
5500	4175	4540	4974	5500	6151	6976	8057
6000	4555	4952	5426	6000	6710	7610	8789
6500	4934	5365	5878	6500	7269	8244	9522
7000	5314	5778	6330	7000	7828	8878	10254
7500	5693	6190	6783	7500	8387	9513	10987
8000	6073	6603	7235	8000	8946	10147	11719
8500	6452	7016	7687	8500	9506	10781	12451
9000	6832	7428	8139	9000	10065	11415	13184
9500	7211	7841	8591	9500	10624	12049	13916
10000	7591	8254	9043	10000	11183	12683	14649

M.82

Ground distance to air distance conversion table.

FLIGHT PLANNING FROM BREAKE RELEASE TO LANDING CLIMB: 250KTS/300KTS/M.80 - CRUISE: M.82 - DESCENT: M.82/300KTS/250KTS IMC PROCEDURE: 240 KG (6 MIN)		
REF. LANDING WEIGHT = 140.000 KG NORMAL AIR CONDITIONING ANTI ICING OFF	ISA CG = 37,0 %	FUEL CONSUMED (KG) TIME (H.MIN)

AIR DIS. (NM)	FLIGHT LEVEL						CORRECTION ON FUEL CONSUMPTION (KG/1.000 KG)		
	310	330	350	370	390	410	FL310 FL330	FL350 FL370	FL390 FL410
200	3537 0.39	3531 0.39					11		
300	4764 0.51	4684 0.52	4622 0.52	4579 0.52	4555 0.52	4548 0.52	13	16	18
400	5993 1.04	5840 1.04	5711 1.04	5609 1.05	5536 1.05	5489 1.05	16	18	22
500	7225 1.16	6998 1.17	6803 1.17	6642 1.17	6519 1.17	6434 1.17	18	21	25
600	8460 1.29	8160 1.29	7898 1.30	7679 1.30	7506 1.30	7383 1.30	20	24	29
700	9698 1.41	9323 1.42	8996 1.43	8718 1.43	8496 1.43	8335 1.43	22	27	32
800	10938 1.54	10490 1.55	10096 1.55	9759 1.56	9490 1.56	9291 1.56	25	29	36
900	12180 2.06	11659 2.07	11199 2.08	10804 2.08	10486 2.09	10251 2.09	27	32	40
1000	13425 2.19	12831 2.20	12305 2.21	11851 2.21	11485 2.21	11213 2.21	29	35	44
1100	14673 2.31	14005 2.32	13413 2.33	12901 2.34	12487 2.34	12180 2.34	32	38	48
1200	15924 2.44	15182 2.45	14525 2.46	13954 2.47	13492 2.47	13149 2.47	34	41	51
1300	17178 2.56	16363 2.58	15640 2.59	15010 3.00	14501 3.00	14123 3.00	37	44	55
1400	18434 3.09	17546 3.10	16758 3.12	16070 3.12	15514 3.12	15101 3.12	39	47	59
1500	19693 3.21	18732 3.23	17879 3.24	17132 3.25	16530 3.25	16083 3.25	42	50	64
1600	20955 3.34	19921 3.36	19003 3.37	18197 3.38	17550 3.38	17069 3.38	45	53	68
1700	22221 3.46	21114 3.48	20129 3.50	19266 3.51	18574 3.51	18060 3.51	47	56	72
1800	23489 3.59	22310 4.01	21260 4.03	20337 4.04	19601 4.04	19054 4.04	50	59	77
1900	24761 4.11	23508 4.13	22394 4.15	21412 4.16	20632 4.16	20052 4.16	53	63	82
2000	26035 4.24	24710 4.26	23531 4.28	22491 4.29	21667 4.29	21067 4.29	56	66	87
2100	27311 4.37	25914 4.39	24671 4.41	23573 4.42	22707 4.42	22078 4.42	58	69	92
2200	28591 4.49	27122 4.51	25814 4.53	24658 4.55	23750 4.55	23093 4.55	61	73	97
2300	29875 5.02	28333 5.04	26960 5.06	25746 5.07	24796 5.08	24113 5.08	64	76	102
2400	31161 5.14	29546 5.16	28110 5.19	26837 5.20	25846 5.20	25136 5.20	67	79	107
2500	32450 5.27	30764 5.29	29263 5.32	27932 5.33	26920 5.33	26165 5.33	70	82	113
2600	33742 5.39	31985 5.42	30419 5.44	29030 5.46	27982 5.46	27198 5.46	73	86	118
2700	35038 5.52	33209 5.54	31577 5.57	30131 5.59	29047 5.59	28237 5.59	75	90	122

PACK FLOW LO	PACK FLOW HI OR/AND CARGO COOL ON	ENGINE ANTI ICE ON	TOTAL ANTI ICE ON
ΔFUEL = -0,4 %	ΔFUEL = +1 %	ΔFUEL = +1,5 %	ΔFUEL = +7 %

"Flight Planning From Brake Release To Landing" table.

Answer
See correction on graph.

a) Computing the air distance
We can use the ground distance/air distance conversion table of the previous section, but it is easier and faster to apply the following formula:
Air distance = ground distance x (TAS / GS)
= 2,000 x (470 / 470 – 30)
= 2,136 NM
Note: for this type of question, if the TAS is not given in the question text, we need to use the "Ground/Air distance" table to convert ground distance in air distance.

b) Reading the "Flight Planning From Brake Release To Landing" table (in red in the table)
With FL 330, reading the table gives the following information:
D_{AIR} = 2,100 NM ⇨ consumption = 25,914 kg;
D_{AIR} = 2,300 NM ⇨ consumption = 27,122 kg;
By interpolation, with a 2,136 NM air distance, the trip fuel is 26,349 kg.

c) Trip fuel correction according to bleed and weight (in blue in the table)
The fuel correction depending on bleed is shown at the bottom of the table.
total anti-icing ON correction: + 7 %;
Pack HI (High) correction: + 1 %.
The air bleed correction is: 26,349 x 1.08 = 28,457 kg.

This is determined with a 140,000 kg reference landing weight. As the planned landing weight is 160,000 kg, we must apply a correction due to the weight difference between 160,000 kg and 140,000 kg.
Reading the weight correction column on the right of the table indicates a 59 kg correction for a 1,000 kg difference against 140,000 kg, i.e. a total weight correction equal to 59 x (160,000 – 140,000)/1,000 = 1,180 kg.
Total fuel consumption = 28,457 + 1,180 = 29,637 kg.

Answer **C**.

FLIGHT PLANNING FROM BREAKE RELEASE TO LANDING CLIMB: 250KTS/300KTS/M.80 - CRUISE: M.82 - DESCENT: M.82/300KTS/250KTS IMC PROCEDURE: 240 KG (6 MIN)									
REF. LANDING WEIGHT = 140.000 KG NORMAL AIR CONDITIONING ANTI ICING OFF			ISA CG = 37,0 %		FUEL CONSUMED (KG) TIME (H.MIN)				
AIR DIS. (NM)	FLIGHT LEVEL						CORRECTION ON FUEL CONSUMPTION (KG/1.000 KG)		
	310	330	350	370	390	410	FL310 FL330	FL350 FL370	FL390 FL410
200	3537 0.39	3531 0.39					11		
300	4764 0.51	4684 0.52	4622 0.52	4579 0.52	4555 0.52	4548 0.52	13	16	18
400	5993 1.04	5840 1.04	5711 1.04	5609 1.05	5536 1.05	5489 1.05	16	18	22
500	7225 1.16	6998 1.17	6803 1.17	6642 1.17	6519 1.17	6434 1.17	18	21	25
600	8460 1.29	8160 1.29	7898 1.30	7679 1.30	7506 1.30	7383 1.30	20	24	29
700	9698 1.41	9323 1.42	8996 1.43	8718 1.43	8496 1.43	8335 1.43	22	27	32
800	10938 1.54	10490 1.55	10096 1.55	9759 1.56	9490 1.56	9291 1.56	25	29	36
900	12180 2.06	11659 2.07	11199 2.08	10804 2.08	10486 2.09	10251 2.09	27	32	40
1000	13425 2.19	12831 2.20	12305 2.21	11851 2.21	11485 2.21	11213 2.21	29	35	44
1100	14673 2.31	14005 2.32	13413 2.33	12901 2.34	12487 2.34	12180 2.34	32	38	48
1200	15924 2.44	15182 2.45	14525 2.46	13954 2.47	13492 2.47	13149 2.47	34	41	51
1300	17178 2.56	16363 2.58	15640 2.59	15010 3.00	14501 3.00	14123 3.00	37	44	55
1400	18434 3.09	17546 3.10	16758 3.12	16070 3.12	15514 3.12	15101 3.12	39	47	59
1500	19693 3.21	18732 3.23	17879 3.24	17132 3.25	16530 3.25	16083 3.25	42	50	64
1600	20955 3.34	19921 3.36	19003 3.37	18197 3.38	17550 3.38	17069 3.38	45	53	68
1700	22221 3.46	21114 3.48	20129 3.50	19266 3.51	18574 3.51	18060 3.51	47	56	72
1800	23489 3.59	22310 4.01	21260 4.03	20337 4.04	19601 4.04	19054 4.04	50	59	77
1900	24761 4.11	23508 4.13	22394 4.15	21412 4.16	20632 4.16	20052 4.16	53	63	82
2000	26035 4.24	24710 4.26	23531 4.28	22491 4.29	21667 4.29	21067 4.29	56	66	87
2100	27311 4.37	25914 4.39	24671 4.41	23573 4.42	22707 4.42	22078 4.42	58	69	92
2200	2859[illegible] 4.49	27122 4.51	25814 4.53	24658 4.55	23750 4.55	23093 4.55	61	73	97
2300	29875 5.02	28333 5.04	26960 5.06	25746 5.07	24796 5.08	24113 5.08	64	76	102
2400	31161 5.14	29546 5.16	28110 5.19	26837 5.20	25846 5.20	25136 5.20	67	79	107
2500	32450 5.27	30764 5.29	29263 5.32	27932 5.33	26920 5.33	26165 5.33	70	82	113
2600	33742 5.39	31985 5.42	30419 5.44	29030 5.46	27982 5.46	27198 5.46	73	86	118
2700	35038 5.52	33209 5.54	31577 5.57	30131 5.59	29047 5.59	28237 5.59	75	90	122
PACK FLOW LO ΔFUEL = -0,4 %		PACK FLOW HI OR/AND CARGO COOL ON ΔFUEL = +1 %			ENGINE ANTI ICE ON ΔFUEL = +1,5 %		TOTAL ANTI ICE ON ΔFUEL = +7 %		

2.5.3 - Analytical method: "Cruise integrated range" tables and climb and descent correction tables

The A310 "Cruise integrated range" tables (see below) are designed according to the same principles as for the B737. They were computed for a specified cruise speed and a flight level and allow quick determination of cruise fuel consumption for a specified air distance.

For a different flight condition from the one of the table, corrections indicated at the bottom of the table should be taken into account.

The trip fuel computing principle is slightly different from the B737: to obtain the trip fuel, complete the "Cruise integrated range" table with the total trip air distance corresponding to the distance from overhead of the departure airport to overhead of the destination airport, in order to read the fuel amount required to cover this distance.

The climb and descent fuel corrections published by the manufacturer should be taken into account to obtain the final trip fuel (see next pages).

INTEGRATED CRUISE											
MAX. CRUISE THRUST LIMITS NORMAL AIR CONDITIONING ANTI-ICING OFF				ISA CG = 37,0 %		DISTANCE (NM) TIME (MIN)		LR		FL 350	
WEIGHT (1000 KG)	0	.2	.4	.6	.8	1.0	1.2	1.4	1.6	1.8	TAS (KTS)
126	0	22	43	65	87	108	130	151	173	194	377
	0	3	7	10	14	17	21	24	27	31	
128	216	237	259	280	302	323	344	366	387	408	385
	34	37	41	44	47	51	54	57	60	64	
130	430	451	472	493	514	536	557	578	599	620	392
	67	70	73	77	80	83	86	89	93	96	
132	641	662	683	704	725	746	767	788	809	829	400
	99	102	105	108	112	115	118	121	124	127	
134	850	871	892	913	933	954	975	995	1016	1037	411
	130	133	136	139	142	145	148	151	154	157	
136	1057	1078	1099	1119	1140	1160	1181	1201	1222	1242	418
	160	163	166	169	172	175	178	180	183	186	
138	1263	1283	1304	1324	1345	1365	1385	1406	1426	1446	420
	189	192	195	198	201	204	207	210	213	215	
140	1467	1487	1507	1528	1548	1568	1589	1609	1629	1649	421
	218	221	224	227	230	233	236	239	241	244	
142	1669	1690	1710	1730	1750	1770	1790	1810	1830	1850	423
	247	250	253	256	259	261	264	267	270	273	
144	1870	1890	1910	1930	1950	1970	1990	2010	2030	2050	425
	276	278	281	284	287	290	292	295	298	301	
146	2070	2090	2109	2129	2149	2169	2189	2208	2228	2248	427
	304	306	309	312	315	318	320	323	326	329	
148	2268	2287	2307	2327	2346	2366	2385	2405	2425	2444	429
	331	334	337	340	342	345	348	351	353	356	
150	2464	2483	2503	2522	2542	2561	2581	2600	2619	2639	431
	359	361	364	367	370	372	375	378	380	383	
152	2658	2678	2697	2716	2736	2755	2774	2793	2813	2832	434
	386	388	391	394	396	399	402	404	407	410	
154	2851	2870	2889	2909	2928	2947	2966	2985	3004	3023	437
	412	415	418	420	423	425	428	431	433	436	
156	3042	3062	3081	3100	3119	3138	3157	3175	3194	3213	439
	439	441	444	446	449	452	454	457	459	462	
158	3232	3251	3270	3289	3308	3327	3345	3364	3383	3402	441
	464	467	470	472	475	477	480	482	485	487	
160	3421	3439	3458	3477	3495	3514	3533	3551	3570	3589	442
	490	493	495	498	500	503	505	508	510	513	
162	3607	3626	3645	3663	3682	3700	3719	3737	3756	3774	444
	515	518	520	523	525	528	530	533	535	538	
164	3793	3811	3830	3848	3866	3885	3903	3922	3940	3958	446
	540	543	545	548	550	553	555	558	560	563	
166	3977	3995	4013	4031	4050	4068	4086	4104	4123	4141	448
	565	567	570	572	575	577	580	582	585	587	
168	4159	4177	4195	4213	4232	4250	4268	4286	4304	4322	450
	589	592	594	597	599	601	604	606	609	611	
170	4340	4358	4376	4394	4412	4430	4448	4466	4484	4502	451
	614	616	618	621	623	625	628	630	633	635	
172	4520	4538	4555	4573	4591	4609	4627	4645	4662	4680	453
	637	640	642	644	647	649	652	654	656	659	
PACK FLOW LO ΔFUEL = -0,4 %			PACK FLOW HI OR/ AND CARGO COOL ON ΔFUEL = +1 %			ENGINE ANTI ICE ON ΔFUEL = +1,5 %			TOTAL ANTI ICE ON ΔFUEL = +6 %		

"Cruise integrated range" table: LR at level 350

Climb correction tables

Climb to a fixed level (applicable to LR, M.80, M.82 and M.84):

FL	CORRECTION ON FUEL CONSUMPTION (1000 kg) WEIGHT AT BRAKE RELEASE (1000 kg)											time correction
	140	150	160	170	180	190	200	210	220	230	240	
410	2.3	2.4	2.6	2.7	2.7	-	-	-	-	-	-	5 min
390	2.2	2.3	2.5	2.6	2.8	2.9	-	-	-	-	-	5 min
370	2.1	2.2	2.4	2.5	2.7	2.8	2.9	-	-	-	-	5 min
350	2.0	2.1	2.2	2.4	2.5	2.7	2.8	2.9	3.0	3.1	-	6 min
330	1.9	2.0	2.1	2.3	2.4	2.5	2.7	2.8	2.9	3.0	3.1	6 min
310	1.8	1.9	2.0	2.2	2.3	2.4	2.5	2.7	2.8	2.8	3.0	5 min
290	1.7	1.8	1.9	2.0	2.1	2.3	2.4	2.5	2.6	2.8	2.9	5 min
270	1.8	1.7	1.8	1.9	2.0	2.1	2.2	2.4	2.5	2.6	2.7	5 min
250	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.4	2.5	4 min
200	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	3 min
150	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.5	1.6	1.7	1.8	3 min
100	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.3	3 min

Climb to optimum cruise altitude:

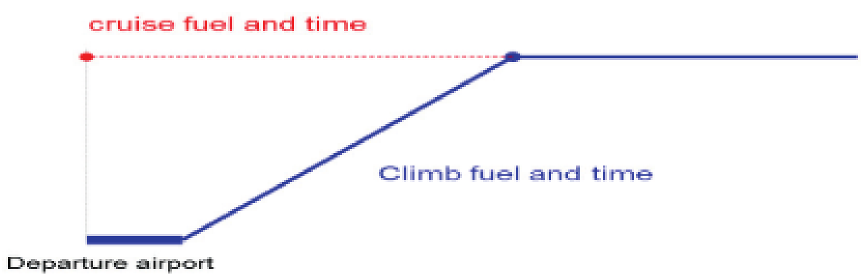
CLIMB TO OPTIMUM FL

SPEED	CORRECTION ON FUEL CONSUMPTION (1000 kg) WEIGHT AT BRAKE RELEASE (1000 kg)											time correction
	140	150	160	170	180	190	200	210	220	230	240	
LRC	2.3	2.4	2.6	2.7	2.8	2.8	2.8	3.0	3.0	3.0	3.0	6 min
M.80	2.3	2.4	2.6	2.6	2.7	2.8	2.8	3.0	3.0	3.0	3.0	6 min
M.82	2.2	2.4	2.6	2.6	2.6	2.8	2.8	2.9	3.0	3.0	3.0	6 min
M.84	2.2	2.3	2.4	2.5	2.5	2.5	2.6	2.7	2.8	2.8	2.8	7 min

The climb correction in the above tables represents the fuel consumption and flight time difference between:

- climb from brake release to cruise level;
- cruise corresponding to the same level and from overhead of the departure airport.

Note. Complete the above tables with the weight on brake release.



Climb correction = climb fuel and time – cruise fuel and time

Descent correction tables

Descent from a fixed cruise level:

LONG RANGE CRUISE

FL	CORRECTION ON FUEL CONSUMPTION (1000 kg)							
	WEIGHT OVERHEAD DESTINATION (1000 kg)							time correction
	130	140	150	160	170	180	190	
290 and above	0.6	0.7	0.7	0.8	0.9	1.0	1.1	10 min
270	0.6	0.7	0.7	0.8	0.9	0.9	1.0	8 min
250	0.6	0.6	0.7	0.7	0.8	0.8	0.9	
200	0.5	0.6	0.6	0.7	0.7	0.8	0.8	
150	0.5	0.5	0.6	0.6	0.6	0.7	0.7	
100	0.4	0.4	0.4	0.5	0.5	0.5	0.5	

Descent from optimum cruise altitude:

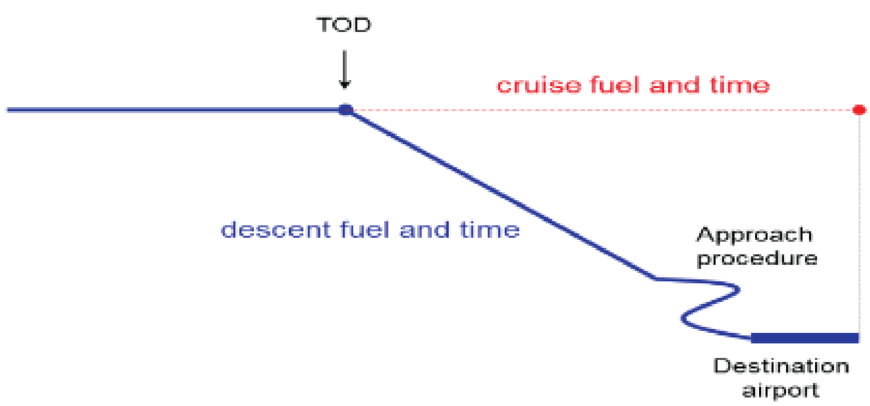
LRC, M.80, M.82, M.84 FROM OPTIMUM FL

CORRECTION ON FUEL CONSUMPTION (1000 kg)							
WEIGHT OVERHEAD DESTINATION (1000 kg)							time correction
130	140	150	160	170	180	190	
0.6	0.7	0.8	0.9	1.0	1.0	1.1	11 min

The descent correction in the above tables is computed according to the same principle as for the climb correction tables. It represents the fuel consumption and flight time difference between:

- descent from the top of descent (TOD) to landing, including the arrival procedure;
- cruise corresponding from TOD to overhead the arrival airport.

It is important to note that these tables are completed with the estimated top of descent weight.



Descent correction = descent fuel and time – cruise fuel and time

Example

Refer to the "Cruise integrated range" table and to the climb and descent correction tables.
What is the trip fuel from take-off to landing to cover a 2,000 NM air distance, using the following data?
Take-off weight: 150,000 kg.
Planned cruise altitude: FL 350.
Long range cruise.
Temperature: ISA.
CG: 37 %.

A) 20,260 kg
B) 22,360 kg
C) 19,660 kg
D) 21,760 kg

Answer

a) Computing the cruise consumption, using the "Cruise integrated range" table (see correction in the table on next page)
Reading the table gives the following results (see correction in table)

	Weight (kg)		Air Miles (NM)
Start of segment	150,000	→	2,464
Air distance travelled			– 2,000

End of segment	130,336	←	464

Consumption during the cruise segment is: 150,000 – 130,336 = 19,664 kg.

b) Computing the climb correction
With a 150 t weight at brake release, and a cruise level FL 350, reading the climb table gives a 2,100 kg climb correction (see correction in the table below).

c) Computing the descent correction
Estimated descent weight = take-off weight – cruise fuel – climb fuel
= 150,000 – 19,664 – 2,100
= 128,236 kg (≈ 130,000 kg)
With a cruise level FL 350 (FL 290 and above), reading the descent table gives a 600 kg descent correction (see correction below).

Note. The 600 kg increase in descent is basically due to the approach procedure.

d) Total trip fuel: 19,664 + 2,100 + 600 = 22,364 kg.

Answer B.

INTEGRATED CRUISE											
MAX. CRUISE THRUST LIMITS NORMAL AIR CONDITIONING ANTI-ICING OF		0,336		ISA CG = 37,0 %		DISTANCE (NM) TIME (MIN)		LR		FL 350	
WEIGHT (1000 KG)	0	.2	.4	.6	.8	1.0	1.2	1.4	1.6	1.8	TAS (KTS)
126	0 0	22 3	43 7	65 10	87 14	108 17	130 21	151 24	173 27	194 31	377
128	216 34	237 37	259 41	280 44	302 47	323 51	344 54	366 57	387 60	408 64	385
130	430 67	451 70	472 73	493 77	514 80	536 83	557 86	578 89	599 93	620 96	392
132	641 99	662 102	683 105	704 108	725 112	746 115	767 118	788 121	809 124	829 127	400
134	850 130	871 133	892 136	913 139	933 142	954 145	975 148	995 151	1016 154	1037 157	411
136	1057 160	1078 163	1099 166	1119 169	1140 172	1160 175	1181 178	1201 180	1222 183	1242 186	418
138	1263 189	1283 192	1304 195	1324 198	1345 201	1365 204	1385 207	1406 210	1426 213	1446 215	420
140	1467 218	1487 221	1507 224	1528 227	1548 230	1568 233	1589 236	1609 239	1629 241	1649 244	421
142	1669 247	1690 250	1710 253	1730 256	1750 259	1770 261	1790 264	1810 267	1830 270	1850 273	423
144	1870 276	1890 278	1910 281	1930 284	1950 287	1970 290	1990 292	2010 295	2030 298	2050 301	425
146	2070 304	2090 306	2109 309	2129 312	2149 315	2169 318	2189 320	2208 323	2228 326	2248 329	427
148	2268 331	2287 334	2307 337	2327 340	2346 342	2366 345	2385 348	2405 351	2425 353	2444 356	429
150	2464 359	2483 361	2503 364	2522 367	2542 370	2561 372	2581 375	2600 378	2619 380	2639 383	431
152	2658 386	2678 388	2697 391	2716 394	2736 396	2755 399	2774 402	2793 404	2813 407	2832 410	434
154	2851 412	2870 415	2889 418	2909 420	2928 423	2947 425	2966 428	2985 431	3004 433	3023 436	437
156	3042 439	3062 441	3081 444	3100 446	3119 449	3138 452	3157 454	3175 457	3194 459	3213 462	439
158	3232 464	3251 467	3270 470	3289 472	3308 475	3327 477	3345 480	3364 482	3383 485	3402 487	441
160	3421 490	3439 493	3458 495	3477 498	3495 500	3514 503	3533 505	3551 508	3570 510	3589 513	442
162	3607 515	3626 518	3645 520	3663 523	3682 525	3700 528	3719 530	3737 533	3756 535	3774 538	444
164	3793 540	3811 543	3830 545	3848 548	3866 550	3885 553	3903 555	3922 558	3940 560	3958 563	446
166	3977 565	3995 567	4013 570	4031 572	4050 575	4068 577	4086 580	4104 582	4123 585	4141 587	448
168	4159 589	4177 592	4195 594	4213 597	4232 599	4250 601	4268 604	4286 606	4304 609	4322 611	450
170	4340 614	4358 616	4376 618	4394 621	4412 623	4430 625	4448 628	4466 630	4484 633	4502 635	451
172	4520 637	4538 640	4555 642	4573 644	4591 647	4609 649	4627 652	4645 654	4662 656	4680 659	453

PACK FLOW LO	PACK FLOW HI OR/ AND CARGO COOL ON	ENGINE ANTI ICE ON	TOTAL ANTI ICE ON
ΔFUEL = -0,4 %	ΔFUEL = +1 %	ΔFUEL = +1,5 %	ΔFUEL = +6 %

"Cruise integrated range" table

Climb correction table

FL	CORRECTION ON FUEL CONSUMPTION (1000 kg)											
	WEIGHT AT BRAKE RELEASE (1000 kg)											time correction
	140	150	160	170	180	190	200	210	220	230	240	
410	2.3	2.4	2.6	2.7	2.7	-	-	-	-	-	-	5 min
390	2.2	2.3	2.5	2.6	2.8	2.9	-	-	-	-	-	5 min
370	2.1	2.2	2.4	2.5	2.7	2.8	2.9	-	-	-	-	5 min
350	2.0	2.1	2.2	2.4	2.5	2.7	2.8	2.9	3.0	3.1	-	6 min
330	1.9	2.0	2.1	2.3	2.4	2.5	2.7	2.8	2.9	3.0	3.1	6 min
310	1.8	1.9	2.0	2.2	2.3	2.4	2.5	2.7	2.8	2.8	3.0	5 min
290	1.7	1.8	1.9	2.0	2.1	2.3	2.4	2.5	2.6	2.8	2.9	5 min
270	1.8	1.7	1.8	1.9	2.0	2.1	2.2	2.4	2.5	2.6	2.7	5 min
250	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.4	2.5	4 min
200	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	3 min
150	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.5	1.6	1.7	1.8	3 min
100	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.3	3 min

Descent correction table

LONG RANGE CRUISE

FL	CORRECTION ON FUEL CONSUMPTION (1000 kg)							
	WEIGHT OVERHEAD DESTINATION (1000 kg)							time correction
	130	140	150	160	170	180	190	
290 and above	0.6	0.7	0.7	0.8	0.9	1.0	1.1	10 min
270	0.6	0.7	0.7	0.8	0.9	0.9	1.0	8 min
250	0.6	0.6	0.7	0.7	0.8	0.8	0.9	
200	0.5	0.6	0.6	0.7	0.7	0.8	0.8	
150	0.5	0.5	0.6	0.6	0.6	0.7	0.7	
100	0.4	0.4	0.4	0.5	0.5	0.5	0.5	

2.6 - Fuel log

During the theoretical exam of module 033, candidates are not requested to fully complete a fuel log. This would require a relatively long processing time, not compatible with the exam.

We shall illustrate a typical question that may be asked during the exam for drafting a fuel log.

Example

Using the table on next page, compute the endurance and fuel for a twin jet engine aircraft.
The selected contingency fuel is 5 % of the planned trip fuel and the fuel flow for the extra fuel is 2,400 kg/hr.

What is the endurance?
A) 4 hrs 06 min
B) 3 hrs 52 min
C) 3 hrs 37 min
D) 4 hrs 12 min

	Fuel (kg)	Time (hrs:min)
Trip fuel	5,800	02:32
Contingency fuel	....	....
Alternate fuel	1,800	00:42
Final reserve fuel	1,325	....
Minimum take-off fuel	....	
Extra fuel	....	....
Actual take-off fuel	....	
Taxi fuel	200	
Parking fuel	10,000	....

Answer

Complete the blank lines in the table, in the following order.

• "Contingency fuel" line

Contingency fuel = trip fuel x 5 % = 5,800 x 5 % = 290 kg

As the fuel flow is equal to the "fuel/flight time" ratio, the cruise fuel flow is:

5,800 / 2.53 = 2,292 kg/hr.

Thus, the contingency fuel endurance is 290 / 2202 = 0.126 hr, i.e. 7.34 min.

• "Final reserve fuel" line

For a jet aircraft, the regulated final reserve fuel is 30-minute holding at 1,500 ft. We can complete the final reserve fuel endurance with 30 min.

• "Minimum take-off fuel" line

minimum take-off fuel = trip fuel + contingency fuel + alternate fuel + final reserve fuel
= 5,800 + 290 + 1,800 + 1,325
= 9,215 kg

• "Actual take-off fuel" line

actual take-off fuel = parking fuel – taxi fuel
= 10,000 – 200
= 9,800 kg

• "Extra fuel" line

extra fuel amount = actual take-off fuel – minimum take-off fuel
= 9,800 – 9,215
= 585 kg

With a 2,400 kg/hr fuel flow, the extra fuel endurance is: 585 / 2,400 = 0.24 hr, i.e. 14.38 min

• "Parking fuel" line

The sum of all the flight times gives a 4 hrs 06 min endurance for this flight plan.

Result of the endurance/fuel computation

	Fuel (kg)	Time (hrs:min:sec)
Trip fuel	5,800	02:32
Contingency fuel	290	00:07:34
Alternate fuel	1,800	00:42
Final reserve fuel	1,325	00:30
Minimum take-off fuel	9,215	
Extra fuel	585	00:14:38
Actual take-off fuel	9,800	
Taxi fuel	200	
Parking fuel	10,000	04:06

Answer A.

03 SPECIFIC FUEL COMPUTATION PROCEDURES

In addition to the basic regulatory requirements concerning the fuel amount to be carried for a commercial flight, a number of specific features concerning the fuel regulation exist and are applicable to the following procedures:

- Decision Point procedure;
- procedure for an isolated airport;
- Predetermined point procedure.

This section will also describe:

- the fuel tankering procedure: this is an operational method concerning the fuel tankering policy commonly applied by the airlines;
- ETOPS flight planning

3.1 – Reduced Contingency Fuel (RCF) or Decision Point procedure (DPP)

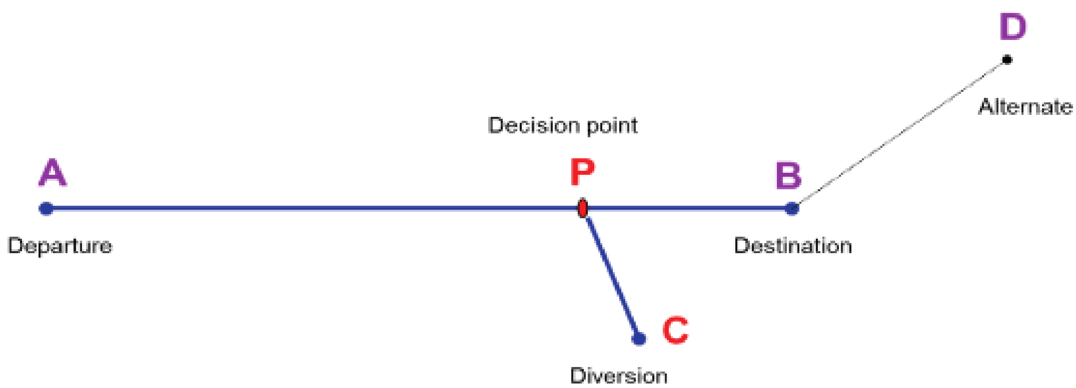
3.1.1 - Principle

This procedure concerns the contingency fuel.

We have seen that the contingency fuel is required to address trip hazards, such as a route diversion to bypass a cumulonimbus, a more unfavorable effective wind than forecast, a lower cruise level than the level planned in the initial flight plan…
Historically, the contingency fuel was defined as the higher fuel amount between 5 % of the trip fuel and 5-minutes flight at holding speed and 1,500 ft.
For a long-range flight, the contingency fuel usually is 5 % of the trip fuel, corresponding to a relatively high amount of fuel to carry for a 10 to 15-hours flight. Therefore, the regulation implemented a procedure with a decision point, in order to allow the operators to decrease the contingency fuel and, thus, increase the traffic load on a limitative trip.

The principle of this procedure is as follows (see diagram below). Instead of filing a flight plan for the A-B trip with alternate to D, it is filed for the A-P trip with diversion to C (optional refuel destination), in order to decrease the total fuel amount to carry. For this purpose, the operator selects a decision point P located on the route of an A-B trip.
When reaching this point, the pilot computes the remaining fuel onboard and decides one of the following two solutions:

- either proceed with the flight to destination airport B, if the remaining fuel is higher than the regulated amount required to reach B;
- or divert to diversion airport C, accessible via the decision point to refuel before resuming the flight to B.



To illustrate this procedure with a real example, let's consider a flight from the Réunion island (airport A) to Paris Charles de Gaulle (B), with Paris Orly as alternate airport at arrival. Marseilles is selected as diversion airport (C).
The crew will select a decision point P on the route (which is not systematically an airport), where a decision will be made to:

- either proceed with the flight to the commercial destination – Paris – if the contingency fuel was not consumed during the trip;
- or divert to Marseilles to refuel before resuming the flight to Paris.

3.1.2 - Fuel required

According to the regulation, the fuel amount to carry out the "Decision Point procedure" procedure should be the higher of the following two fuel amounts Q1 and Q2.

Q1 is the sum of the following amounts:

- taxi fuel;
- trip fuel to the destination airport, via the decision point;
- contingency fuel equal to or higher than 5 % of the estimated fuel from the decision point to the destination airport;
- alternate fuel or no alternate fuel if the decision point is at less than 6 hours from the destination aerodrome;
- final reserve fuel;
- additional fuel; and

- extra fuel, if requested by the pilot in command.

Q2 is the sum of the following amounts:

- taxi fuel;
- trip fuel from the departure airport to the diversion airport accessible via the decision point;
- contingency fuel equals to 5% or not less than 3 % (provided that an en-route alternate aerodrome is available at diversion aerodrome) of the estimated fuel from the departure aerodrome to the diversion airport;
- Alternate fuel if an alternate aerodrome for diversion aerodrome is required.
- final reserve fuel;
- additional fuel; and
- extra fuel, if requested by the pilot in command.

$Q1 = Taxi_A + \text{Trip fuel}_{AB} + 5\ \%\ \text{Trip fuel}_{PB} + Final_{B\ or\ D} + Additional + \text{Extra fuel} + Alternate_{BD}$ (or no alternate fuel if the decision point P is at less than 6 hours from the destination aerodrome B)

$Q2 = Taxi_A + \text{Trip fuel}_{AC} + 5\%\ \text{or}\ 3\ \%\ \text{Trip fuel}_{AC} + Final_C + Additional + \text{Extra fuel}$ + Alternate fuel (if an alternate aerodrome for diversion aerodrome C is required).

So, to measure the fuel gain for a specified trip with the "Decision Point procedure", we must compare what is comparable, i.e. the fuel amount required for a standard trip (Q_{STD}) and amount Q1 of the Decision Point procedure. We can see the benefit from a contingency fuel corresponding to 5 % of the trip fuel from A to P; this amount is the difference between 5 % of the AB trip fuel and 5 % of the PB trip fuel, as shown in the box below.

$$Q1 = Taxi_A + \text{Trip fuel}_{AB} + \underline{5\ \%\ \text{Trip fuel}_{PB}} + Final_{B\ or\ D} + Additional + \text{Extra fuel}\ (+\ Alternate_{BD})$$

$$Q_{STD} = Taxi_A + \text{Trip fuel}_{AB} + \underline{5\ \%\ \text{Trip fuel}_{AB}} + Final_D + Additional + \text{Extra fuel}\ (+\ Alternate_{BD})$$

3.2 - Isolated aerodrome procedure

3.2.1 - Principle

This procedure concerns additional fuel.
An isolated airport is an airport for which no alternate airport is available, such as Easter islands, or airports in desert areas for instance.
The definition of an isolated airport also applies to an airport temporarily stated as isolated when the associated alternate airport is no longer appropriate.

3.2.2 - Fuel required for an aircraft

In case of planning to such airport, the departure fuel load should include:

- taxi fuel;
- trip fuel;
- contingency fuel;
- additional fuel:
  - for piston engines aircraft, the LOWER of the following two amounts:

  - 45-minutes flight plus 15 % of the **cruise** planned flight time;
  - or 2-hours flight;
- for turbine engines aircraft, the fuel required for a 2-hours flight at normal cruise power after reaching the destination airport;

- and extra fuel, if requested by the pilot in command.

NB. The final reserve fuel is included in the additional fuel.

Example

A piston engines aircraft has a 20 USG average cruise consumption for a 3 hr planned time. If the destination airport is an isolated airport, the aircraft shall carry (in addition to the contingency fuel) an additional fuel amount equal to:

A) 20 USG B) 40 USG C) 24 USG D) 12 USG

Answer

Compute the additional fuel for the procedure with isolated airport.

For a piston engines aircraft flying to an isolated airport for which no alternate airport is available, the departure fuel amount should include an additional fuel which cannot be less than the lower amount between:

- 45-minutes flight plus 15 % of the planned cruise flight time; i.e. 1 hr 12 min or 1.2 hr flight;
- or 2-hours flight.

The additional fuel amount to carry is the LOWER flight time, thus it equals to 1.2 x 20 = 24 US gal.

Answer **C**.

Example

A jet aircraft has a 4,060 kg/hr cruise fuel flow and 3,690 kg/hr holding fuel flow. If the destination airport is an isolated airport, the aircraft shall carry (in addition to the contingency fuel) an additional fuel amount equal to:

A) 7,380 kg
B) 8,120 kg
C) 1,845 kg
D) 3,500 kg

Answer

Compute the additional fuel for the procedure with isolated airport.

For a turboprop engine aircraft, the take-off fuel amount should include additional fuel that cannot be less than 2 hours at normal cruise power (not in holding pattern) after reaching the destination airport.

As the hourly cruise consumption is 4,060 kg/hr, in two hours, the additional fuel amount is: 4,060 x 2 = 8,120 kg.

It should be noted that the final reserve fuel is included in this amount.

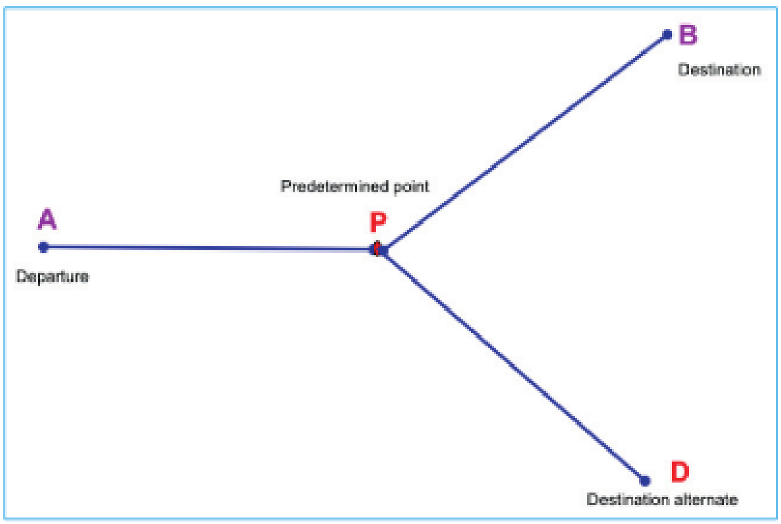
Answer **B**.

3.3 - Predetermined point procedure (PDD)

3.3.1 - Principle

The regulation in force specifies that: *"If the operator's fuel policy includes planning to a destination alternate aerodrome where the distance between the destination aerodrome and the destination alternate aerodrome is such that a flight can only be routed via a predetermined point to one of these aerodromes."*

In other words, it is applied to a long-distance flight operated to "an isolated aerodrome"; island for instance where the destination alternate terrain is located at a considerable distance away from the destination aerodrome. Generally, the long-distance flight is usually limited by the maximum fuel tank capacity, thus, it is possible that the aeroplane cannot reach a destination alternate aerodrome after reaching its destination. Hence, the PDP procedure will bring the aeroplane to its destination not on the most direct route, but via a predetermined point P from which, the crew has to decide either to proceed the flight to destination or divert to destination alternate aerodrome D selected during flight preparation stage.



3.3.2 - Fuel required

The fuel amount to carry in the Decision Point Procedure (DPP) should be the higher of the following two fuel amounts Q1 and Q2:

• **Q1** is the sum of the following amounts:
- taxi fuel;
- trip fuel to the destination airport via the predetermined point;
- contingency fuel;
- additional fuel:
  - for piston engines aircraft, the lower of the following two amounts:
    - 45-minutes flight plus 15% of the cruise planned flight time;
    - or 2-hours flight;
  - for turbine engines aircraft, the fuel required to fly for 2 hours at normal cruise consumption after reaching the destination airport; and
- extra fuel, if requested by the pilot in command.

NB. The final reserve fuel is included in the additional fuel.

- Q2 is the sum of the following amounts:
  - taxi fuel;
  - trip fuel from the departure airport to the destination alternate aerodrome accessible via the predetermined point;
  - contingency fuel;
  - additional fuel:
    - for piston engines aircraft: it corresponds to the amount required for a 45 minutes flying time;
    - for turbine engines aircraft, the fuel required to fly during 30 minutes at holding speed in standard condition at 1,500 ft above the destination alternate aerodrome elevation; and
  - extra fuel, if requested by the pilot in command.

NB. The final reserve fuel is included in the additional fuel.

For piston engines aircraft

Q1 = $Taxi_A$ + Trip $fuel_{AB}$ + Contingency fuel + Additional fuel (45' flight + 15 % cruise or 2 hr flight) + Extra fuel

Q2 = $Taxi_A$ + Trip $fuel_{AD}$ + Contingency fuel + Additional fuel (45' flight) + Extra fuel

For turbine engines aircraft

Q1 = $Taxi_A$ + Trip $fuel_{AB}$ + Contingency fuel + Additional fuel (2 hr cruise minimum) + Extra fuel

Q2 = $Taxi_A$ + Trip $fuel_{AD}$ + Contingency fuel + Additional fuel (30' holding at 1,500 ft) + Extra fuel

Example

For a flight from A to B with alternate C, calculate the fuel required for an aeroplane with reciprocating engines according to the predetermined point procedure (PDP).

Distance A-B:	530 NM (480 NM at cruising altitude)
Distance A-C via PDP:	495 NM
TAS:	170 kt
Wind component:	- 15 kt
Fuel consumption:	35 kg/h

Taxi fuel is supposed to be negligible

A) 169 kg

B) 143 kg

C) 145 kg

D) 127 kg

Answer

GS = 170 – 15 = 155 kt.

The fuel amount to carry in the Predetermined Point Procedure (PDP) should be the higher of the following two fuel amounts Q1 and Q2:

<u>Q1</u>

- Trip fuel:
  Trip time = 530 NM / 155 kt = 3.42 h → trip fuel = FF x time = 35 x 3.42 = 119.7 kg
- Contingency fuel = 5% of trip fuel = 5% x 119.7 = 6 kg
- Additional fuel: cruise time = 480 NM / 155 = 3.1 h → 15% of cruise time = 28 min → additional fuel = ((45 min + 28 min) / 60) x 35 kg/h = 42.6 kg

Total fuel Q1 = 119.7 + 6 + 42.6 = 168.28 kg

<u>Q2</u>

- Trip fuel:
  Trip time = 495 NM / 155 kt = 3.19 h → trip fuel = FF x time = 35 x 3.19 = 111.8 kg
- Contingency fuel = 5% of trip fuel = 5% x 111.8 = 5.6 kg
- Additional fuel = (45 min / 60) x 35 kg/h = 26.3 kg

Total fuel = 111.8 + 5.6 + 26.3 = 143.7 kg

The higher amount is Q1 = 168.28 kg, rounded up to 169 kg

3.4 - Fuel tankering procedure

3.4.1 - Principle

Fuel cost may vary considerably between airports.

Therefore, in order to optimize refueling and ensure the flight under good economic conditions, it may well be worth carrying extra fuel when the fuel price at the destination airport is noticeably higher than that of the departure airport.

The surplus fuel thus carried may be used for the return flight or flight continuation for the next round trip.

However, fuel tankering generates a surplus fuel burn due to the increased aircraft total weight.

The loss due to the fuel consumption increase may be compensated by the gain resulting from the fuel price differential between departure and destination airports.
It would then be required to first check that the fuel cost balance is favorable. In other words, the price differential between departure and destination should be high enough for a fuel tankering to be economically profitable.

We shall discuss the fuel tankering computing methods proposed for the B737 and for the A310.

3.4.2 - Fuel tankering procedure for B737-400

The computing principle proposed by the manufacturer is based on the following question: For a fuel price at departure, what is the fuel price at destination beyond which fuel tankering is profitable?

The question is addressed through the following two steps.

"Fuel Tankering" graph (fig. 4.8.1)
This graph, published for long range cruise and M.74, determines the percent of surplus fuel burn due to fuel tankering. For instance, a 15 % surplus fuel burn, means that a 15 kg surplus fuel burn should be taken into account to carry 100 kg.

WARNING! the distance read on the graph is an air distance. The ground distance should thus be converted into air distance before completing the graph.

"Fuel Price Differential" graph (fig. 4.8.2)
Surplus fuel burn obtained with the previous graph and the fuel price at departure, this graph allows the minimum fuel price to be obtained at destination (break-even fuel price) beyond which fuel tankering would be profitable.

Example

An aircraft is scheduled to perform a Mach number 0.74, at level 310, ISA + 15°C, and a 40,000 kg landing weight (without tankering fuel). The wind component is + 25 kt and the trip distance is 1,000 NM ground.

With the information that the fuel price at the departure airport is equal to 75 cents/US gal, determine the fuel price corresponding to the break-even fuel price at the destination airport to consider fuel tinkering.
A) 80 cents
B) 85 cents
C) 90 cents
D) 95 cents

Answer on next pages.

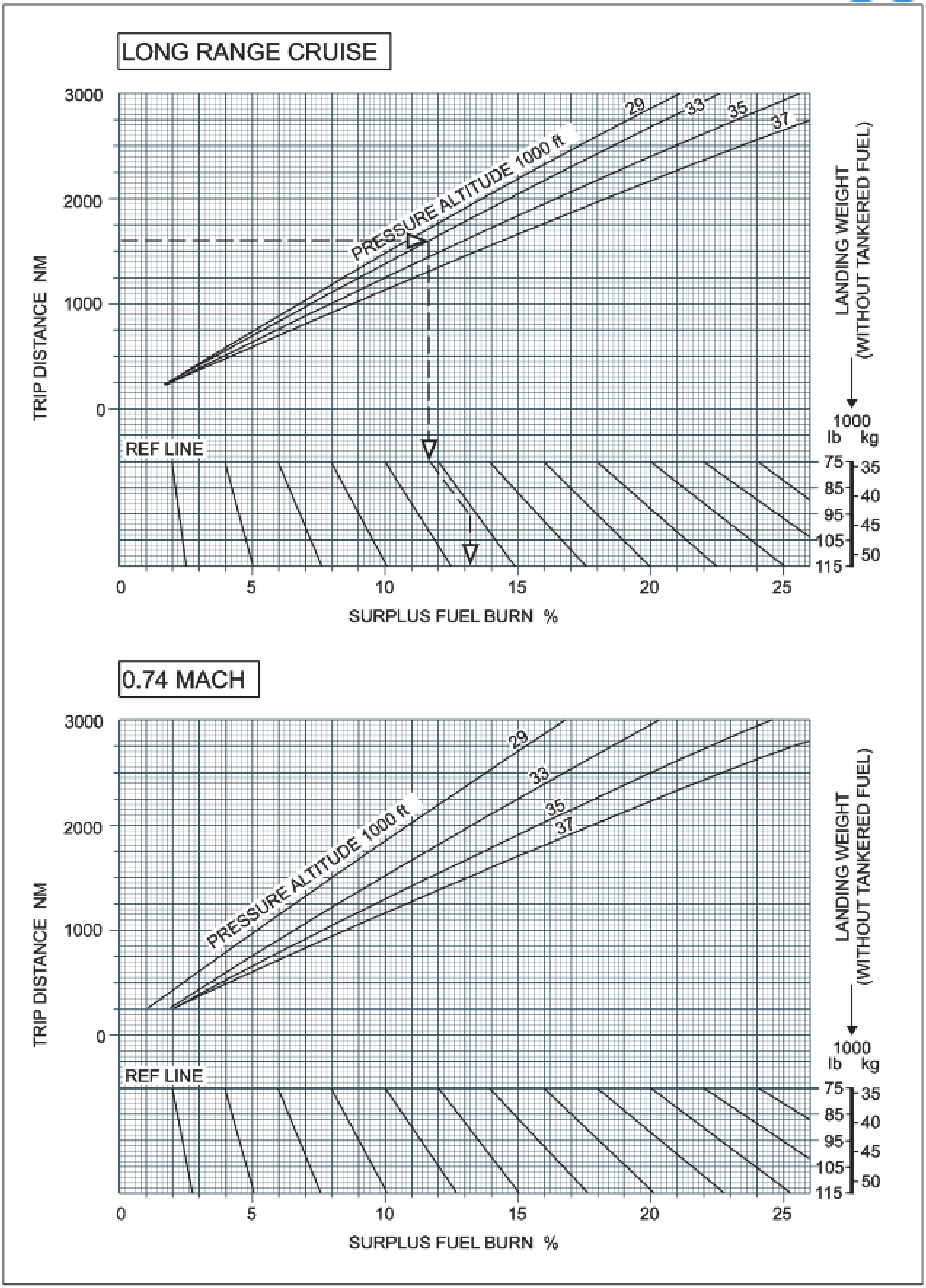


Figure 4.8.1 Fuel Tankering (LRC and 0.74 M)

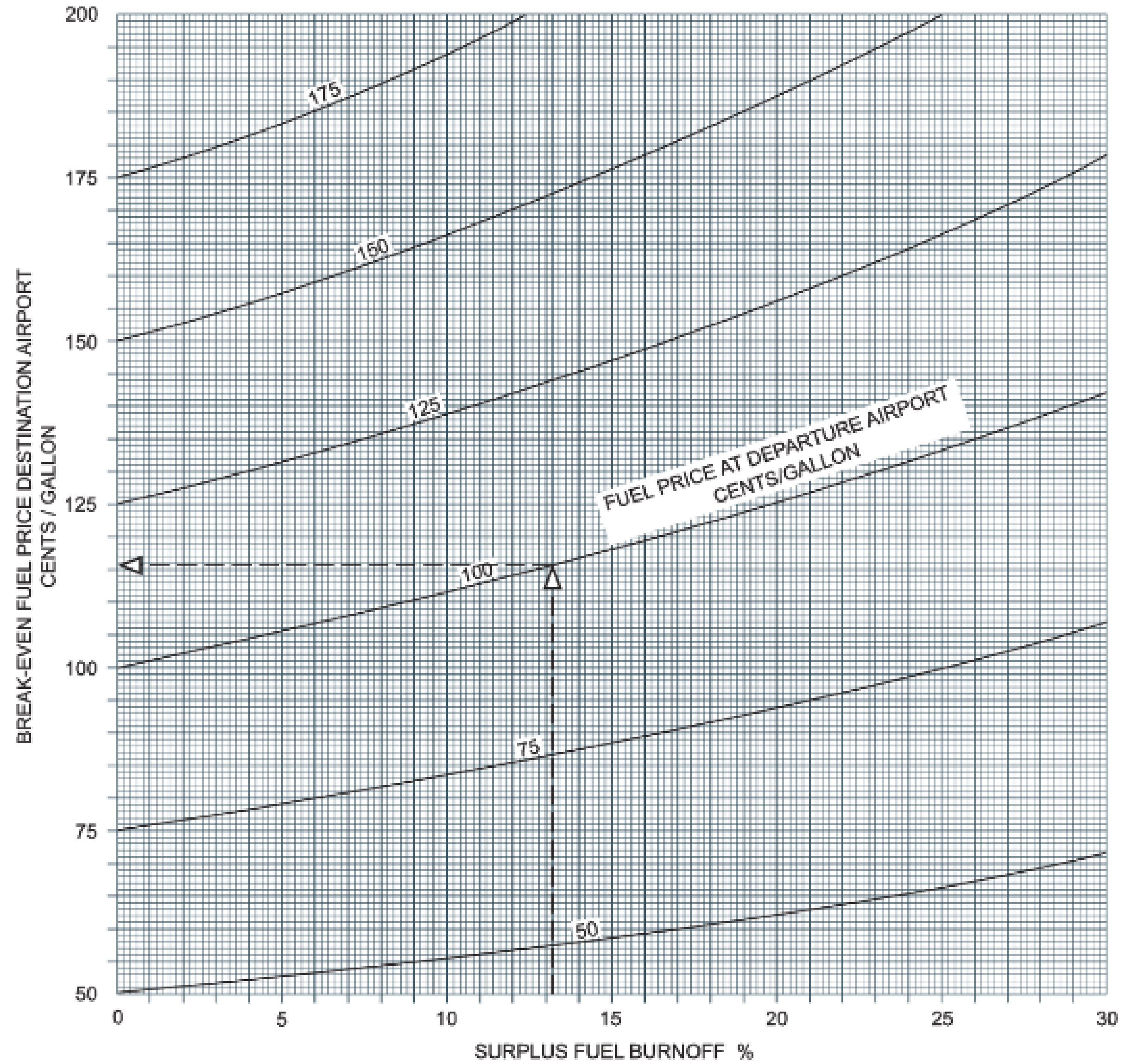


Figure 4.8.2 Fuel Price Differential

Answer

a) Step 1: reading the "Fuel Tankering" graph (see correction on next page)

Using the computer at M.74, FL 310, and ISA + 15°C allows to determine a 450 kt true airspeed.

The formula $D_{AIR} = (D_{GROUND} \times TAS) / GS$ with GS = 450 + 25 = 475 kt, gives D_{AIR} = 1,000 x 450 / 474 = 947 NM.

Reading the graph indicates 6.2 % surplus fuel burn (approx.).

b) Step 2: reading the "Fuel Price Differential" graph

With a 6.2 % surplus fuel burn and a 75 cent price at departure, the graph gives the fuel price corresponding to the break-even fuel price at the destination airport: 80 cents.

Thus, it would be economically profitable to consider fuel tankering if the fuel price applied on the destination airport is more than 80 cents/US gal.

Answer **A**.

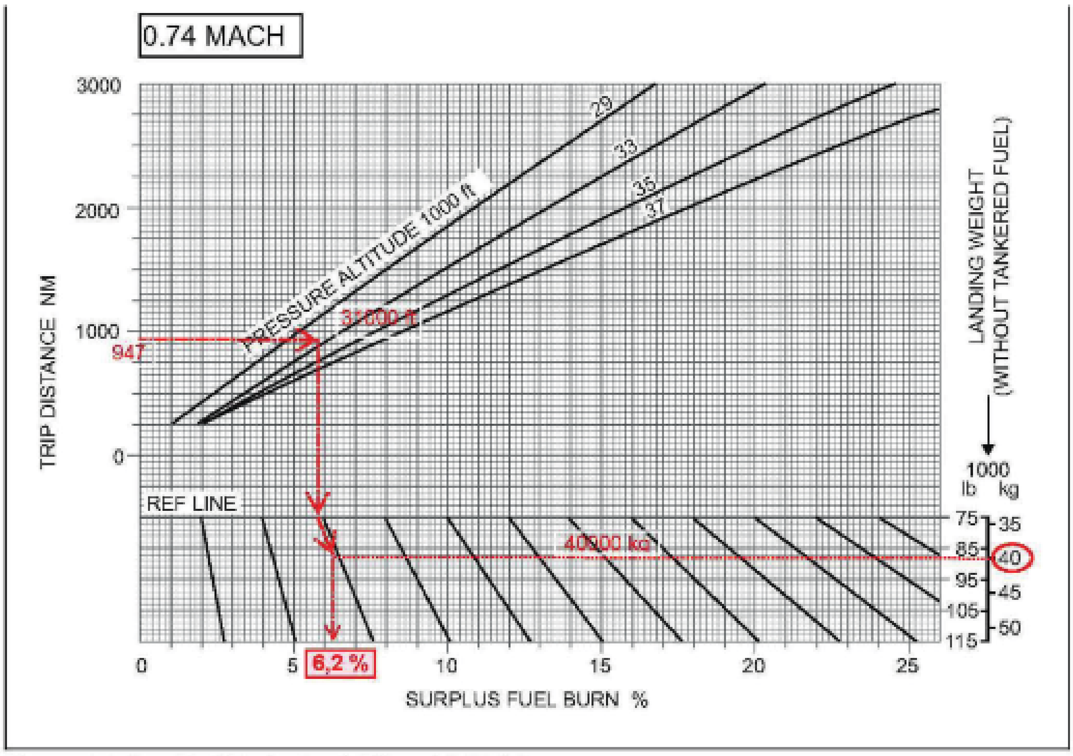


Figure 4.8.1 Fuel Tankering (LRC and 0.74 M)

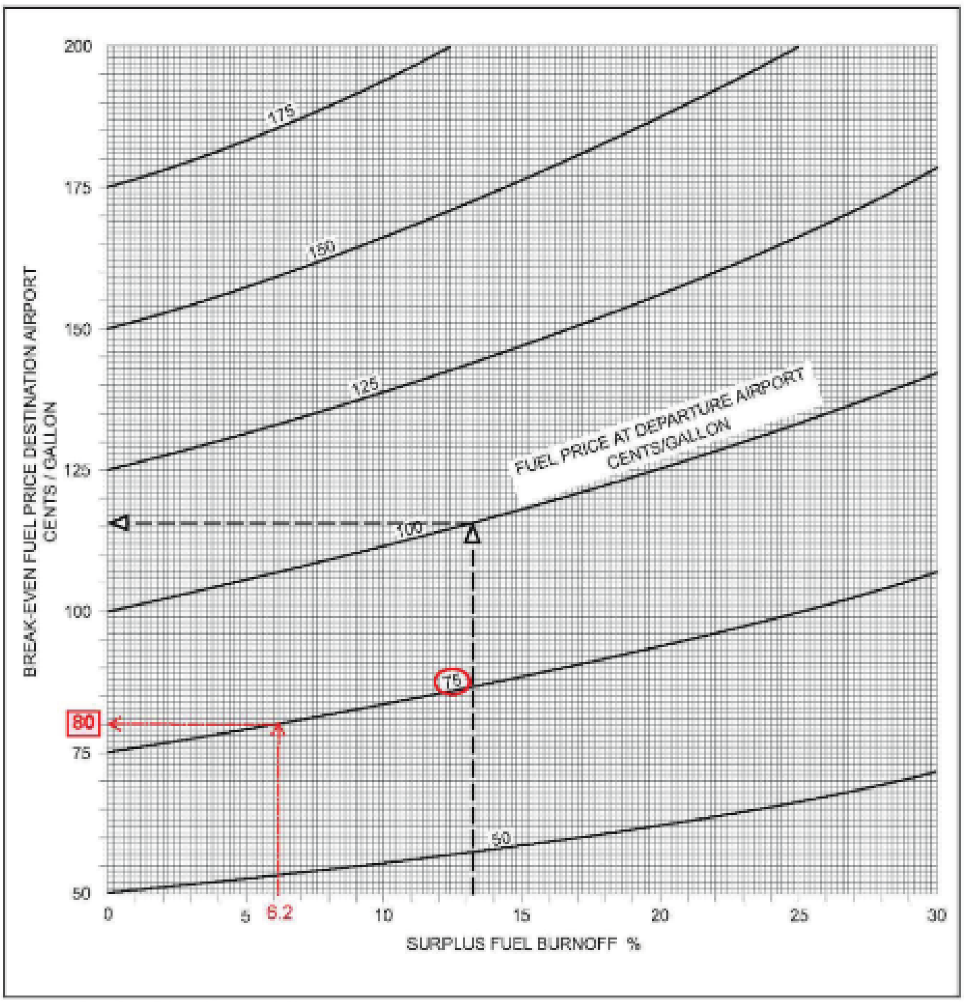


Figure 4.8.2 Fuel Price Differential

3.4.3 - Fuel tankering procedure for A310

For the A310, the fuel tankering procedure is different from the B737. We have to determine the optimum surplus fuel tankering depending on the fuel price ratio between departure and destination airports.

For this purpose, apply the following two steps.
Use the graph to determine the optimum take-off weight depending on the departure/destination fuel price ratio and trip distance.
WARNING! The optimum take-off weight thus computed must be limited to the certified maximum take-off weight.

The fuel tankering mass is obtained by the difference between the optimum take-off weight already computed and the planned take-off weight.
WARNING! The computed surplus fuel amount must be limited to the fuel tank maximum capacity. Also, the certified maximum landing weight should not be exceeded taking the trip fuel into account.

Example

Considering the 0.92 departure/destination fuel price ratio, the pilot in command decides to optimize the fuel tankering using the following data:

- cruise flight level: FL 350;
- trip distance: 1,830 NM;
- planned take-off weight: 190,000 kg (with the 30,000 kg regulated fuel amount, including 22,000 kg trip fuel);
- certified maximum landing weight: 180,000 kg;
- certified maximum take-off weight: 205,000 kg;
- maximum tank capacity: 40,000 kg;

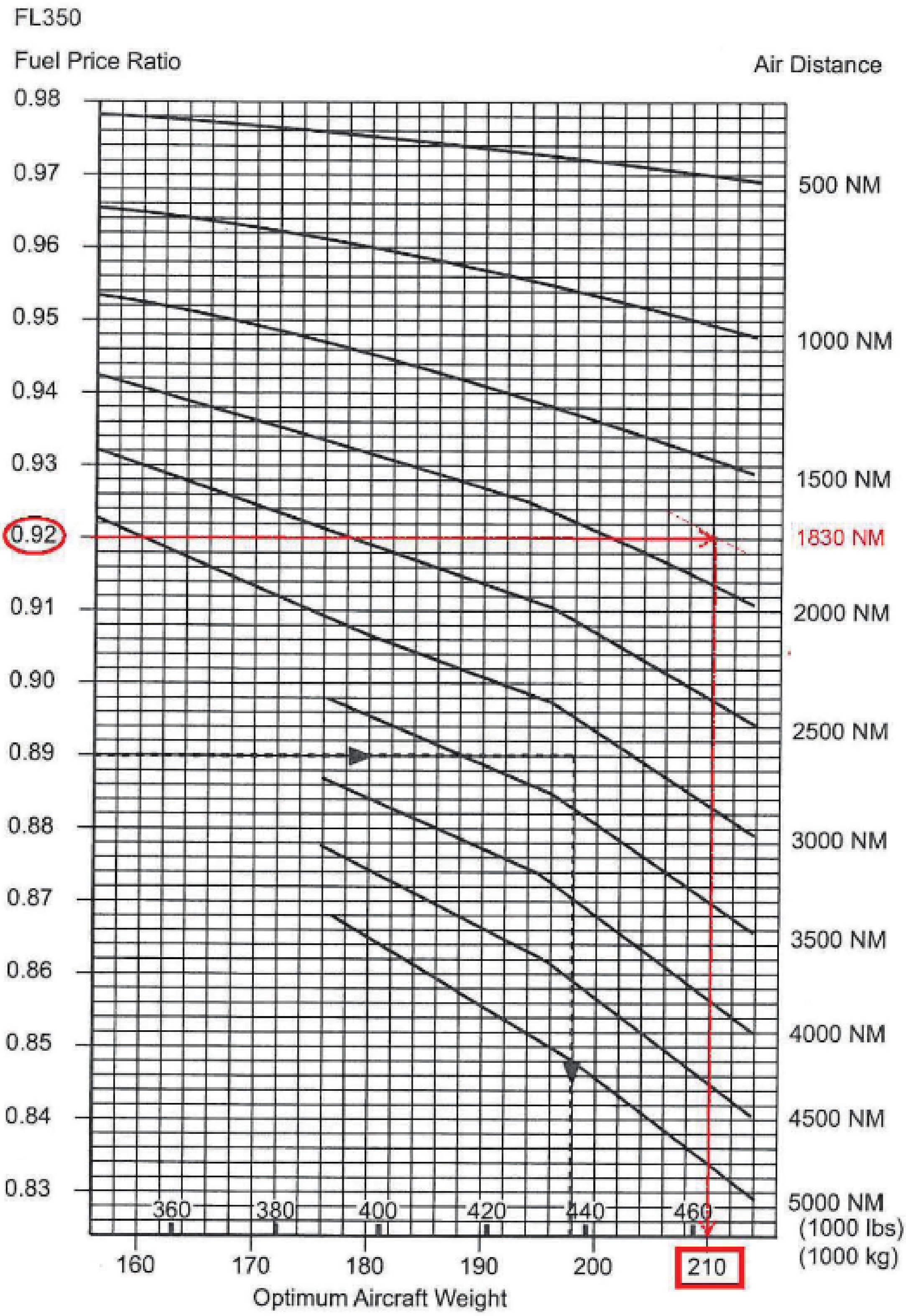
The fuel tankering amount will be:

A) 10,000 kg B) 0 kg
C) 12,000 kg D) 15,000 kg

Answer

a) Step 1: Read the graph
Using the graph below, with a 0.92 fuel price ratio and a 1,830 NM air distance, the optimum take-off weight for fuel tankering is 210,000 kg.
This weight is higher than the certified maximum take-off weight. It should thus be limited to 205,000 kg.
b) Step 2: Compute the extra fuel tankering
Tankering fuel = optimum take-off weight – planned take-off weight
= 205,000 – 190,000
= 15,000 kg
But, with a new 205,000 kg take-off weight (190,000 + 15,000), the planned landing weight will be: 205,000 – 22,000 (trip fuel) = 183,000 kg. This is higher than the certified maximum landing weight (180,000 kg).
Fuel tankering should thus be limited to: 15,000 – 3,000 = 12,000 kg (3,000 kg is the difference between 183,000 kg and 180,000 kg).

However, with 30,000 kg regulated fuel, when adding 12,000 kg extra fuel, the 40,000 kg maximum tank capacity is exceeded.
So, the maximum possible fuel tankering amount for this flight is 10,000 kg.



Answer A.

3.5 - ETOPS flight planning

The ETOPS concept is based on the operation of a twin engine aircraft on a route including a point far-off an adequate airport by a longer distance than the distance travelled by the aircraft, in standard conditions, zero wind, within 60 minutes at the approved one engine cruise speed.
This flight is known as an "ETOPS flight".

A waiver to the above rule is possible to extend the maximum ETOPS distance by more than 60 minutes (90, 120, 180, 207, 330 minutes, etc.) if:

- at the certification level, the manufacturer must demonstrate that his aircraft systems and the propulsion system meet the ETOPS requirements in terms of design and reliability;
- at operational level, the operator must demonstrate that his organization and means, in terms of flight crew training, flight planning, operation monitoring and maintenance, ensure safe ETOPS operations.

3.5.1 - Critical fuel

Regulated fuel amount allowing, from the departure airport, to reach the route critical point and to perform an en-route alternate to an ETOPS diversion airport in the conditions of the worst following scenario:

- simultaneous engine and pressurization failure: after an emergency descent, the flight is continued at 10,000 ft to an ETOPS diversion airport at the speed selected by the operator;
- pressurization failure with all engines operative: after an emergency descent, the flight is continued at 10,000 ft to an ETOPS diversion airport at the LR speed.

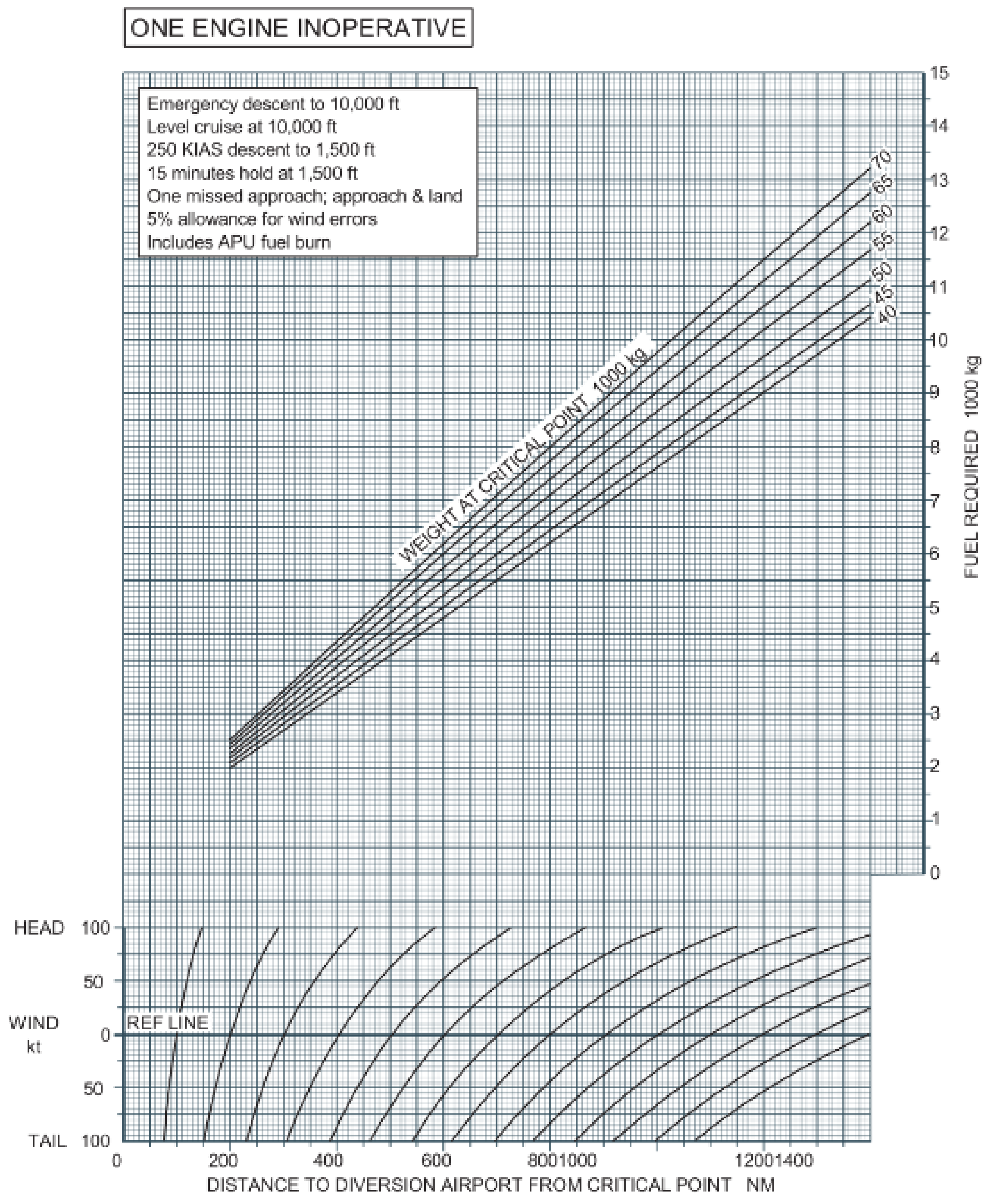
The following graphs (figures 4.7.1a and 4.7.1b) allow determination of the fuel amount for both above scenarios. These graphs are relatively easy to use. Readers should refer to Chapter 033 06 "Flight Monitoring and In-Flight Re-Planning" to see a concrete example of their use.

3.5.2 - Maximum ETOPS distance

For a specified flight, the maximum ETOPS distance is the range at the ETOPS single engine approved speed in standard conditions, zero wind, within a flight duration defined by the ETOPS capability (90, 120, 180, 207, 330 minutes, etc.).
Note. On the ETOPS charts, distances from the ETOPS diversion airports are shown by circles.

The B737-400 table (fig. 4.7.2), allows determination of the maximum distance in question. For this purpose, complete the table at the one engine speed approved by the authorities with the estimated weight upon the ETOPS diversion and ETOPS capacity of the aircraft to read the maximum ETOPS distance.

Example
Refer to table (fig 4.7.2)
During an ETOPS flight, an aircraft must not fly further from its adequate diversion airport by more than 180 minutes.
In LR cruise regime and standard conditions, with a 50,000 kg weight upon diversion, what is the maximum ETOPS air distance?



INCREASE FUEL REQUIRED BY 0.5% FOR EACH 10°C HOTTER THAN ISA CONDITIONS.
IF ICING CONDITIONS EXIST, INCREASE FUEL REQUIRED BY 20% TO ACCOUNT FOR ENGINE & WING A.I. ON & ICE ACCUMULATION ON UNHEATED SURFACES.
ALLOWANCE FOR PERFORMANCE DETERIORATION NOT INCLUDED.
COMPARE THE FUEL REQUIRED FROM THIS CHART WITH CRITICAL FUEL RESERVES FOR TWO ENGINES OPERATIVE. USE THE HIGHER OF THE TWO.

Figure 4.7.1a Critical Fuel Reserve – One Engine Inoperative

A) 1,200 NM B) 1,101 NM C) 915 NM D) 975 NM

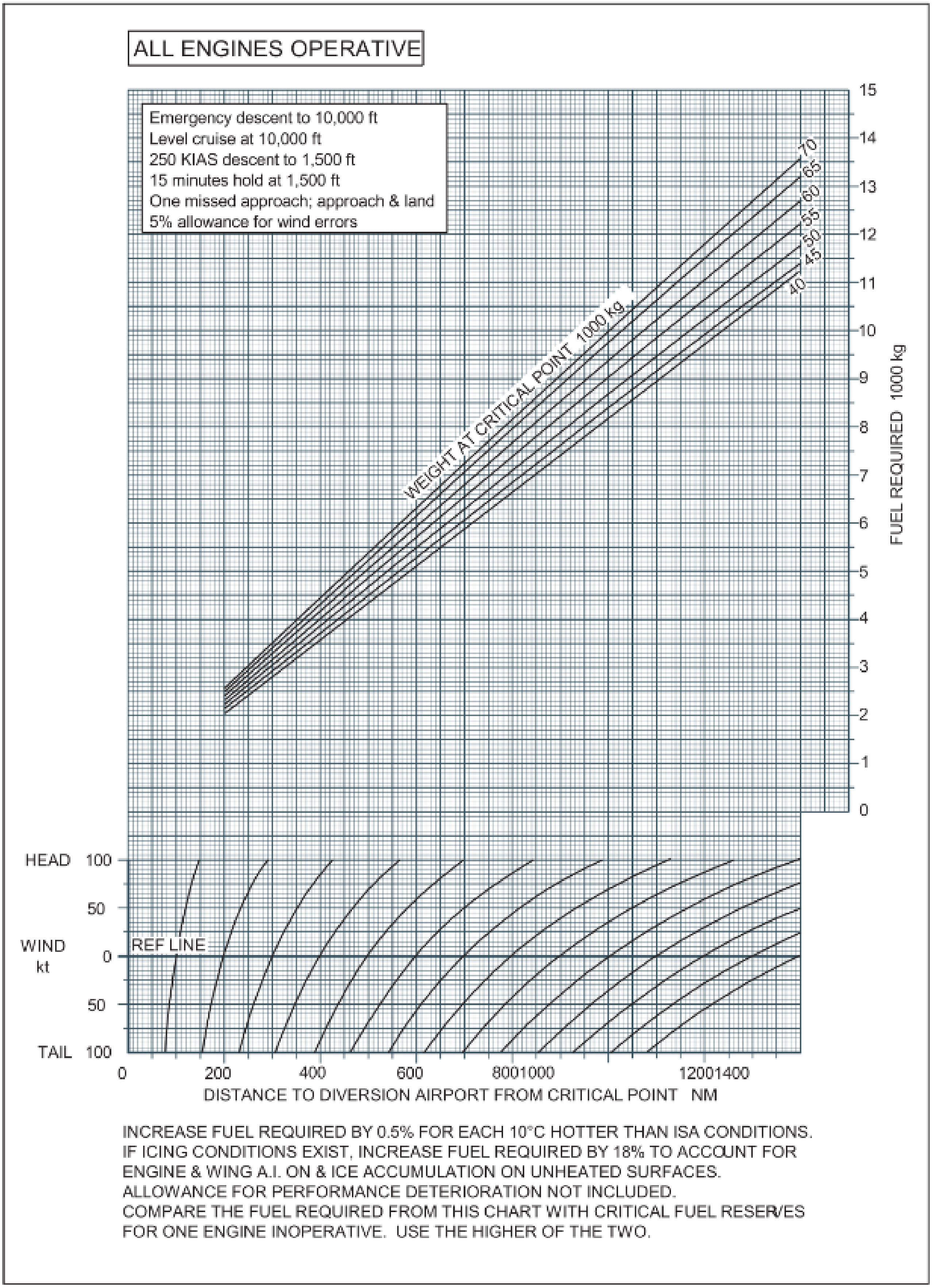


Figure 4.7.1b Critical Fuel Reserve – All Engines Operating

Speed M/KIAS	Div. Wt 1000 kg	TIME MINUTES														
		60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
	35	406	472	539	605	672	738	805	871	938	1004	1071	1137	1204	1271	1337
	40	402	467	533	598	663	729	794	860	925	990	1056	1121	1187	1252	1318
	45	397	462	526	590	654	718	782	846	910	975	1039	1103	1167	1231	1295
.70/280	50	392	454	517	580	642	705	768	830	893	956	1018	1081	1144	1207	1269
	55	385	446	507	568	630	691	752	813	875	936	997	1058	1119	1181	1242
	60	377	437	497	557	616	676	736	796	855	915	975	1035	1094	1154	1214
	65	369	427	486	544	602	660	718	776	835	893	951	1009	1067	1125	1183
	70	363	419	476	532	589	645	702	758	815	871	928	985	1041	1098	1154
	35	412	478	545	612	678	745	811	878	945	1011	1078	1145	1211	1278	1345
	40	409	474	540	606	672	737	803	869	935	1000	1066	1132	1198	1263	1329
	45	404	469	533	598	663	727	792	856	921	986	1050	1115	1180	1244	1309
.74/290	50	400	463	526	590	653	717	780	844	907	970	1034	1097	1161	1224	1288
	55	393	455	517	579	641	704	766	828	890	952	1014	1077	1139	1201	1263
	60	386	447	508	568	629	690	751	812	872	933	994	1055	1116	1176	1237
	65	378	437	497	556	615	675	734	793	853	912	971	1031	1090	1149	1209
	70	372	430	488	546	603	661	719	777	835	893	950	1008	1066	1124	1182
	35	415	482	548	615	681	748	814	881	948	1014	1081	1147	1214	1280	1347
	40	413	479	545	611	677	743	810	876	942	1008	1074	1140	1206	1272	1338
	45	410	476	541	607	672	737	803	868	933	999	1064	1130	1195	1260	1326
.74/310	50	407	472	536	601	665	730	794	859	923	988	1052	1116	1181	1245	1310
	55	402	466	529	592	656	719	783	846	908	973	1036	1100	1163	1226	1290
	60	397	459	521	583	646	708	770	833	895	957	1019	1082	1144	1206	1269
	65	391	452	513	574	635	696	757	818	879	940	1002	1063	1124	1185	1246
	70	385	445	505	565	625	685	744	804	864	924	984	1044	1103	1163	1223
	35	416	482	548	614	680	746	811	877	943	1009	1075	1141	1207	1273	1339
	40	415	481	547	613	678	744	810	875	941	1007	1072	1138	1204	1270	1335
	45	414	480	545	610	676	741	806	871	937	1002	1067	1133	1198	1263	1328
.74/330	50	412	477	542	607	671	736	801	865	930	995	1059	1124	1189	1254	1318
	55	408	472	536	600	664	728	792	856	920	984	1048	1112	1176	1240	1304
	60	404	467	530	593	656	719	783	846	909	972	1035	1098	1161	1224	1287
	65	399	461	523	586	648	710	772	834	896	958	1020	1082	1144	1207	1269
	70	395	457	518	579	640	701	762	823	884	945	1006	1067	1128	1190	1251
	35	368	428	488	548	608	668	728	787	847	906	965	1024	1083	1141	1200
	40	372	433	493	554	614	674	735	794	854	914	973	1032	1092	1151	1209
	45	376	437	497	558	619	679	739	799	859	919	979	1038	1097	1157	1216
LRC	50	379	440	501	561	622	682	742	803	862	922	982	1041	1101	1160	1219
	55	380	441	502	562	623	683	743	803	863	922	982	1041	1100	1159	1218
	60	381	442	503	563	624	684	744	804	863	923	982	1041	1100	1159	1218
	65	381	442	503	563	623	683	742	802	861	921	980	1038	1097	1156	1214
	70	383	444	504	564	623	683	742	802	860	919	978	1036	1094	1152	1210

ISA
BASED ON DRIFT DOWN STARTING AT OR NEAR OPTIMUM ALTITUDE

Figure 4.7.2 Area of Operation – Diversion Distance One Engine Inoperative

Answer

Speed M/KIAS	Div. Wt 1000 kg	TIME MINUTES														
		60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
.70/280	35	406	472	539	605	672	738	805	871	938	1004	1071	1137	1204	1271	1337
	40	402	467	533	598	663	729	794	860	925	990	1056	1121	1187	1252	1318
	45	397	462	526	590	654	718	782	846	910	975	1039	1103	1167	1231	1295
	50	392	454	517	580	642	705	768	830	893	956	1018	1081	1144	1207	1269
	55	385	446	507	568	630	691	752	813	875	936	997	1058	1119	1181	1242
	60	377	437	497	557	616	676	736	796	855	915	975	1035	1094	1154	1214
	65	369	427	486	544	602	660	718	776	835	893	951	1009	1067	1125	1183
	70	363	419	476	532	589	645	702	758	815	871	928	985	1041	1098	1154
.74/290	35	412	478	545	612	678	745	811	878	945	1011	1078	1145	1211	1278	1345
	40	409	474	540	606	672	737	803	869	935	1000	1066	1132	1198	1263	1329
	45	404	469	533	598	663	727	792	856	921	986	1050	1115	1180	1244	1309
	50	400	463	526	590	653	717	780	844	907	970	1034	1097	1161	1224	1288
	55	393	455	517	579	641	704	766	828	890	952	1014	1077	1139	1201	1263
	60	386	447	508	568	629	690	751	812	872	933	994	1055	1116	1176	1237
	65	378	437	497	556	615	675	734	793	853	912	971	1031	1090	1149	1209
	70	372	430	488	546	603	661	719	777	835	893	950	1008	1066	1124	1182
.74/310	35	415	482	548	615	681	748	814	881	948	1014	1081	1147	1214	1280	1347
	40	413	479	545	611	677	743	810	876	942	1008	1074	1140	1206	1272	1338
	45	410	476	541	607	672	737	803	868	933	999	1064	1130	1195	1260	1326
	50	407	472	536	601	665	730	794	859	923	988	1052	1116	1181	1245	1310
	55	402	466	529	592	656	719	783	846	908	973	1036	1100	1163	1226	1290
	60	397	459	521	583	646	708	770	833	895	957	1019	1082	1144	1206	1269
	65	391	452	513	574	635	696	757	818	879	940	1002	1063	1124	1185	1246
	70	385	445	505	565	625	685	744	804	864	924	984	1044	1103	1163	1223
.74/330	35	416	482	548	614	680	746	811	877	943	1009	1075	1141	1207	1273	1339
	40	415	481	547	613	678	744	810	875	941	1007	1072	1138	1204	1270	1335
	45	414	480	545	610	676	741	806	871	937	1002	1067	1133	1198	1263	1328
	50	412	477	542	607	671	736	801	865	930	995	1059	1124	1189	1254	1318
	55	408	472	536	600	664	728	792	856	920	984	1048	1112	1176	1240	1304
	60	404	467	530	593	656	719	783	846	909	972	1035	1098	1161	1224	1287
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	70	395	457	518	579	640	701	762	823	884	945	1006	1067	1128	1190	1251
LRC	35	368	428	488	548	608	668	728	787	847	906	965	1024	1083	1141	1200
	40	372	433	493	554	614	674	735	794	854	914	973	1032	1092	1151	1209
	45	376	437	497	558	619	679	739	799	859	919	979	1038	1097	1157	1216
	50	379	440	501	561	622	682	742	803	862	922	982	1041	1101	1160	1219
	55	380	441	502	562	623	683	743	803	863	922	982	1041	1100	1159	1218
	60	381	442	503	563	624	684	744	804	863	923	982	1041	1100	1159	1218
	65	381	442	503	563	623	683	742	802	861	921	980	1038	1097	1156	1214
	70	383	444	504	564	623	683	742	802	860	919	978	1036	1094	1152	1210

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BASED ON DRIFT DOWN STARTING AT OR NEAR OPTIMUM ALTITUDE

Figure 4.7.2 Area of Operation – Diversion Distance One Engine Inoperative

Reading table 4.7.2 with the specified conditions (180 minute ETOPS flight, long range cruise speed, 50,000 kg weight) gives a 1,101 NM maximum ETOPS air distance.

Answer B.

04

PRE-FLIGHT PREPARATION

We have already seen that during long-term flight preparation stage, the pilot must collect all the following aeronautical information in order to complete his navigation log:

- the ATC procedures of the departure, diversion, destination, and alternate airports;
- the planned routes for IFR navigation;
- the en-route and airport communication and radio navigation frequencies;
- approach radio navigation aids;
- the restricted, prohibited or dangerous areas; the military drill areas, the en-route obstacles and air activities (parachuting, gliding zones, hot air balloons, etc.);
- etc.

During short-term preparation stage, or "Pre-flight preparation", the in-depth study of all the recent information is emphasized to update the navigation log. This study includes an in-depth analysis of:

- the recent information concerning the latest updates of the aeronautical information required for air traffic;
- the latest weather reports and forecasts, in order to update the navigation log and finalize the fuel computation;
- the study and determination of critical points in accordance with the latest wind data. These critical points are very useful decision aids for the flight crew in case of a potential event occurring during the flight (technical failure, emergency medical problem onboard, etc.).

For this purpose, this Chapter discusses the following three key elements of the flight folder:

- aeronautical information (AIP, NOTAM);
- meteorological information (METAR, SPECI, TAF, SIGNICANT WEATHER CHART, WINTEM chart);
- computation of the Point of Equal Time (PET) and Point of Safe Return (PSR).

01 NOTAM – AIP

The primary source of aeronautical information is provided by the aeronautical Authorities of each State, which exchange such data with other States.

It is up to each State to designate the agency in charge of publishing aeronautical information.

The aeronautical information is communicated to international aeronautical communities in AIP and NOTAM documents.

AIP (Air Information Publication)

The permanent air information publications are published by the aeronautical service of each country. They are available to users.
The temporary modifications to the information contained in the AIP are published in special pages. They supplement the AIP via SUP AIP. The SUP AIP basically concern procedure modifications and modifications or creation of spaces with specific status.

NOTAM (Notice To Airmen)

These are messages published by the Aeronautical Information Service. A NOTAM will be generated and published quickly, whenever information is of a temporary nature and short-term or when major permanent or long-term temporary modifications in use are done on short notice.

1.1 - AIP

1.1.1 - General

The Air Information Publications (AIP) are intended to meet the international requirements regarding exchanges of permanent aeronautical information essential for air traffic.
The AIP are thus a basic and official source for permanent aeronautical information and temporary or long-term modifications.
Permanent aeronautical information is periodically updated, every 28 days, with update bulletins, in accordance with an international timetable defined by the ICAO, called AIRAC (Aeronautical Information Regulation and Control).

1.1.2 - AIP structure

The format of an AIP must comply with the provisions of the ICAO Annex 15. It includes three parts:

- "GEN", for general information;
- "ENR", for information relating to the en-route phase;
- "AD", for information relating to airports.

Each part is in turn divided into sections and sub-sections describing the following main elements of aeronautical information.

Part 1: "General (GEN)"

GEN 0 – Preface
GEN 1 – National regulations and requirements (customs and health formalities, facilitations, etc.)
GEN 2 – Tables and codes
GEN 3 – Services (search and rescue procedures, etc.)
GEN 4 – Taxes for aerodromes/heliports and air navigation services

Part 2: "En-route (ENR)"

ENR 0 – Preface
ENR 1 – General rules and procedures
ENR 2 – Air traffic services airspaces
ENR 3 – ATS routes
ENR 4 – Radio navigation aids/systems
ENR 5 – Navigation warnings
ENR 6 – En-route charts

Part 3: "Aerodromes (AD)"

AD 0 – Preface
AD 1 – Aerodromes/heliports – Introduction
AD 2 – Aerodromes
AD 3 – Heliports

1.2 - NOTAM

NOTAM are messages published by the Aeronautical Information Service in order to supplement the AIP and to distribute information quickly, whenever it is necessary to inform immediately about a change or an event.
The NOTAM messages are distributed through telecommunication and can be viewed on the official sites.
The temporary aeronautical information (usually lasting less than three months) is thus published in NOTAM. If the NOTAM validity is planned to exceed three months, the information will be published via a SUP AIP.
The NOTAM messages are intended for flight crews or personnel in charge of flight operations, to indicate the following items.

1.2.1 – Ground- and satellite-based facilities and services

Prior to each flight, during the pre-flight preparation and briefing stage, part of a pilot's duty is to check whether navigation aids devices will be available on their intended route and at their destination airport to make sure that navigating during the flight and on landing will be possible; thus the crew is recommended to check the availability of all facilities and services required for the planned flight. This check concerns:

- conventional ground-based radio-navigation devices (VOR, DME, NDB, ILS, LOC…) and,
- satellite-based devices (GPS, SBAS, GBAS…) as most of current commercial air transport flights are operated using RNAV/RNP/GNSS procedure.

To perform this check, pilots have to refer to NOTAMs and other techniques and tools described below.

1.2.2 - Departure, destination and alternate aerodromes

a) Analyse the latest state at departure, destination and alternate aerodromes

This analysis is done using NOTAMs which are issued (and reported) for a number of reasons occurred at aerodromes, such as:

- Implementation, closure or major modification in the operation of an airport.
- Works in progress on runways that impact ground maneuvering areas and reduction in the available runway lengths for take-off and landing.
- Presence of temporary obstacles in the take-off cone that may modify the take-off path (e.g. presence of cranes due to works).
- Interruption or reactivation of major elements in the airport light beacon systems.
- Activation or withdrawal of radio or airport aids.
- Activation, withdrawal or major modification of visual aids.
- Modifications of conditions on the movement area (snow, water, ice); see the SNOWTAM definition hereafter.
- Change to the SSIS protection of an airport (category change, for instance).
- Installation, withdrawal or reactivation of hazard beacons identifying obstacles.

With regard to runway condition, in the case of a contaminated runway (runway covered with contaminants, such as snow, slush or ice), the runway contamination status is specified in a specific NOTAM known as a "SNOWTAM". It provides information about the type of contaminant, its thickness, the friction coefficient etc.

b) Check satellite-based facilities and GBAS/SBAS augmentation

- Satellite based facilities check

As stated above, it is recommended that the checking of satellite availability during the expected time of use is incorporated into the flight preparation stage. There are several sources of information or tools which can be relevant to pilots:

- Local aviation authorities publish GNSS NOTAM and EGNOS NOTAM (European Geostationary Navigation Overlay Systems) in case of predicted prolonged out-of-service state.
  In France, EGNOS NOTAMs are issued if the EGNOS signal is expected to be unavailable for more than 5 minutes for a terrain on which a GNSS approach is published.
  In the United States, the availability of WAAS (Wide Area Augmentation System) is done through the consultation of a website: https://www.gps.gov/support/user/#aviation

- The EUROCONTROL "AUGUR", a web-based tool that keeps users informed about the number of operational satellites and provides a way of confirming GPS's positioning availability and integrity for a flight.

- GBAS/SBAS augmentation check

One of the most important phases of flight is the approach. When a RNAV/GNSS approach is planned at destination, it is important to check GBAS/SBAS availability during the expected time of use. To perform this check, it is necessary to refer to the current NOTAMs for the flight area FIR and the arrival aerodrome.
Note that for SBAS facility, the EGNOS has its own predictive and real time overview tool, which can be displayed in convenient maps.

1.2.3 – Airway routings and airspace structure

Airway routings and airspace structure NOTAM alert pilots of potential hazards along a flight route that could affect the safety of the flight. This includes :

- Establishment, withdrawal or major modification of procedures for the air traffic services.
- Frequency change of the radio navigation and radio-communication aids.
- Modifications to the regulations and requiring immediate actions: e.g. creation of prohibited areas due to SAR (Search And Rescue) operations.
- Time slot of activities in areas with a specific status.
- Existence of dangers impacting the air traffic (obstacles, military drills, air shows, etc.).
- Implementation, withdrawal or modification in the operation of air services.
- Epidemics and modifications to health regulations.
- Release of toxic products into the atmosphere.
- Cosmic radiation forecast

A NOTAM called "NOTAM Trigger", is a specific NOTAM distributed in order to draw the user's attention to the presence of a SUP AIP modifying permanent aeronautical information.
For information, a NOTAM specimen is provided hereafter (the candidates are not required to know how to decode a NOTAM for the 033 certificate exam).

```
ORION REF: 5539927_                              BY: LFFAYNYX  ON: 071218 1707
 NOTAM REF: A  4794 / 07 / __ CLASS 1_ NOF LFFA COID OFF  STATUS: A  TYPE: R
 REFERING : A  4784 / 07 /     CLASS 1   NOF LFFA               GAF: Y
 Q) FIR: LFFF   QCODE: QCACR  TRAFFIC: IV  PURPOSE: B    SCOPE: E
    LOWER: 195  UPPER: 265    CO-ORDINATES: 4725N 00027E  RADIUS:  60
 A) LOC: LFFF F PARIS FIR                 DEST:
 B) _ FROM: 071218 1707  C) TO: 080318 2359   PERM:
 D) TIME SCHEDULE:
 E) COM  _  freq secteur de ctl oy paris ctl 134.880mhz hors service :
            utiliser freq ot paris ctl 118.725mhz
 F) LOWER LIMIT: FL195  G) UPPER LIMIT: FL265
```

1.2.4 – Pre-flight preparation of GNSS acheivability

a) Why it is important to check GNSS achievability.

Today's usual flights are dependent on GNSS, therefore, it is strongly recommended to check whether the GNSS signal is achievable in order to avoid a possible dangerous situation of being unaware of your position.

b) RAIM NOTAM and NANU messages.

As stated above, the pilots' briefing should include study of:
- the integrity of satellite signal. This could be done via Receiver Autonomous Integrity Monitoring (RAIM) and,
- any predicted outage of the navigation source via GNSS NOTAMs, and Notice Advisory to Navstar Users (NANUs) messages.

✓ RAIM (signal integrity)

The RAIM function is to assess the integrity of the Global Positioning System (GPS) signals. There are 2 ways of having RAIM prediction for GPS:

- The RAIM prediction can be obtained from the Eurocontrol AUGUR web page where it can be checked whether enough satellites are operational and if a necessary the number of satellites that will be visible while en-route and on approach.
- Another option is an in-device RAIM prediction. In this case, the RAIM function is a part of every GNSS device certified for IFR operations which constantly and automatically monitors and assesses integrity of the GPS signals. In-device RAIM prediction computation is based on almanac information sent by GPS satellites.

- ✓ Besides, the pilot must check any NOTAM that may affect the availability or feasibility of the RNAV procedures he is likely to perform. There may be different NOTAMs that indicate the unavailability of the GNSS signal:
  - A EGNOS NOTAM is created when a longer period of unavailability of navigation source is predicted.
    Attached is an example of EGNOS NOTAM for predicted unavailability:

```
A1234/10 NOTAMN
Q) LFBB/ QGAAU/ I/ NBO/ A/ 000/ 999/ 4100N00200E005
A) LFBO
B) 0908240145
C) 0908250225
D) 24 0145-0230 0630-0645 25 0155-0225
E) EGNOS UNAVBL FOR LPV
```

  - Notice Advisory to Navstar Users (NANU) messages issued by US Coastal Guard: It is an advisory message to inform users of a change in the GPS constellation. These messages are released 72 hours in advance of planned maintenance. These messages are also used to notify users of unscheduled outages.
    Attached is a sample of NANU message.

```
2020016------------------------
NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2020016

SUBJ: SVN67 (PRN06) FORECAST OUTAGE JDAY 114/2145 - JDAY 115/0945

1.      NANU TYPE: FCSTDV
        NANU NUMBER: 2020016
        NANU DTG: 162213Z APR 2020
        REFERENCE NANU: N/A
        REF NANU DTG: N/A
        SVN: 67
        PRN: 06
        START JDAY: 114
        START TIME ZULU: 2145
        START CALENDAR DATE: 23 APR 2020
        STOP JDAY: 115
        STOP TIME ZULU: 0945
        STOP CALENDAR DATE: 24 APR 2020


2.   CONDITION: GPS SATELLITE SVN67 (PRN06) WILL BE UNUSABLE ON JDAY 114
     (23 APR 2020) BEGINNING 2145 ZULU UNTIL JDAY 115 (24 APR 2020)
     ENDING 0945 ZULU.


3.   POC: CIVILIAN - NAVCEN AT 703-313-5900, HTTPS://WWW.NAVCEN.USCG.GOV
     MILITARY - GPS OPERATIONS CENTER AT HTTPS://GPS.AFSPC.AF.MIL/GPSOC,
     DSN 560-2541,
     COMM 719-567-2541, GPSOPERATIONSCENTER@US.AF.MIL,
     HTTPS://GPS.AFSPC.AF.MIL
     MILITARY ALTERNATE - JOINT SPACE OPERATIONS CENTER, DSN 276-3526.
     COMM 805-606-3526.
```

c) Use of augmented and non-augmented GNSS in connection with the achievability check.

Regarding the achievability check, the main difference in use of an augmented GNSS (GBAS – Ground Based Augmentation System or SBAS – Satellite Based Augmentation System) compared to non-augmented GNSS is that once the pilot is receiving SBAS or GBAS augmented signal, it is not necessary to check integrity.
Indeed, the SBAS and GBAS contain a ground-based station which evaluates the GNSS precision and availability in real time and sends corrections and integrity status info to the on-board GNSS device.

d) Difference in planned and unplanned outage of GNSS or SBAS.

Pilots have to prepare to the outage of GNSS or SBAS signals and they must have a suitable backup plan prepared when flying dependent on these systems. We make the difference between a planned and an unplanned outage:

- ✓ A planned outage of GNSS or SBAS is well known during flight preparation because relevant monitoring tools (AUGUR) and NOTAMs will most probably indicate some problems and unavailability.
  In the event of the planned unavailability of GNSS, the crew is supposed to use other means of navigation or to choose another destination or to delay the flight.

- ✓ In case of unplanned outage i.e. an outage that occurs during the flight, it is possible that the pilot will become aware that signals integrity is lost. In that case the pilot is alerted by either a warning, which explains that the displayed position has reduced accuracy, or, in case of total loss of the navigation signal.
  - If the signal is lost when flying en-route, tune in a ground navigation aid of a nearby aerodrome or en-route aid.
  - If the signal is lost during arrival, departure, and approach, the GNSS device will stop showing navigation information completely. Therefore, Pilot must be prepared to correctly handle the situation and return to classical radio navigation.

  So, regardless of the phase of flight, it is important that in case of an unplanned outage of GNSS or SBAS, the pilot should develop and maintain good practice in using backup conventional navigation whenever possible.

02 METEOROLOGICAL INFORMATION

During flight planning, the meteorological information to be studied must cover the full flight (estimated time slot of the flight, and geographic range of the trip).
It must be picked up as close as possible to the time of departure.

The meteorological record includes:
- surface weather data communicated in airport weather messages: METAR, TAF, etc.;
- altitude weather data, specified on charts.

2.1 - Airport meteorological messages

Two types of airport meteorological messages are available:

- observation messages: METAR, SPECI;
- forecast messages: TAF.

Thoroughly reading these messages allows getting the current meteorological information of the departure airport and getting an idea of the weather forecast at destination and alternate airport, on which the accessibility of these airports depends.

Furthermore, the latest meteorological information on the en-route meteorological charts allows the flight crews to update the flight plan data. More specifically:

- updating the selection of optimum altitudes according to the wind and maximum altitudes according to the temperature;
- updating the true altitude computation according to the temperature difference recorded at the flight level with regard to the standard temperature, in order to maintain the required obstacle clearances;
- confirming or modifying the magnetic headings and ground speeds for each segment of the route. These parameters, especially the ground speeds, allow recomputing the flight time and the fuel consumption for each segment of the route in order to derive the flight time and the total fuel consumption to destination.

2.1.1 - METAR

The METAR or SPECI are airport observation messages. They are generated by the weather stations performing weather observations.

The METAR are regular, highly reliable messages. They are systematically sent every hour or half-an-hour, to describe the weather conditions of an airport at a specified time. They may also include an indication on the weather changes over a two-hour period starting from the observation time. Other special observation messages may be generated and sent occasionally, in case of significant weather change (worsening or improved). These are the SPECI messages.

The same codes are used for METAR and SPECI. It is important to perfectly know the codes of these messages for correct application of meteorological information.

e) Typical structure of a METAR

The METAR or SPECI provide the following information:

- identification group (type of message, ICAO code of the airport, date and UTC time);
- surface direction and speed of the wind;
- visibility;
- runway visual range;
- current weather;
- cloud amount;
- outside air temperature/ dew point temperature;
- QNH;
- trend, additional information.

Example

METAR: LFPO 081400Z 28015G25KT 9999 -RA BKN014TCU BKN028 15/14 Q1005 NOSIG=

LFPO	081400Z	28015G25KT	9999	-RA
Airport	Date and time	Wind	Visibility	Weather

BKN014TCU BKN028	15/14	Q1005	NOSIG=
Clouds	Temperature / dew point	QNH	Trend

f) Decoding the METAR or SPECI

Group	Comments	Examples	Meaning
Identification	Message name Airport ICAO code Date and time of observation	METAR LFPO 081400Z	Observation message Paris Orly Day 8 of the month, 14:00 UTC
Wind (kt)	Wind direction and speed **G** = gusts **VRB** if wind < 3 kt or if the wind direction varies by 180° or more	28015G25KT VRB02KT 15009KT 120V200	Wind from 280°, 15 kt speed, 25 kt gusts. Variable direction wind, 2 kt speed. Wind from 150°, 9 kt speed, variable direction between 120° and 200°.
Visibility (m)	Prevailing visibility, expressed in meters	0000 9999 3000 NDV	Visibility < 50 m Visibility ≥ 10 km Visibility = 3,000 m No direction indication
RVR = runway visual range (m)	L: left C: center R: right D: down U: up N: no change P: more than M: less than	R08L/0300 R26/1000D R26/M0100 R26/P1000	The RVR on runway 08 left is equal to 300 m The RVR on runway 26 is 1,000 m, down The RVR on runway 26 is less than 100 m The RVR on runway 26 is more than 1,000 m

Current weather	VC: vicinity +: severe -: moderate Weather code (refer to meteo book)	-SHRA VCSH TSRA	Moderate shower Shower in the vicinity Storms with rain
Clouds	NSC: No Significant Clouds W ///: non visible sky NCD: No Cloud Detected The ceiling is expressed in hundreds of feet	FEW SCT BKN OVC SCT020	Few (1 to 2 oktas) Scattered (3 to 4 oktas) Fragmented (5 to 7 oktas) Overcast (8 oktas) Scattered clouds at 2,000 ft
CAVOK	Visibility ≥ 10 km No significant clouds and no significant weather for aviation below 5,000 ft or the transition altitude, whatever the higher.		CAVOK replaces the visibility group, the current weather and clouds when the required conditions are present at the time of observation
Temperature / dew point temperature	M: negative	05/M02	Temperature 5°C and dew point temperature - 2° C
QNH	QNH value in hPa	Q1005	QNH = 1,005 hPa.
Other information	RE: recent WS: wind shear	RESHSN WS RWY34	Recent snow shower Wind shear on runway 34
Trend	NOSIG: no significant change predicted within the two hours following the observation time NSW: no significant weather NSC: no significant cloud BECMG: weather condition change indicator TEMPO: temporary variation indicator for one or more parameters		

Types of Weather Phenomenon					
Element 4: Precipitation		**Element 5: Obscuration**		**Element 6: Other**	
DZ	Drizzle	BR	Mist, vis. ≥ 5/8SM (or ≥ 1000m)	DS	Dust Storm
GR	Hail, diam. ≥ 5mm (.25")	DU	Widespread Dust	FC	Funnel cloud(s) e.g., tornado or waterspout
GS	Small Hail / Snow Pellets, diam. < 5mm (.25")	FG	Fog, vis. < 5/8SM (or ≥ 1000m)	PO	Well-developed dust/sand whirls
IC	Ice Crystals	FU	Smoke	SQ	Squalls
PL	Ice Pellets	HZ	Haze	SS	Sandstorm
RA	Rain	PY	Spray		
SG	Snow Grains	SA	Sand		
SN	Snow	VA	Volcanic Ash		
UP	Unknown Precipitation (Automated only)				

2.1.2 - TAF

The TAF (Terminal Aerodrome Forecast) is a forecast message for weather conditions on an airport. Two types of TAF are available:

- Short TAF: the message is valid for 9 hours, repeated every 3 hours;
- Long TAF: the message is valid for 24 hours or 30 hours, repeated every 6 hours.

Both messages are available one hour before the start of being valid.
If significant weather changes occur during the valid period, they are directly described in the message, via the development and probability forecast groups.
The codes used in the TAF and METAR are nearly identical. Only the layout is different.

a) Typical structure of a TAF

LONG TAF: LFPO 081100Z 0812/0918 25006KT 9999 SCT007 BKN017 TEMPO 0812/0818 6000 -SHRA BKN010 SCT020CB PROB40 TEMPO 0812/0816 28015G30KT 2000 TSRA TEMPO 0903/0908 3000 BR BKN006 BECMG 0908/0911 30010KT SCT013 BKN025 BECMG 0915/0918 CAVOK=

LFPO	081100Z	0812/0918	25006KT	9999	
Airport	Date and time	Validity period	Wind	Visibility	Weather

SCT007 BKN017	TEMPO 0812/0818 6000 -SHRA BKN010 SCT020CB PROB40…
Clouds	Development forecast

g) Decoding the TAF

Group	Comments	Examples	Meaning
Identification	Message name Airport ICAO code Date and time of transmission	TAF LFPO 081100Z	Forecast message Paris Orly 8th of the month, 11:00 UTC
Validity period	Date and time of the validity start/day and time of the validity end	0812/0918	Valid from 8th, 12:00 UTC to 9th 18:00 UTC
Wind (kt)	Same as METAR		
Visibility (m)	Same as METAR		
Significant weather	Same as METAR		
Clouds	Same as METAR		
Development and probability group	**FM** (From): predicted start of change	FM 081900 31010KT	8th of the month, from 19:00 UTC, 310°/10 kt wind
	BECMG: weather condition change indicator	BECMG 0915/0918 CAVOK	9th of the month, from 15:00 to 18:00 UTC, weather becomes CAVOK.
	TEMPO: temporary variations indicator for one or more parameters.	TEMPO 0812/0818 6000 –SHRA	Temporarily, on 8th of the month between 12:00 and 18:00, the visibility is 6 000 m and light rain showers are expected.
	PROB: occurrence probability indicator for the described phenomena; always followed by TEMPO	PROB40 TEMPO 0812/0816 28015G30KT	With a 40 % occurrence probability, temporarily, on 8th of the month between 12:00 and 18:00 UTC, the wind is 250°/15 kt with 30 kt gusts.
Extreme temperatures/estimated date and time	**Tn**: min. temperature **Tx**: max. temperature **M**: for negative temperature	TnM02/1106Z Tx10/1115Z	On 11th of the month at 6:00, the minimum temperature is –02 °C On 11th of the month at 15:00, the maximum temperature is 10 °C

Note. In the exam, the following types of messages may be found:

- *SA1330 121330Z 13005KT…;*
- *FC0900 121000Z 121212 15015G30KT…;*
- *FT0900 121000Z 121812 18005KT…*

With: SA = METAR, FC = short TAF, FT = long TAF.

The weather condition codes are ICAO codes. As an example, we refer to the following METAR/TAF messages.

Example

BIRMINGHAM EGBB/BHX

SA0850 280850 18014KT 9999 SCT024 BKN030 BKN045 12/08 Q1011=

FC0600 280600Z 280816 190015G27KT 9999 BKN025 TEMPO 0812 5000 –DZ BKN012 BECMG1214 19022G37=

FT0400 280434Z 281212 19022G37 9999 BKN025 TEMPO 1902 5000 RA BKN010 BECMG 2201 25007KT

1. What is the total duration of the weather forecast?

A) 9 hours B) 18 hours C) 24 hours D) 28 hours

2. What is the estimated lowest visibility at 280800Z?

A) 50 km B) 5,000 m C) 10 km or more D) 2,500 m

Answer 1

The question concerns the forecast; therefore, we are interested in the TAF messages.

In the short TAF message (FC0600), the forecast period is 280816: on 28th of the month, the forecast covers a period from 8:00 UTC to 16:00 UTC.

In the long TAF message (FT0400), the forecast period is 281212: the forecast covers a period from 12:00 UTC on 28th to 12:00 UTC on the next day.

Therefore, the total TAF forecast is from 8:00 UTC on 28th to 12:00 UTC on the 29th, i.e. a 28 hour forecast.

Answer **D**.

Answer 2

The question concerns the forecast on the 28th of the month at 8:00 UTC; therefore, we are interested in the TAF messages.

In the short TAF message (FC0600): “TEMPO **0812 5000** – DZ” group.

Temporarily, from 8:00 UTC to 12:00 UTC, the visibility is 5,000 m, due to the presence of low intensity (“–” sign) drizzle (DZ).

Answer **B**.

Note. The long TAF message also indicates a 5,000 m visibility with the “TEMP 1902 5000 RA” group. But, the forecast period (19:00 UTC to 2:00 UTC) is not the one stated!

2.2 - Altitude weather charts

2.2.1 - General

The aeronautical meteorological offices collect weather data worldwide through weather stations, in order to work out forecast and to provide graphical representations as charts.
These charts indicate one or more weather elements at altitude for a specified period, a specified vertical space and a defined airspace. Therefore numerous altitude weather charts are available.

In the meteorological information on the altitude charts, the following two types of charts can be considered:

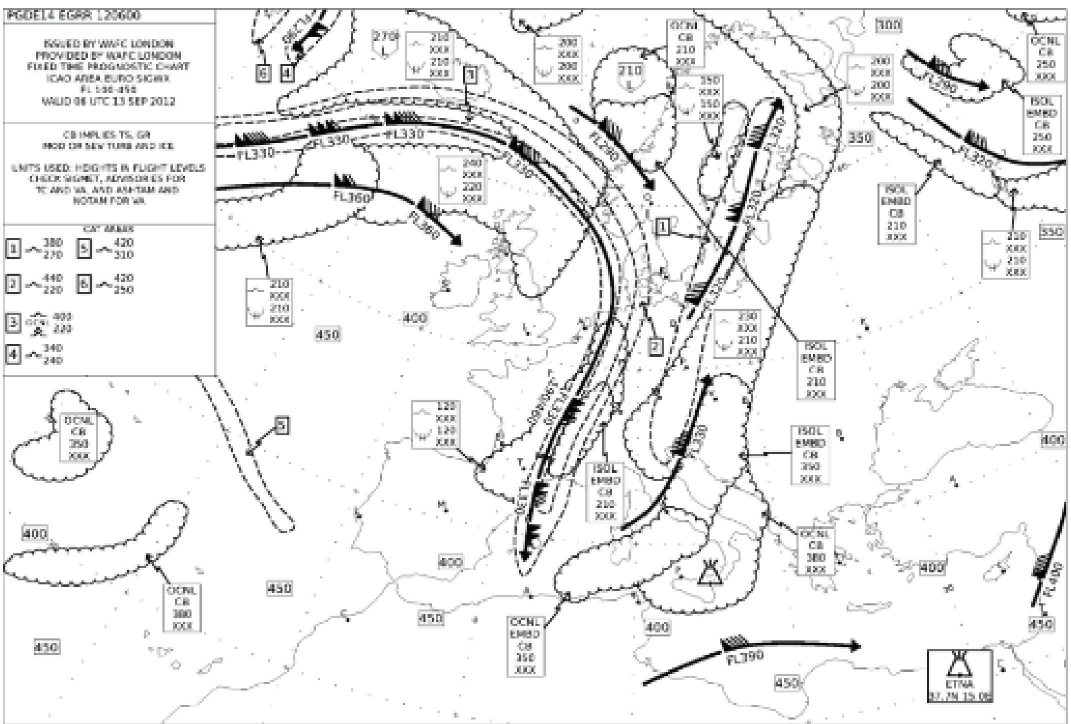
- Significant Weather Charts (SWC);
- altitude wind and temperature chart: WINTEM chart.

2.2.2 - Significant Weather Chart (SWC)

As its name indicates, the Significant Weather Chart (SWC) is a chart of the significant weather forecast at a specified hour or period and for a specified airspace. Only the important phenomena and clouds are displayed on this type of chart.

In addition to the altitude SWC issued by the World area forecast system, Meteo France issues the SWC for the EUROC area. For this type of chart, only cloud masses with a cloud amount exceeding 4/8 (BKN and OVC) are described. On the French SWC, the cloud layers with an SCT cloud amount are also described.

In the exam, the SWC being used are primarily SWC EUR. They have the same characteristics as the SWC EUROC charts.



Example of SWC (Significant Weather Chart) EUR.

Display of fronts and convergence zones

	cold front
	warm front
	stationnary front
	occluded front
	Trough of warm air aloft (TROWAL)

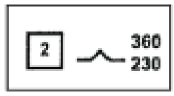
Clear air turbulence (CAT) display

This term is used in aviation to indicate a specific turbulence at medium and high altitude, off a dense cloudy environment, thus justifying the clear air atmosphere.

This atmospheric turbulence results from high variations in the wind direction or velocity.

The ICAO acronym for this phenomenon is CAT (Clear Air Turbulence).

In the example on the right, extracted from the previous SWC, the CAT occurs between FL 230 and FL 360.



Significant weather symbols

	moderate turbulence
	severe turbulence
CAT ABV 100	moderate to severe turbulence in Clear Air above 10000 feet
	moderate icing
	severe icing

	rain		ice pellets
	drizzle		hail
	rain shower		haze
	freezing rain		mist
	snow		fog
	snow shower		fog, depositing rime
	heavy rain shower		thunderstorm
	squalls		thunderstorm, heavy, with rain and/or snow
	ice pellets (shower)		thunderstorm, heavy, with hail
	lightning		

Clouds

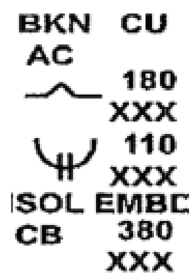
The following qualifying abbreviations are used to describe the cumulonimbus (CB) and towering cumulus (TCU) only.

- ISOL: Isolated CB or TCU;
- OCNL: Occasional CB or TCU;
- FREQ: Frequent CB or TCU;
- EMBD: CB (only) embedded in a layer.

For the other types of clouds (AC = altocumulus; AS = altostratus; CC = cirrocumulus; CU = cumulus; ST = stratus, etc.), the conventional qualifications in number of oktas are used:

- FEW: few (1 to 2 oktas);
- SCT: Scattered (3 to 4 oktas);
- BKN: broken (5 to 7 oktas);
- OVC: overcast (8 oktas);
- LYR: layered.

WARNING! The powerful and large-scale vertical motions driving the cumulonimbus (CB) generate a series of important phenomena for aviation: icing, turbulence and windshear. Associated with this type of clouds, they often have a high intensity.



Thus, even if signs  and  respectively indicate moderate turbulence and icing, implicitly, the presence of CB always means risk of moderate to severe potential turbulence and icing.

In the example on the right, "XXX" indicates that the CB base is below FL 100 (chart bottom, see title block) and the top is at FL 380.

Jet axes

The center symbol represents the jetstream axis with indication of the maximum wind (130 kt, see wind values below) and its altitude. The line with the double bar indicates 3,000 ft maximum altitude changes and/or 20 kt wind velocity changes

Reminder:

 10 kt  5 kt  50 kt 0 calme

Example 1

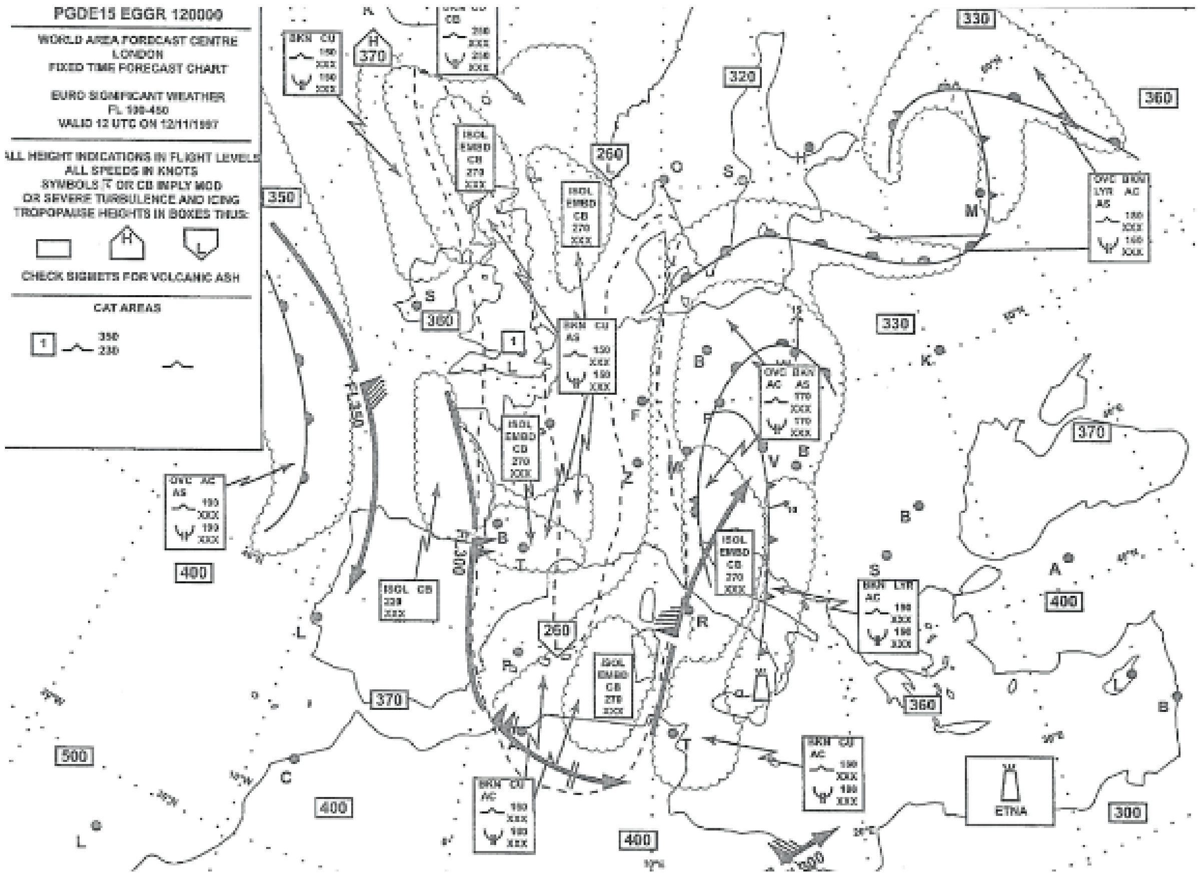
Refer to the Significant Weather Chart below.
The wind direction and maximum speed (°/kt) just North of Tunis (36° N – 010° E) are:
A) 250/85 B) 180/105 C) 190/95 D) 280/110

Answer
The jetstream North-West of Tunis is southerly (» 190°) and its maximum speed is 95 kt: 1 triangle (50 kt) + 4 barbs (40 kt) + ½ bard (5 kt).
Answer C.

Example 2

Refer to the Significant Weather Chart below.

What is the best description of the maximum turbulence intensity, if applicable, forecast at FL 262 above Toulouse (44° N – 001° E)?



A) Light   B) None   C) Severe   D Moderate

Answer

Identify Toulouse (44 °N – 001° E) on the chart. Two significant weather boxes are displayed. The first box (the most northern) indicates the presence of moderate turbulence (symbol ʌ) between FL < 100 (xxx) and FL 150. Level 260 is not concerned by these turbulences.

The second box indicates that the area is also covered with isolated cumulonimbus embedded in the layer (ISOL EMBD CB) with a base below FL 100 (xxx, the chart starts at FL 100) and a top at FL 270. The key in the title block in the top left-hand corner of the chart indicates that "CB imply mod or severe turbulence and icing". Thus, the CB presence always means there is a risk of icing and moderate to severe turbulence.

Answer **C**.

Example 3

See the Significant Weather Chart above.

What is the best description of the significant clouds forecast above Toulouse (44° N – 001° E)?

A) Altocumulus/cumulus with a base below FL 100 and top at FL 150; isolated cumulonimbus embedded in the layer with a base below FL 100 and top at FL 270

B) Well separated cumulonimbus with a base at FL 100 and top at FL 270.

C) Isolated cumulonimbus embedded in the layer of the surface at FL 270.

D) 5 to 7 oktas cumulus and altocumulus with a base below FL 100 and top at FL 270.

Answer

Both boxes North and North-East of Toulouse (44° N – 001° E) indicate the presence of:

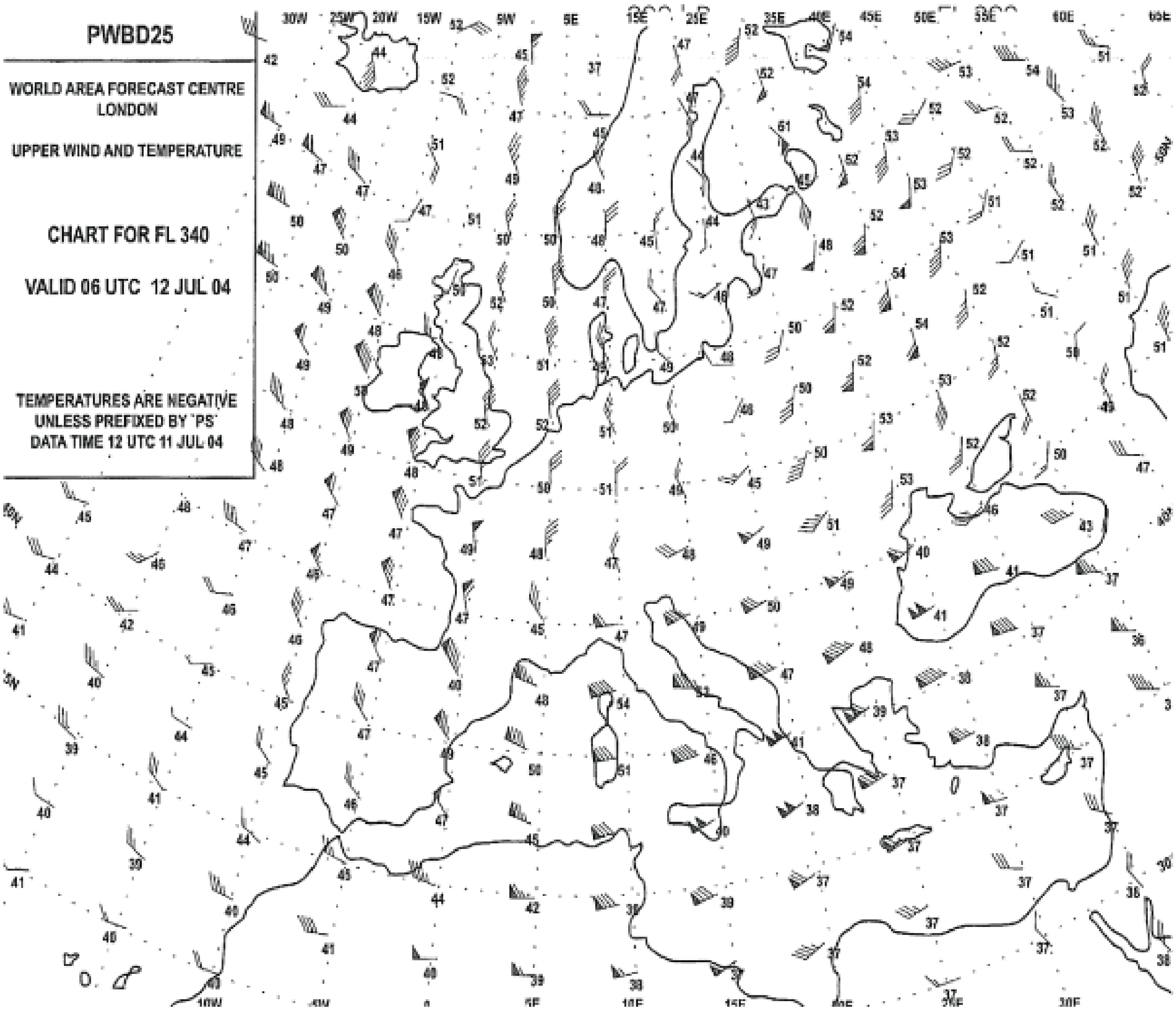
- BKN clouds, type CU (cumulus)/AC (altocumulus) with a base below FL 100 (xxx, the chart starts at FL 100) and top at FL 150;
- isolated cumulonimbus, embedded in the layer (ISOL EMBD CB), with a base below FL 100 (xxx) and top at FL 270.

Answer **A**.

2.2.3 - WINTEM chart

The WINTEM chart is a WINd and TEMperature forecast chart on isobaric surfaces. It is thus intended for fixed flight levels.

Isobaric surface	Flight level
950 hPa	FL 20
850 hPa	FL 50
700 hPa	FL 100
500 hPa	FL 180
300 hPa	FL 300
250 hPa	FL 340
[illegible]	[illegible]



Example of WINTEM chart.

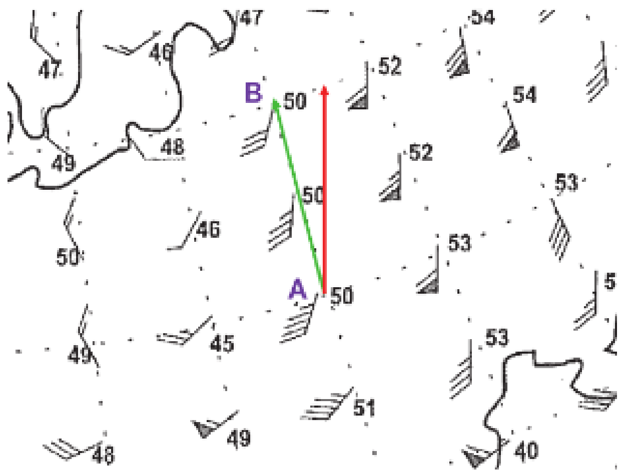
WINTEM title block

The title block at the top of the WINTEM chart provides information about the weather center, the validity period and the flight level of the chart (FL 340 in our example).

Wind display

Winds indicated on the chart are represented by an arrow system with barbs and feathers.

The arrows indicate the wind direction with regard to the true North and the number of barbs and feathers indicate its velocity in kt.



Note. While the wind direction in the ATIS messages is indicated in relation to the magnetic North, it is useful to note that the METAR, TAF and WINTEM chart wind direction is indicated in relation to the true North!

WARNING: on the chart, the true North is indicated by the green arrow, not the vertical one (red arrow).

Example

Refer to the extract of the above WINTEM chart.

What is the average wind (direction and speed) along the AB course?

A) 225°/45 kt B) 210°/35 kt

C) 220°/30 kt D) 218°/36 kt

Answer

Along this course, the following winds are specified: 225°/45 kt, 210°/35 kt and 220°/30 kt. The average wind along this course is 218°/36 kt.

Answer D.

Example

Refer to the extract of the above WINTEM chart.

What is the effective average wind component along the track from A to B?

A) – 28 kt B) – 25 kt

C) + 28 kt D) + 25 kt

Answer

Compared with the previous question, it is important to carefully read the question.

We are talking about **wind projection** along the AB track here.

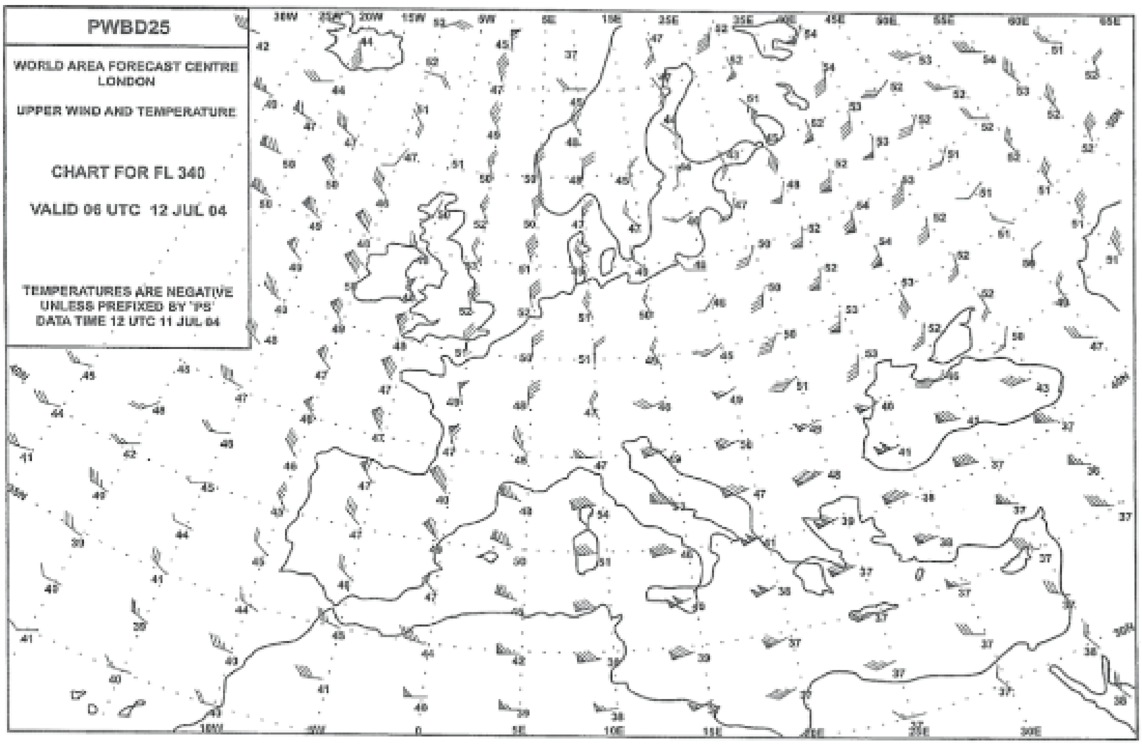
As the TR(T) from A to B is 360° and the average wind direction is 218° (see question above), the effective wind component from A to B is:

cos (360° – 218°) x 36 = – 28 kt (the value obtained with the formula is negative, meaning that it is a tailwind).

The effective average wind component along the A-B track is + 28 kt.

Answer **C**.

Temperature display



Temperatures are specified in degrees Celsius. The negative temperatures are not signified. The positive temperatures are prefixed with a + sign.

Example

See the above chart.

What is the temperature difference (°C) with regard to the ISA temperature at 50° N – 010° E?

A) – 58 B) – 6 C) + 2 D) + 10

Answer

At point (50 °N – 010° E) and at FL 340 (chart level specified in the legend of the box in the top left-hand corner of the chart), the outside air temperature (OAT) is – 51 °C.

ΔISA = OAT – ISA = – 51 – (15 – 2 x 34) = + 2 °C

Answer **C**.

Note. *The temperatures on the WINTEM chart are published* ***for the flight level specified in the box in the top left-hand corner of the chart****. It is thus easy to get a temperature estimate for another flight level, starting from the specified temperature and flight level and applying the temperature correction rules of the standard atmosphere (2° C per 1,000 ft).*

03 UPDATING THE FLIGHT PLAN IN ACCORDANCE WITH THE METEOROLOGICAL DATA

When all meteorological datasets are obtained, the pilot will thoroughly study the weather reports and weather forecast and the final decision to proceed with the flight will be up to the pilot alone. If the flight feasibility is confirmed, and if the latest meteorological datasets are different from the ones used for the initial completion of the navigation log and the fuel log, it will be necessary to update the flight plan items in order to confirm or discard some operational choices, in particular:

3.1 - Selected cruise altitudes

- The temperature affects the maximum cruise altitude. Refer to the Flight Manual to determine the maximum altitude not to be exceeded depending on the temperature.
- The wind data may lead the pilot to select an altitude for which the forecast wind is the least penalizing (or the most favorable) possible.
- Furthermore, we have seen in Chapter 1 that the atmospheric pressure and the temperature affect the flight true altitude. Therefore, the variation of both parameters must be taken into account to update the aircraft's real altitude in order to ensure that the obstacle clearances are always complied with. It is recommended for the student to review the altimeter correction rules "pressure and temperature corrections", specified in Chapter "033-01, IFR Navigation".

3.2 - Magnetic heading and ground speed

- Using the latest wind data and the altitudes finally selected for the flight, it is necessary to recalculate the magnetic headings according to the drift angles and the ground speeds using the navigation computer for each flight segment, in order to update the estimated time of arrival to each waypoint and the time of arrival for the complete flight.
- The TOC (Top Of Climb) and TOD (Top Of Descent) computations must also be reviewed depending on the variation of the ground speed during the climb phase and the descent phase.

3.3 - Fuel

Chapter 033-03 "Fuel" explained that the cruise fuel computation depends, first on the Fuel Flow (FF) and secondly on the ground speed. But a change in temperature and/or altitude also directly affects the Fuel Flow (FF). The performance data published in the Flight Manual allows the pilot to correct the FF according to these two parameters.

04 POINT OF EQUAL TIME (PET) AND POINT OF SAFE RETURN (PSR)

4.1 - General

During flight planning, the flight crew must be able to anticipate actions to be taken in case of emergency during the flight.
Depending on the type of incident a crew is facing, decisions will vary:

- a technical problem may lead the crew to fly back to the departure airport or continue the flight to the destination or to a diversion airport;
- in the case of an medical emergency onboard, it may be necessary to divert to the appropriate airport being closest in flight time.

In order to make a wise decision at any time during the flight, the crew will need to define the Points of Equal Time (PET) in order to determine the fastest route in flight time between two airports, as well as the Points of Safe Return (PSR), to know if the regulatory fuel is sufficient to fly back to the departure point.

4.2 - Point of Equal Time (PET)

4.2.1 - Point of Equal Time principle

The Point of Equal Time (PET) between two airports is the point located on the aircraft route from which the same flight time to join one airport or the other would be equal.

The two airports may be the departure airport and the destination airport or any other diversion airport couple being accessible from the flight route.

Determining the PET on the route followed by the aircraft and plotting on the en-route chart, allows crew to quickly know which diversion airport is closest in flight time in case a problem occurs during the flight.

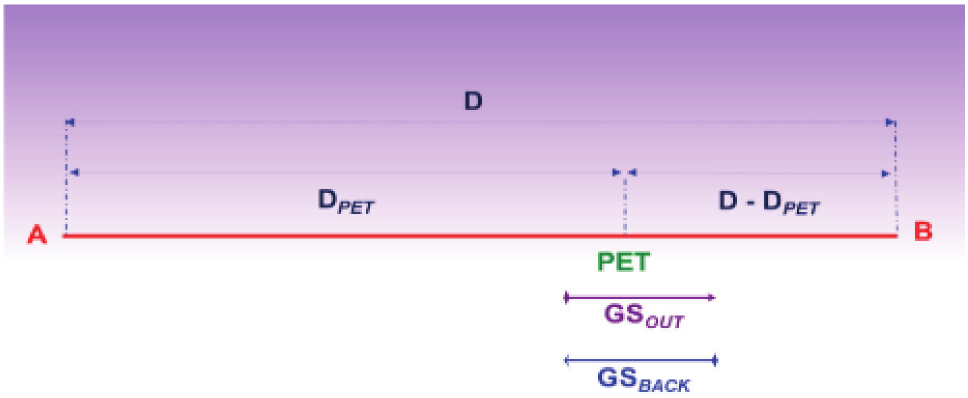
As for oceanic or desert flights, due to the absence of a diversion airport on the route, determining the PET between the departure and destination airports allows crew to quickly make a decision concerning the flight continuation in case of emergency: continue the flight to the destination or fly back to the departure airport.

Therefore, the Point of Equal Time is a question of flight time.

4.2.2 - PET computation formulas

By definition, in zero wind conditions, this point is thus located half-way between the two airports.

With wind, the position of the PET varies depending to the effective wind encountered on the route. This position is determined in accordance with the following computing principle.



With:

D	= distance between two airports A and B
D_{PET}	= distance of Point of Equal Time at A
$D - D_{PET}$	= distance of the Point of Equal Time at B
GS_{BACK}	= return ground speed
GS_{OUT}	= outward ground speed

For defining the PET, we have:
Return time from PET to A = outward time from PET to B
Hence:

$$\frac{D_{PET}}{GS_{BACK}} = \frac{D - D_{PET}}{GS_{OUT}}$$

$$\Leftrightarrow D_{PET} \times GS_{OUT} = D \times GS_{BACK} - D_{PET} \times GS_{BACK}$$

The position of the Point of Equal Time (D_{PET}) on the A-B route is:

$$D_{PET} = \frac{D \times GS_{BACK}}{GS_{OUT} + GS_{BACK}}$$

In exam questions, candidates are also often asked to compute the estimated time (T_{PET}) required to reach the Point of Equal Time from the departure point.
In such case,

$$T_{PET} = \frac{D_{PET}}{GS_{OUT}}$$

Applying the above formula, it is easy to understand that, to determine and graphically create the PET on the en-route charts, it is important to integrate the following two key parameters in the computation:

- the effective wind to join the airport;
- the airspeed to be applied, depending on the emergency scenario, to determine the GS_{OUT} and the GS_{BACK}. Indeed, in the case of engine failure or depressurization the airspeed will not be the same as the airspeed with all engines operative.

Note. *The method for creating Points of Equal Time and Points of Safe Return on the en-route charts is not included in the 033 certificate syllabus. Therefore, it will not be developed in this book. If* *interested by an in-depth approach to this specific item, the student should refer to the 061 book, "Navigation".*

4.2.3 - Examples

During the tests, we shall often use the computer to determine the ground speeds, GS_{OUT} and GS_{BACK}, according to the TAS, the true track and the direction of the wind and its speed.
Report to this part of the course in the 061 book "Navigation".

Example

A flight is planned between two airports A and B, spaced by 338 NM.
Available data:

- true track from A to B: 045°;
- reported wind: 225°/35 kt;
- TAS: 120 kt.

What are the position of the Point of Equal Time from the departure airport and the estimated time to reach the Point of Equal Time (PET) from point A?
A) Distance 169 NM; time: 85 min
B) Distance 218 NM; time: 85 min
C) Distance 120 NM; time: 46 min
D) Distance 185 NM; time: 72 min

Answer

• Using the computer

TR(T) = 045° — GS_{OUT} = outward ground speed = 155 kt
Wind 225°/35 — GS_{BACK} = return ground speed = 85 kt
TAS = 120 kt

• Computing the PET position

D_{PET} = D x GS_{BACK} / (GS_{OUT} + GS_{BACK})
= 338 x 85 / (155 + 85)
= 119.7 NM ≈ **120 NM**

Therefore, arriving to the PET point (located 119.7 NM away from the departure airport), the same time will be required to return to the departure airport from this point as to continue the flight to destination, located 218.3 NM (338 – 119.7) away from the equal time point.

• Computing the estimated time to reach the PET from the departure airport

T_{PET} = D_{PET} / GS_{OUT}
= 120 / 155
= 0.77 h, or **46 min**

Answer **C**.

4.3 - Point of Safe Return (PSR)

4.3.1 - Point of Safe Return principle

The Point of Safe Return (PSR), also known as Point of No Return (PNR) is the furthest point on the route beyond which the aircraft could not fly back to the departure point, considering its onboard safety endurance. The following definition is another way for explaining the PSR: the furthest point located on the route at which the outward distance from the departure point to the PSR point is equal to the return distance from this point.

It is important to distinguish between the total endurance and the onboard safe endurance:

- the total endurance is the maximum flight time corresponding to the total amount of usable fuel onboard. This fuel amount is indicated by the fuel gauges and validated by the in-flight fuel monitoring;
- the onboard safe endurance is the maximum time during which an aircraft can fly without using its regulatory reserve fuel.

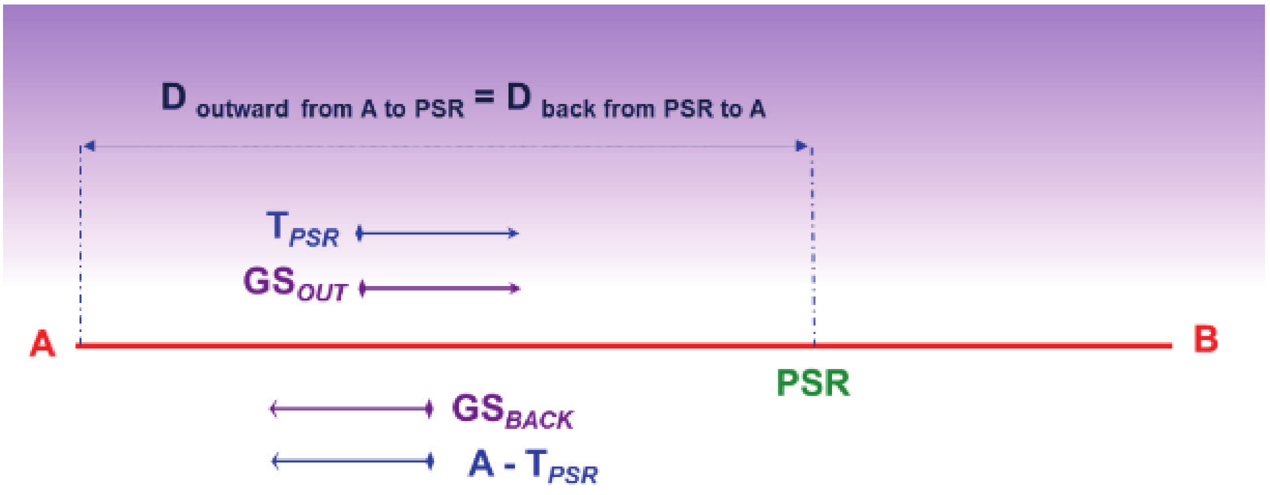
Thus, the PSR is computed with the total usable fuel amount minus the regulatory reserve fuel (final reserve fuel and alternate reserve fuel).

In practice, determining the point of safe return would be required for flights to so-called isolated airports, where the only possible solution in case of emergency is to return to the departure airport or to continue the flight to the destination. This applies to flights from the continent to Tahiti or Easter Islands, for instance.

4.3.2 - PSR computation formulas

In zero wind conditions, the point of safe return is combined with the route mid-point between two airports. In other words, the distance and the outward flight time from the departure airport to the PSR, are respectively equal to the distance and return flight time from the PSR to the departure airport.

With wind, the outward time from the departure airport to the PSR and the return time from this point are different.



With:

A	= safe endurance on departure
T_{PSR}	= flight time from A to PSR
$A - T_{PSR}$	= flight time from PSR to A
GS_{BACK}	= return ground speed from PSR to A
GS_{OUT}	= outward ground speed from A to PSR

To define the PSR, we have:
outward distance from A to PSR = return distance from PSR to A
$T_{PSR} \times GS_{OUT} = (A - T_{PSR}) \times GS_{BACK}$

Therefore, the **estimated time (T_{PSR})** to reach the PSR from the departure point is:

$$T_{PSR} = \frac{A \times GS_{BACK}}{GS_{OUT} + GS_{BACK}}$$

In exam questions, candidates are also often asked to compute the distance of the point of safe return (D_{PSR}) with regard to the departure airport.
In such cases,

$$D_{PSR} = T_{PSR} \times GS_{OUT}$$
$$= \frac{A \times GS_{BACK}}{GS_{OUT} + GS_{BACK}} \times GS_{OUT}$$

It should be noted that, for determining the PSR, the above formulas are applicable only for a normal flight. Indeed, if you try to determine the PSR in the case of engine failure, for instance, you would have to know in advance the time of the failure, as the departure endurance will not be the same depending on the failure time!

4.3.3 - - Examples

Example 1

Given:
Distance from departure to destination: 500 NM
Safe Endurance: 4 h
TAS: 140 kt
GS Out: 150 kt
GS Home: 130 kt
What is the distance and time of the PSR from the departure point?

A) Distance 221 NM; Time 89 min.
B) Distance 232 NM; Time 107 min.
C) Distance 139 NM; Time 60 min.
D) Distance 279 NM; Time 111 min.

Answer

- Computing the estimated time to reach the PSR from point A

Tpsr = A x GS_{BACK} / (GS_{OUT} + GS_{BACK})
= 4 x 130 / (130 +150)
= 1h 85 or 60 + 51 = 111 min

- Computing the PSR position

Dpsr = Tpsr x GS out

= 1,86 x 150
= 279 NM

Answer **D**.

Note: if the Fuel Flow Out and Back are different, we need to apply the following formula to compute D_{PSR}:

$$D_{PSR} = \frac{\text{Fuel Quantity}}{FC_{OUT} + FC_{BACK}}$$

With:

FC_{OUT} = Fuel Consumption OUT in kg/NM = FF_{OUT}/ GS_{OUT}

FC_{BACK} = Fuel Consumption BACK in kg/NM = FF_{BACK}/ GS_{BACK}

Example 2

An aircraft performs a planned flight from A to B.

The total fuel amount available onboard is 50,000 kg, but the aircraft must land with a 5,000 kg reserve fuel.

From A to B, the TAS is 400 kt, the headwind component is 30 kt, and the Fuel Flow is 7,800 kg/hr.

Assuming that the aircraft must fly back from the Point of Safe Return (PSR), its TAS would be 380 kt, the tail wind component is 30 kt, and the Fuel Flow is 7,500 kg/hr.

What are the position of the Point of Safe Return and the estimated time to reach the Point of Safe Return from the departure point?

A) 1 270 NM; 206 min
B) 1 250 NM; 174 min
C) 1,071 NM; 174 min
D) 1 143 NM; 185 min

Answer

• Computing the safe endurance (A)

A = usable fuel/ average hourly consumption

Usable fuel = total fuel onboard – reserve fuel= 50,000 – 5,000 = 45,000 kg

Average hourly consumption = 7,800 + 7,500) / 2 = 7,650 kg/hr

A = 45,000 / 7,650
= 5.88 hr

• Computing the estimated time to reach the PSR from point A

T_{PSR} = A x GS_{BACK} / (GS_{OUT} + GS_{BACK})

With GS_{OUT} = outward ground speed = 400 – 30 = 370 kt

and GS_{BACK} = retum ground speed = 380 + 30 = 410 kt

T_{PSR} = 5.88 x 410 / (370 + 410)
= 3.09h; or 3 hr 05 min
= 185 min

• Computing the PSR position

We need to calculate the Fuel Consumption for each flight segment:

FC_{OUT} = FF_{OUT}/ GS_{OUT} = 7800 / 370 = 21.08 kg/NM

FC_{BACK} = FF_{BACK}/ GS_{BACK} = 7500 / 410 = 18.29 kg/NM

D_{PSR} = Fuel quantity / (FC_{OUT} + FC_{BACK})
= 45000 / (21.08 + 18.29)
= 1,143 NM

Answer D.

05

ICAO FLIGHT PLAN

01 INDIVIDUAL FLIGHT PLAN

1.1 - Flight plan format

1.1.1 - Mandatory filing of the flight plan

A flight plan will be filed before:

- any IFR flight;
- any flight or part of flight likely to benefit from the air traffic control services;
- any flight during which the aircraft shall cross borders;
- any flight to be performed in designated regions, or during which the aircraft shall follow designated routes, when such filing is required by the competent air traffic service authority for easier flight information service, alert service and search and rescue operations;
- any flight to be performed in designated regions, or during which the aircraft shall follow designated routes, when such filing is required by the competent air traffic service authority for easier communication with the appropriate military units or the air traffic services in neighbour States, in order to avoid the possible requirement for an interception for identification purposes.

1.1.2 - Flight plan form

See the flight plan form on next page.

1.2 - Guidelines for flight plan preparation

1.2.1 - General

The preparation must strictly comply with the specified formats and with the prescribed method for specifying the data. To insert data, start with the first planned space. Leave the shaded areas blank. Fields in the first part are reserved for the air traffic control and communication services.
Express the hours in UTC (Universal Time Coordinated) and the estimated durations with a group of four digits (hours and minutes).

International Flight Plan

PRIORITY ADDRESSEE(S)

<=FF

<=

FILING TIME ORIGINATOR

<=

SPECIFIC IDENTIFICATION OF ADDRESSEE(S) AND / OR ORIGINATOR

3 MESSAGE TYPE 7 AIRCRAFT IDENTIFICATION 8 FLIGHT RULES TYPE OF FLIGHT

<=(FPL — — — <=

9 NUMBER TYPE OF AIRCRAFT WAKE TURBULENCE CAT. 10 EQUIPEMENT & CAPABILITIES

— / — 10-a

13 DEPARTURE AERODROME TIME 10-b

— <= / <=

15 CRUISING SPEED LEVEL ROUTE

—

<=

16 DESTINATION AERODROME TOTAL EET HR MIN ALTN AERODROME 2ND ALTN AERODROME

<=

18 OTHER INFORMATION

—

<=

SUPPLEMENTARY INFORMATION (NOT TO BE TRANSMITTED IN FPL MESSAGES)

19 ENDURANCE HR MIN PERSONS ON BOARD EMERGENCY RADIO UHF VHF ELBA

—E/ P/ R/

SURVIVAL EQUIPMENT POLAR DESERT MARITIME JUNGLE JACKETS LIGHT FLUORES UHF VHF

/ /

DINGHIES

NUMBER CAPACITY COVER COLOR

D / <=

AIRCRAFT COLOR AND MARKINGS

A/

REMARKS

N / <=

PILOT-IN-COMMAND

C/)<=

FILED BY ACCEPTED BY ADDITIONAL INFORMATION

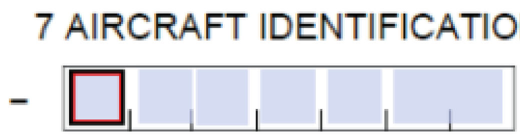
1.2.2 - Completing a flight plan

Complete fields 7 to 18, as specified below.

Also complete field 19, as specified below, when the competent air traffic service authority so requires, or when this otherwise appears to be necessary.

Note. In the form, the field numbers do not follow each other, because they correspond to the numbers of the types of fields in the ATS messages.

a) Field 7: Aircraft identification



Complete one of the following two identifications, using no more than seven characters.

Aircraft registration number, when used as the call sign in voice communication or when the aircraft is not equipped with a radio.
ICAO call sign of the aircraft operator, followed by the flight identification ("AF001", "KLM1283", etc.).

b) Field 8: Flight rules and Type of flight

One or two characters in each field, the first one for the flight rules, and the second for the type of flight.

Flight rules 1

Using one of the letters below, specify the flight rule category that the pilot plans to apply:

- I: for IFR;
- V: for VFR;
- Y: for IFR followed by VFR;
- Z: for VFR followed by IFR.

For the "Y" and "Z" flight rules, specify in field 15 the waypoint(s) where a flight rule switching is planned.

Type of flight 2

Using one of the letters below, specify the type of flight, when so required by the competent air traffic service authority:

- S: for scheduled air transport;
- N: for non-scheduled air transport;
- G: for general aviation;
- M: for military aviation;
- X: for other types of flight not included in the above categories (training, test flights.).

c) Field 9: Number of aircraft, Type of aircraft and Wake turbulence category

Number of aircraft (one or two characters) 1

Specify the number of aircraft if more than one. This is the number of aircraft covered by the flight plan (patrol flight, for instance).

Type of aircraft (two to four characters) 2

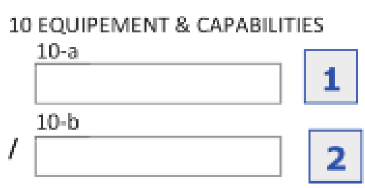
Specify the appropriate official abbreviation such as specified in the ICAO list (doc 8643).
Or specify "ZZZ" if your aircraft is not a current type and has no official abbreviation, or in case of formations flight grouping several types of aircraft. In this case, specify, in field 18, the number of aircraft and the type(s) of aircraft, following "TYP/".

Wake turbulence category (one character) 3

Using a slash followed by one of the following letters, specify the wake turbulence category:

- J (Super Heavy): for Airbus **A380-800** with a certified maximum take-off mass in the order of 560 000 kg and for Antonov **An 225**.
- H (heavy jet): aircraft with a certified maximum take-off weight higher than or equal to 136,000 kg;
- M (medium weight): aircraft with a certified maximum take-off weight less than 136,000 kg but higher than 7,000 kg;
- L (low weight): aircraft with a certified maximum take-off weight less than 7,000 kg.

d) Field 10: Equipment and capabilities



Field 10-a: This item applies to radiocommunications, navigation and approach equipment and capabilities 1

Information about the navigation capabilities are communicated to the ATC for clearance and transmission

- SPECIFY the appropriate letter:
  - N, if no approach aid equipment, radiocommunication (COM/) or radio navigation (NAV/), corresponding to the route is installed on board, or if the equipment is inoperative;

  or,
  - S, if the standard radiocommunication (COM/) and radio navigation (NAV/) approach aid equipment corresponding to the route is installed on board and is operative.

  Note 1. If letter S is used, the typical equipment is considered as a VHF RTF, VOR and ILS component, unless another combination is prescribed by the relevant ATS authority.

- AND/OR

- specify one or more letters or combinations below to specify the COM and NAV approach aid equipment available and operative, and the relevant capabilities.

Letter	Equipment	Letter	Equipment
A	GBAS landing stem	K	MLS
B	LPV (APV with SBAS)	L	ILS
C	LORAN C	M1	ATC RTF SATCOM (Inmarsat)
		M2	ATC RTF (Mtsat)
		M3	ATC RTF (Iridium)
		O	VOR
		P1-P9	Reserved for RCP
D	DME		
E1	FMC ACARS	R	RNP certification *(see note 4)*
E2	D-FIS ACARS		
E3	PDC ACARS		
F	ADF	T	TACAN
G	GNSS *(see note 2)*	U	UHF RTF
H	HF RTF	V	VHF RTF
I	Inertial navigation	W	RVSM approval
J1	CPDLC ATN VDL Mode 2 *(see note 3)*	X	MNPS approval
J2	CPDLC FANS 1/A HFDL		
J3	CPDLC FANS 1/A VDL Mode 4		
J4	CPDLC FANS 1/A VDL Mode 2		
J5	CPDLC FANS 1/A SATCOM (Inmarsat)		
J6	CPDLC FANS 1/A SATCOM (Mtsat)		
J7	CPDLC FANS 1/A SATCOM (Iridium)		
		Y	VHF with 8.33 kHz separation
		Z	Other on-board equipment or capability *(see note 5)*

Note 2. If letter "G" is used, the types of external GNSS version, if applicable, are specified in field 18 after NAV/, separated by spaces.

Note 3. If letter "J" is used, specify in field 18 the airborne equipment, after "DAT/", followed by one or more letters, depending on the case.
Refer to standard RTCA/EUROCAE "interoperability Requirements Standard For ATN Baseline 1 (ATN B1 INTEROP standard – DO-280B/ED-110B)" for the data communication services concerning the ATC clearances and information, the ATC communication management, and the ATC microphone check.

Note 4. If letter "R" is used, the possible performance-based navigation levels are specified in field 18 after PBN/.
Information about the application of the performance-based navigation to a specified route segment, route or region, are provided in the "Performance-Based Navigation Manual".

Note 5. If letter "Z" is used, specify in field 18 the other airborne equipment or other capabilities, after COM, and (or) NAV/, and/or DAT/, as necessary.
The waivers concerning RNAV, CPDLC and 8.33 kHz should be specified, indicating letter "Z" in field 10-a and inserting the appropriate waiver indicator in field 18, respectively under NAV/, DAT/, or COM/, as detailed in the IFPS Users Manual, and in particular:
a) insert EXM833 after COM/;
b) insert RNAVX or RNAVINOP, as applicable, after NAV/;
c) insert CPDLCX after DAT/.

Field 10-b: this item applies to the monitoring equipment and relevant capabilities. **2**

- SPECIFY N if no monitoring equipment is installed on-board or is inoperative,
- OR
- SPECIFY ONE OR MORE of the following characters, up to 20, to describe the monitoring equipment and/or capabilities installed on-board and operative:

SSR Modes A and C

- A: Transponder – Mode A (4 digits – 4,096 codes)
- C: Transponder – Mode A (4 digits – 4,096 codes) and Mode C.

SSR Modes S

- E: Transponder – Mode S, with capability for transmitting the aircraft identification, pressure altitude and Extended Squitters (ADS-B).
- H: Transponder – Mode S, with capability for transmitting the aircraft identification, pressure altitude and enhanced monitoring capability.
- I: Transponder – Mode S, with capability for transmitting the aircraft identification, but not the pressure altitude.
- L: Transponder – Mode S, with capability for transmitting the aircraft identification, pressure altitude and Extended Qquitters (ADS-B), and enhanced monitoring capability.
- P: Transponder – Mode S, with capability for transmitting the pressure altitude, but not the aircraft identification.

- S: Transponder – Mode S, with capability for transmitting the pressure altitude, and the aircraft identification.
- X: Transponder – Mode S, with no capability for transmitting the aircraft identification, or the pressure altitude.

Note 1. *The enhanced monitoring capability is the aircraft capability to transmit data from the aircraft, via a mode S transponder, in downlink mode.*

ADS-B

- B1: ADS-B with dedicated 1,090 MHz transmission ADS-B capability.
- B2: ADS-B with dedicated 1,090 MHz transmission and reception ADS-B capability.
- U1: transmission ADS-B capability using UAT.
- U2: transmission and reception ADS-B capability using UAT.
- V1: transmission ADS-B capability using VDL mode 4.
- V2: transmission and reception ADS-B capability using VDL mode 4.

ADS-C

- D1: ADS-C with FANS 1/A capability.
- G1: ADS-C with ATN capability.

Note 2. *Additional monitoring applications should be specified in field 18, after SUR/.*

Note 3. *Please note that alphanumeric characters not mentioned above are reserved.*

e) Field 13: Departure aerodrome and time

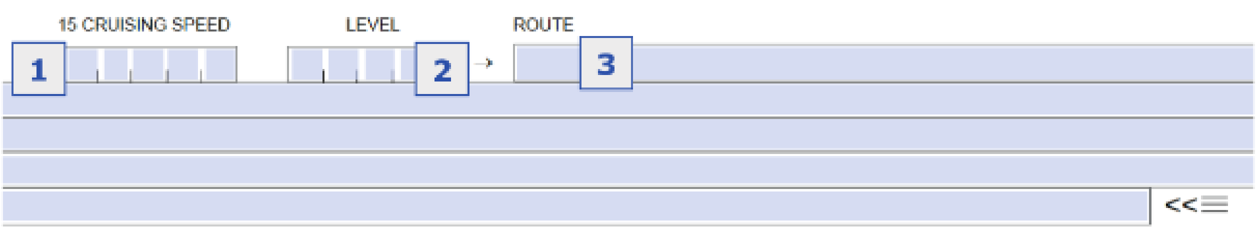
Departure aerodrome 1

Insert the four-letter ICAO identifier of the departure airport. If the identifier is unknown, e.g. in the case of a private aerodrome, insert "ZZZZ" and specify in field 18 the aerodrome name in clear text after "DEP/".

Time 2

Specify with a four-digit number the estimated UTC departure time from the aircraft parking stand or, for a flight plan received from a flying aircraft, the effective or estimated time when crossing the first waypoint of the route to which the flight plan applies.

f) Field 15: Cruising speed, Level, Route



Specify the first cruising speed, the first cruising level and, the route description.

Cruising speed 1

Specify the TAS for the first part or for the whole cruise, using one of the following formats:

- in kt, with a five-character group: letter "N" followed by four digits (e.g. 250 kt is noted "N0250");
- in km/h, with a five-character group: letter "K" followed by four digits (e.g. 400 km/h is noted as "K0400");
- in Mach, when so required by the relevant ATS authority, with a four-character group: letter "M" followed by three digits representing the product of the Mach number multiplied by 100, rounded up to the nearest hundredth (e.g. Mach 0.75 is noted as "M075".

Cruise flight level 2

Specify the cruise flight level for the first part or for the whole cruise, using one of the following formats:

- the flight level, with a four-character group: letter "F" followed by three digits (e.g. FL 085 is noted as "F085");
- the altitude (QNH), in hundreds of feet, with a four-character group: letter "A" followed by three digits (e.g. 2,500 ft is noted as "A025").

When so required by the relevant ATS authority:

- the metric level in tens of meters, is expressed with letter "S" followed by four digits (e.g. 11,000 m is noted as "S1100");
- the altitude in tens of meters, is expressed with letter "M" followed by four digits (e.g. 8,400 m QNH is noted as "M0840").

Route 3

Two cases are considered.

Flight on designated ATS routes

Specify the designator of the first ATS route, if the departure airport is located on the ATS route or is connected. Or, if the departure airport is not located on the ATS route, or is not connected, letters "DCT" (direct to) followed by the waypoint where the aircraft will join the first ATS route, then the ATS route designator.
Then, specify each waypoint where there are plans for a speed or level change, an ATS route change and/or a flight rule change.
Followed, in each case, by the designator of the next route segment, even if it is not different from the previous one; or "DCT", if the flight to the next waypoint will be off a designated route, unless both waypoints are defined by geographic coordinates.

Flight off designated ATS routes

Specify the waypoints normally separated by intervals not exceeding 30 minutes of flight or 370 km (200 NM), including each waypoint where a speed or level change, route change, or flight rule change is planned.
Specify "DCT" between the successive waypoints, unless both waypoints are defined by geographic coordinates or by a bearing and a distance.

Route description conventions

Apply conventions from a) to e) below to describe the route and separate all subdivisions with a space.

a. ATS route (two to seven characters)

Coded designator allocated to the route or route segment, including (if applicable) the coded designator allocated to the SID and STAR (e.g. "BCN1", "UB10", "KODAP2A").

b. significant points (two to eleven characters)

If no designator is allocated, apply one of the following codes.

- Latitude and longitude degrees only: two digits indicating the latitude in degrees, followed by letter "N" or "S", then three digits indicating the longitude in degrees, followed by letter "E" or "W". Numbers have to be completed with zeroes, if necessary. E.g. "47S032W".

- Latitude and longitude degrees and minutes: four digits indicating the latitude in degrees, followed by letter N or S, then five digits indicating the longitude in degrees and tens of minutes, followed by letter E or W. Numbers have to be completed with zeroes, if necessary. E.g. "4700S03205W".

- Bearing with respect to a navigation aid and distance to this aid: identification of this radio navigation aid with two or three characters, then, three digits indicating the bearing in degrees magnetic from the aid, then, three digits indicating the distance to this aid in nautical miles. Numbers have to be completed with zeroes, if necessary. For instance, a waypoint located in the 180° E magnetic bearing and located 40 nautical miles from the DUB VOR should be noted as "DUB180040".

c. Speed or flight level change (21 characters maximum)

The waypoint where a 5% TAS and 0.01 or more Mach change, or a level change will occur, should be indicated as specified in b) above, followed by a slash and the cruising speed or the flight level, with no spaces.

Examples: "LN/N0284A045"; "MAY/N0305F180"; "HADDY/N0420F330"; "4602N07805W/N0500F350"; "46N078W/M082F330"; "DUB180040/N0350M0840".

d. Flight rule change (three characters maximum)

The waypoint where a flight rule change will occur must be expressed as specified in b) above, followed by a space and one of the two following abbreviations:

- "VFR": for switching from IFR flight to VFR flight;
- "IFR": for switching from VFR flight to IFR flight.

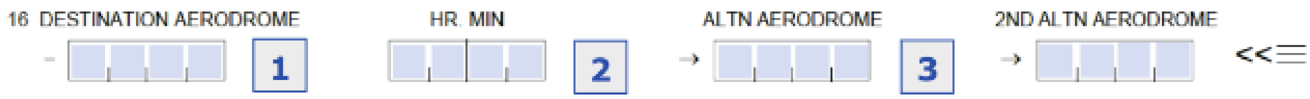
Example: "LN VFR".

e. Climbing cruise (28 characters maximum)

It must be specified with letter "C", followed by a slash; then the waypoint where initiating the climb cruise is planned; then, the speed to be maintained during the climb cruise, followed by the two levels defining the airspace segment to occupy during the climb cruise, or the level above which the climb cruise is planned, followed by letters "PLUS", with no spaces.

Examples: "C/48N050W/M082F290F350"; "C/48N050W/M082F290PLUS".

g) Field 16: Destination aerodrome and total estimated elapsed time, alternate aerodromes



Destination aerodrome 1

Specify the four-letter destination airport ICAO code or "ZZZZ" if no location identifier is allocated to the airport concerned. Then, specify the airport name in field 18, after "DEST".

Total Estimated Elapsed Time (EET) 2

Specify the total Estimated Elapsed Time in hours and minutes from take-off to:

- the waypoint defined with respect to radio navigation aids, where initiation of an instrument approach procedure is planned;
- or arrival overhead the destination airport, if no navigation aid is associated with the destination airport.

Note. *In the case of a flight plan communicated by a flying aircraft, the total Estimated Elapsed Time is the elapsed time estimated from the first route waypoint to which the flight plan applies.*

Alternate aerodrome(s) 3

Specify the four-letter ICAO location identifiers for two alternate airports maximum or, "ZZZZ" if no location identifier is allocated to the alternate airport. Then, specify the airport name in field 18, after "ALTN".

h) Field 18: Other information

Specify "0" (zero), if no information is to be communicated in this field, or any other necessary information, preferably in the following order, using the appropriate designator followed by a slash and the information to be provided.

- STS/ reason for special handling by the ATS services (e.g. search and rescue mission).
- PBN/ Indication of the RNAV and/or RNP capabilities. Specify the greatest possible number of descriptors below applying to the flight, up to 8, i.e. 16 characters maximum.

	RNAV SPECIFICATIONS
A1	RNAV 10 (RNP 10)
B1	RNAV 5 all sensors allowed
B2	RNAV 5 GNSS
B3	RNAV 5 DME/DME
B4	RNAV 5 VOR/DME
B5	RNAV 5 INS or IRS
B6	RNAV 5 LORANC
C1	RNAV 2 all sensors allowed
C2	RNAV 2 GNSS
C3	RNAV 2 DME/DME
C4	RNAV 2 DME/DME/IRU
D1	RNAV 1 all sensors allowed
D2	RNAV 1 GNSS
D3	RNAV 1 DME/DME
D4	RNAV 1 DME/DME/IRU
	RNP SPECIFICATIONS
L1	RNP 4
O1	Basic RNAV 1 all sensors allowed
O2	Basic RNP 1 GNSS
O3	Basic RNP 1 DME/DME
O4	Basic RNP 1 DME/DME/IRU
S1	RNP APCH
S2	RNP APCH with BARO-VNAV
T1	RNP AR APCH with RF (special clearance required)
T2	RNP AR APCH without RF (special clearance required)

- The B-RNAV approved aircraft operators specify the equipment and capabilities corresponding to RNAV5.
- The P-RNAV approved aircraft operators not exclusively relying on the VOR/DME aids for determining the position, specify the equipment and capabilities corresponding to RNAV1.

Note: *To specify a set of P-RNAV equipment exclusively relying on the VOR/DME aids for determining the position, the operators insert letter "Z" into field 10 of the flight plan, and the "EURPRNAV" descriptor after the NAV/ designator into field 18.*

- NAV/ Significant information concerning the navigation equipment, other than the information specified in the PBN/ item, in compliance with the requirements of the relevant ATS authority. Specify the GNSS strengthening in this item, with a space between the strengthening methods, e.g. NAV/GBAS SBAS.
  If applicable, insert RNAVX (no RNAV equipment on-board) or RNAVINOP (no more B-RNAV capability due to a failure or degradation), first specifying letter "Z" in field 10-a.

- COM/ Communication applications or capabilities not specified in field 10-a.

If applicable, insert EXM833 (aircraft exempted from 8.33 equipment) as detailed in the IFPS User Manual, first specifying letter "Z" in field 10-a.

- DAT/ Data applications or capabilities not specified in field 10-a.
  If applicable, insert CPDLCX (aircraft exempted from CPDLC equipment) as detailed in the IFPS User Manual, first specifying letter "Z" in field 10-a.

- SUR/ Monitoring applications or capabilities not specified in field 10-b.

- DEP/ Name and location of the departure airport, if the ZZZZ group is specified in field 13, or of the ATS unit from which additional flight plan data may be obtained, if AFIL is specified in field 13.
  In the case of an airport not mentioned in the relevant air information publication, specify the airport location as follows:
  4 digits specifying the latitude in degrees and in tens of minutes and minutes followed by letter "N" (North) or letter "S" (South), then 5 digits specifying the longitude in degrees and in tens of minutes and minutes, followed by letter "E" (East) or letter "W" (West). Numbers have to be completed with zeroes, if necessary.
  Example: 4620N07805W (11 characters).

  OR,

  Bearing from the closest significant point and distance with respect to this waypoint, as follows:
  Identification of the significant point, then 3 digits specifying the bearing from this waypoint, in degrees magnetic, the 3 digits specifying the distance with respect to this waypoint, in nautical miles. In high latitude regions where, in the opinion of the relevant authority, it is impossible in practice to use the magnetic North as a reference, degrees true may be used. Numbers have to be completed with zeroes, if necessary. For example, a waypoint located in the 180E magnetic bearing and 40 nautical miles away from the "DUB" VOR should be specified as DUB180040.

  OR,

  First waypoint of the route (name or LAT/LONG) or marker beacon, if the aircraft did not take off from an airport.

- DEST/ Name and location of the destination airport, if the ZZZZ group is specified in field 16. In the case of an airport not mentioned in the relevant air information publication, specify the airport location according to the latitude or longitude, or to the bearing from the closest significant point and distance with respect to this waypoint, as described in the above DEP/ section.

- DOF/ 6 digits specifying the aircraft departure date (in YYMMDD format, where YY is the year, MM the month and DD the day).

- REG/ Aircraft nationality or common mark and registration marking, if different from the aircraft identification specified in field 7.

- EET/ Significant points or FIR boundaries and cumulated flight Estimated Elapsed Times when such indications are required by air navigation regional agreements or specified by the relevant ATS authority.
  Examples: EET/CAP0745 XYZ0830
  EET/EINN0204

- SEL/ SELCAL call sign if the aircraft is fitted with the corresponding equipment.

- TYP/ Aircraft type(s) preceded, if need be, without space, by the number(s) of aircraft and separated by a space, if the ZZZZ is specified in field 9.
  Example: –TYP/2F15 5F5 3B2

- CODE/ Aircraft address (expressed by an alphanumeric code containing six hexadecimal characters), when the flight is planned to use the CPDLC via the aeronautical telecommunications network (ATN). Example: aircraft address "F00001" is the lowest address in the specific block managed by ICAO.

- RVR/ The minimum RVR required for the flight.

- DLE/ Delay or en-route holding. Specify the significant point(s) of the route where a delay is predicted, followed by 4 digits specifying the delay duration in hours and minutes (hhmm).
  Example: DLE/MDG0030

- OPR/ ICAO identifier or aircraft operator's name, if different from the aircraft identification specified in field 7.

- ORGN/ 8-letter RSFTA address of the originator or other appropriate coordinates, if the identification of the flight plan originator may be difficult to define, if so required by the relevant ATS authority.
  Note. *In some regions, the flight plan reception centers can automatically insert ORGN/ and the RSFTA address of the originator.*

- PER/ Information about the aircraft performance, with one letter specified in the Procedures for air traffic services, if so required by the relevant ATS authority.

- ALTN/ Name of the destination alternate airport(s), if the ZZZZ group is specified in field 16. In the case of an airport not mentioned in the relevant air information publication: specify the airport location according to the latitude or longitude, or to the bearing from the closest significant point and distance with respect to this waypoint, as described in the above DEP/ section.

- RALT/ four-letter ICAO location indicator for the en route alternate airport(s), in compliance with Doc 7910.
  Location indicators, or name of this airport or airports, if no call sign is allocated. In the case of an airport not mentioned in the relevant air information publication, specify the airport location according to the latitude or longitude, or to the bearing from the closest

significant point and distance with respect to this waypoint, as described in the above DEP/ section.

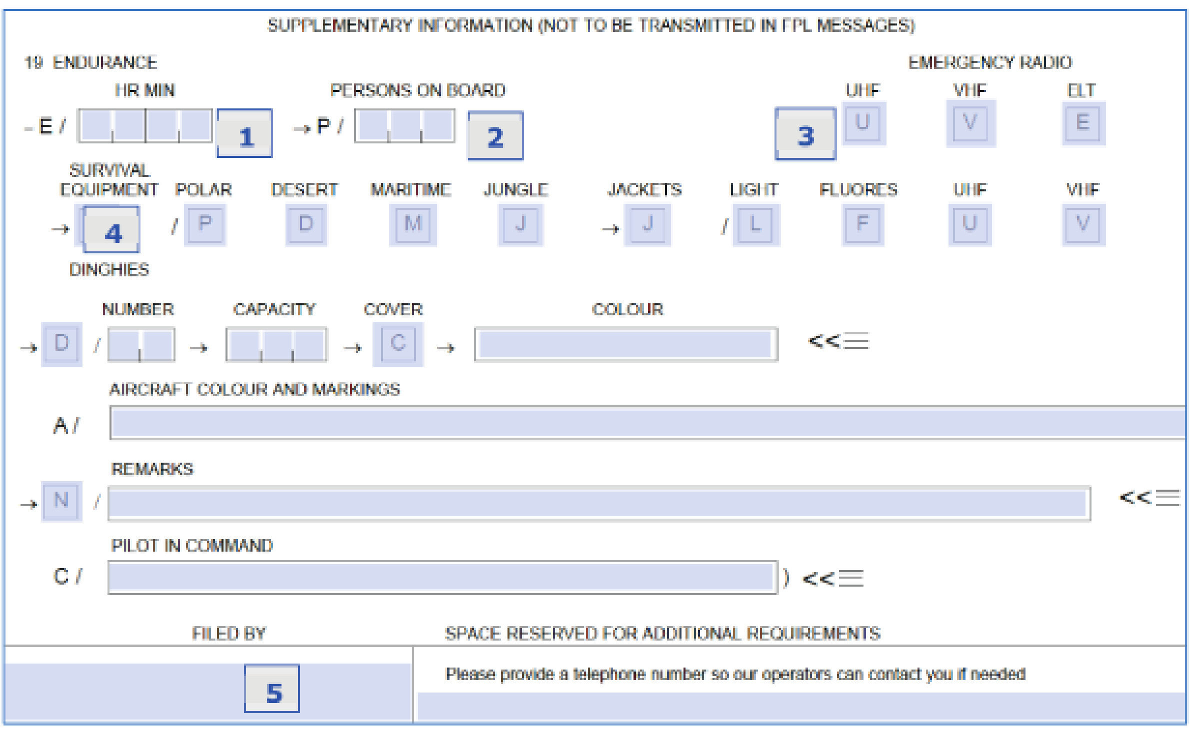
- TALT/ four-letter ICAO location indicator for the en route alternate airport(s) at take-off, in compliance with Doc 7910.
  Location indicators, or name of this airport or airports, if no call sign is allocated. In the case of an airport not mentioned in the relevant air information publication, specify the airport location according to the latitude or longitude, or to the bearing from the closest significant point and distance with respect to this waypoint, as described in the above DEP/ section.

- RIF/ Details about the route leading to the new destination airport, followed by the four-letter ICAO location indicator of the airport. The new route must be subject to a clearance modification during the flight.
  Examples: RIF/DTA HEC KLAX
  RIF/ESP G94 CLA YPPH

- RMK/ Any other remark in clear language required by the relevant ATS authority or deemed necessary.

- RFP/ Indicator of the flight plan substitute iteration number. Under RFP/ specify letter "Q", followed by a digit specifying the filed flight plan substitute iteration number
  Example: RFP/Q2 means "Substitute flight plan #2" (i.e. second substitution)

i) Field 19: supplementary information



Endurance 1

After "E/", specify a four-digit group indicating the endurance in hours and minutes.

Persons on board 2

After "P/", specify the total number of persons (passengers and crew members) present on board. If this number is unknown when filing the flight plan, specify "TBN" (To Be Notified).

Emergency radio equipment 3

After "R/":

- if no UHF 243.0 MHz portable radio is available, cross out letter "U";
- if no VHF 121.5 MHz portable radio is available, cross out letter "V";
- if no portable emergency locator transmitter (ELT) is available, cross out letter "E".

Survival equipment 4

After "S/":

- if no survival equipment in polar environment is available on board, cross out letter "P";
- if no survival equipment in desert environment is available on board, cross out letter "D";
- if no survival equipment at sea is available on board, cross out letter "M";
- if no survival equipment in jungle environment is available on board, cross out letter "J".

After "J/":

- if the life jackets are not fitted with lights, cross out letter "L";
- if the life jackets do not include fluorescein, cross out letter "F";
- Cross out letter "U", or "V", or both, as for "R/" above, to specify the radio equipment of the life jackets.

After "D/":

- if no dinghies are available on board, cross out letter "D";
- if dinghies are available, specify, after "D/", the number of dinghies on board and the total number of persons who can get in the dinghies.

After "C/":

- if no dinghies are available on board, or if they do not possess a cover, cross out letter "C";
- if the dinghies are covered, specify the dinghy color.

After "A/", specify the aircraft color and significant markings.

After "N/":
if no remarks are mentioned, cross out letter "N", or specify any other survival equipment available on board and any other remark regarding the survival equipment.

After "C/", specify the name of the pilot in command.

Filing the flight plan 5

Specify the name of the unit, service or person filing the flight plan.

1.2.3 - Example of flight plan preparation

Prepare a flight plan, using the following elements.
A non-scheduled transport flight is planned from Cambridge (EGSC) to Munich (EDDM) with a B737 of the Fictive Air airline.
Actual take-off weight: 51,000 kg (Maximum Structural Take-Off Weight: 56,000 kg).
Aircraft registration: N-GTRX.
Standard radio and navigation equipment + UHF R/T.
Secondary Surveillance Radar (SSR): transponder mode A, codes 4096 + mode C.
Flight rule: IFR.
Alternate aerodrome: Stuttgart (EDDS).
ATC: estimated elapsed time to reach the Brussels FIR boundary: 29 min.
Fuel boarded: 5.5 t. This amount should allow a 2 hr 30 min endurance.
Number of passengers: 107.
Crew members (pilots + cabin crew): 5.
Route: from VOR LAMBOURNE (LAM) to airways UB3 – DOVER – UG1 – NATTENHEIM (NTM) – UB6 – MUNICH.

Flight details

Estimated time of departure from the parking stand: 0900 UTC.
15 min flight planned for connecting to airways by LAMBOURNE VOR.
From Lambourne to Sprimont (SPI): the planned TAS will be 330 kt at FL 250.
From Sprimont to Munich: the planned TAS will be 350 kt at FL 290.

Other information

A portable emergency locator transmitter is available on board.
The life jackets are equipped with emergency light and UHF radio.
Four yellow dinghies with a 32 person capacity per dinghy are available.
The aircraft color is white.

Answer

U S Department of Transportation

International Flight Plan

PRIORITY: <=FF

ADDRESSEE(S) <=

FILING TIME | ORIGINATOR <=

SPECIFIC IDENTIFICATION OF ADDRESSEE(S) AND / OR ORIGINATOR

3 MESSAGE TYPE: <=(FPL

7 AIRCRAFT IDENTIFICATION: — NGTRX

8 FLIGHT RULES: — I

TYPE OF FLIGHT: — N <=

9 NUMBER: —

TYPE OF AIRCRAFT: B737

WAKE TURBULENCE CAT.: / M

10 EQUIPMENT (10 EQUIPMENT & CAPABILITIES): — 10-a SU / 10-b C <=

13 DEPARTURE AERODROME: — EGSC

TIME: 1020 <=

15 CRUISING SPEED: — N0330

LEVEL: F250

ROUTE: DCT LAM UB3 DVR UG1 SPI/N350F290 UG1 NTM UBG MUN <=

16 DESTINATION AERODROME: EDDH

TOTAL EET HR MIN: 0140

ALTN AERODROME: EDDS

2ND ALTN AERODROME: <=

18 OTHER INFORMATION: — EET/EBUR 0029 OPR/FICTIVE AIR <=

SUPPLEMENTARY INFORMATION (NOT TO BE TRANSMITTED IN FPL MESSAGES)

19 ENDURANCE HR MIN: — E/ 0230

PERSONS ON BOARD: P/ 112

EMERGENCY RADIO: R/ UHF X | VHF X | ELBA E

SURVIVAL EQUIPMENT: S / POLAR X | DESERT X | MARITIME M | JUNGLE X

JACKETS: J / LIGHT L | FLUORES X | UH U | VHF X

DINGHIES: D / NUMBER 04 | CAPACITY 128 | COVER C | COLOR YELLOW <=

AIRCRAFT COLOR AND MARKINGS: A/ WHITE

REMARKS: N / <=

PILOT-IN-COMMAND: C/ JOHNSON)<=

FILED BY	ACCEPTED BY	ADDITIONAL INFORMATION
FICTIVE AIR		

Usually, the airlines use and file a flight plan in electronic format.
For information, a sample of this type of format is provided below.

Facsimile of an electronic flight plan

(1)	(FPL-AFR010-IS
(2)	-B744/H-SRIWYX/S
(3)	-LFPG1355
(4)	-N0495F260 DCT AMOGA UT225 VESAN UL613 SOVAT/N0496F320 UL613 SANDY/N0491F340 UL613 DET UB4 LESTA UP6 DOGAN/M085F360 UP6 56N010W NATD 59N040W/M085F370 NATD LOACH/N0492F390 NATD FOXXE/N0492F390 N264A TAFFY DCT ENE ENE4
(5)	-KJFK0715 KEWR
(6)	-EET/EGTT0019 EGPX0103 EISN0112 EGPX0116 EGCX0126 58N020W0210 CZQX0249 59N040W0328 57N050W0412 CZQM0446 CZUL0529 CZQM0555 KZBW0604 REG/FGITF SEL/AFCS RMK/TCAS AND AGCS EQUIPPED DOF/010723
(7)	-E/0822 P/348 R/UVE D/08 472 C YELLOW A/WHITE C/FRANCES)

(1) FPL (Flight Plan Log) header, aircraft identification, flight rule and flight type.
(2) Aircraft type and wake turbulence category, communication and navigation equipment.
(3) Departure aerodrome and time
(4) Route (including cruising speed and level).
(5) Destination aerodrome and total estimated elapsed time, alternate aerodrome.
(6) Other information (significant points, aircraft registration, selcal, etc.).
(7) Supplementary information (endurance, emergency and survival equipment), if so required by the relevant ATS authority.

02 REPETITIVE FLIGHT PLAN (RPL)

2.1 - Principle

When flights have identical basic characteristics and are regularly and frequently operated, it is easier to file a repetitive flight plan, also known as RPL (Repetitive Flight Plan), instead of a series of identical individual flight plans.
In such case, the operator files a repetitive flight plan with the relevant ATS services, for storage and repetitive use.

According to the ICAO rules, the repetitive flight plan will be used for IFR flights only. To file a repetitive flight plan, the following conditions must be met:

- flight must be regularly operated on the same days during several consecutive weeks and recur at least ten times or every day during at least ten consecutive days;
- the RPL elements must be highly stable;
- the RPL must cover the whole flight, from the departure airport to the destination airport;
- the RPL must be accepted by the countries and ATS authorities concerned by the flight;
- the RPL contents must include relevant information, such as the validity period, the operation day, the aircraft identification, the aircraft type and the turbulence category, the departure and destination airports, the cruising speed and level, as well as the route.

Facsimile of an RPL

For information, a facsimile of an RPL in electronic format is provided below.

(1)	(RPL-AFR268G/010723
(2)	-A320/M
(3)	-LFPG1120
(4)	-N0450F350 DCT AMOGA UT225 VESAN UL613 SOVAT/N0450F360 UL613 SANDY UB4 LESTA UP6 TNT DCT
(5)	-EGCC 0105)
(6)	REMARKS RVR 075 EQPT SRWY/S

(1) RPL header, aircraft identification, date.
(2) Aircraft type and wake turbulence category.
(3) Departure aerodrome and time
(4) Route (including cruising speed and level).
(5) Destination aerodrome and total estimated elapsed time.
(6) Remarks (RVR/aircraft operational minima, COM/NAV equipment).

2.2 - Modifying/cancelling the RPL

The permanent modifications to one element of the RPL must be transmitted to the ATS authorities concerned at least seven days in advance.
In case of unforeseen modifications, the following rules are applicable:

- if the modifications concern the aircraft identification, the departure airport, the destination airport or the route, the RPL must be cancelled for the day, and an individual flight plan must be filed;
- if the modifications concern the aircraft type, the wake turbulence category, the cruising speed or the flight level, they must be notified to the air traffic services as early as possible and, at the latest, 30 minutes before departure.

03 FLIGHT PLAN SUBMISSION PROCEDURES

The rules concerning the flight plan preparation and communication procedures are defined by ICAO and published in the AIP of each State. The key points of these rules are detailed below.

3.1 - Flight plan submission rules

A flight plan must be prepared for each flight. It can be submitted:

- Before departure, by handing it over directly or transmitting it via an approved communication system; In such case, the flight plan must be submitted:
  - ✓ 60 minutes before the estimated time of departure from the parking stand. Flight Plan must be filed to the departure airport authority unit

- ✓ **3 hours before the departure from the parking stand** if flight routes via **North Atlantic OTS**. In this case, Flight Plan must be filed to the **ATFM (Air Traffic Flow Management).**

- In flight, to the unit in charge of the controlled airspace in which the aircraft will fly, or to the telecommunication station, for forwarding to the relevant air traffic control service. In such case, it must be transmitted in due time, in order to be received by the relevant air traffic control service at least 10 minutes before the estimated time of aircraft reaching the planned entry point in a control region or the intersection point between its route and an airway.

  Note that in flight, we could:
  - ✓ file a IFR flight plan
  - ✓ modify an active IFR or VFR flight plan
  - ✓ cancel or close an active VFR flight plan

3.2 - Delay notification or flight plan cancelling

When a flight plan has been submitted, any delay with respect to the estimated time of departure from the parking stand must be notified as early as possible to the relevant air traffic services.
However, the current flight plan must be amended or, if applicable, a new flight plan must be submitted and the old flight plan must be cancelled when the delay exceeds:

- 30 minutes for controlled flights;
- 60 minutes for non-controlled flights.

A flight plan can be cancelled as long as the flight or part of flight for which it was communicated has not started.

It should be noted that, when the pilot decides to cancel the IFR flight plan with the air traffic control service, this flight plan de facto becomes a VFR flight plan.

3.3 - Flight plan activation

The flight plan acceptance by the air traffic control units results in the reception of a flight plan processing number and issue of a clearance upon the start-up request.

It is important to distinguish the following two notions concerning the flight plans according to the ICAO rules: Filed Flight Plan (FPL) and Current Flight Plan (CPL).

Filed flight plan (FPL).

This is the flight plan such as it was filed with an ATS unit by the pilot or his designated representative, before operating the flight. This flight plan does not include subsequent modifications.

Current flight plan (CPL).

The CPL includes the possible modifications resulting from clearances subsequent to the initial flight plan preparation. These clearances are issued by the air traffic control authorities.

In other words, the FPL and the CPL differ by the fact that the filed flight plan (FPL) contains the requested routes and altitudes, while the current flight plan (CPL) contains the routes and altitudes being actually assigned by the ATC to the aircraft.

3.4 - Flight plan closure

Whenever an arrival report is requested, any breach of this requirement may result in severe disturbances in the air traffic control services and induce significant costs resulting from unnecessary search operations.

An arrival report must be handed over directly, via radiotelephone or via data transmission, as early as possible after landing, to the relevant air traffic control unit of the destination airport.
If no relevant air traffic control unit is available on the destination airport, the arrival report will be generated as early as possible after landing and communicated via the fastest means to the closest air traffic control services.

When a flight plan was filed for part of the flight only, and this part is different from the flight part still to be covered to destination, it must be closed via an appropriate report, to the relevant air traffic control unit (e.g. over water flight in the first part of the flight).

The arrival reports transmitted by the aircraft include the following information, in sequence:

- aircraft identification;
- departure aircraft;
- destination airport (in case of alternate only);
- arrival airport;
- arrival time.

3.5 - Flight plan compliance

The flight must be operated in compliance with the filed flight plan, except in case of emergency situation when the actions taken to manage this situation lead the pilot to depart from the current flight plan. In such case, as early as possible, the air traffic control unit must be notified of the measures taken, specifying the reasons for this waiver.

If an aircraft in controlled flight accidentally departs from the filed flight plan, the following actions must be taken:

- if the aircraft deviated from its route, the pilot must take immediate actions in order to return to the route as early as possible;
- if the cruising airspeed deviates or may deviate by ± 5 % with respect to the value recorded in the flight plan, the air traffic control unit must be notified;
- if the estimated elapsed time relating to the first one of the following points, next reporting point or destination airport, may include an error exceeding 2 minutes with respect to the time notified to the air traffic control services, the corrected planned time must be notified as early as possible to the relevant air traffic control unit.

3.6 - Flight plan modification

Any filed flight plan modification request must be notified as early as possible to the relevant air traffic control unit.
The modification requests must include the following information, depending on the type of request:

- cruising level change;
- aircraft identification;
- requested cruising level;
- cruising speed at this level.

06

FLIGHT MONITORING AND IN-FLIGHT RE-PLANNING

01 FLIGHT MONITORING

Flight monitoring involves the two following operations:

- navigation monitoring;
- fuel monitoring.

1.1 - Navigation monitoring

During the flight, the pilot uses the navigation log created during the flight planning for navigation monitoring.

The two basic parameters for navigation monitoring are the magnetic heading and the flight time. In order to determine them, it is necessary to compute the drift angle and the ground speed as accurately as possible in accordance with the flight parameters. Indeed, these condition the estimated time of arrival and the fuel status.
Computing the drift angle enables the correction of the magnetic heading to be followed.
The ground speed enables the flight time to be reset, using the following formula:
Flight time = D_{GROUND} / GS

1.1.1 - Heading monitoring

Chapters 033 01, VFR Navigation and 033 02 IFR Navigation, explained that the tracks displayed on the en-route charts and airport charts are magnetic tracks; then, to determine the ground speed and the drift angle, it is necessary to first convert the magnetic tracks into true tracks: TR(T) = TR(M) + magnetic variation, as the wind direction in altitude is indicated with regard to the true North.
Knowing the wind, the true track and the airspeed and using the navigation computer enables easy determination of the ground speed and drift angle correction.

Example
TR(T) = 346°
Wind = 280/40
TAS = 430 kt
Compute the ground speed and drift angle correction.
A) 414 kt; – 5° B) 414 kt; + 5°
C) 442 kt; – 5° D) 442 kt; + 5°

Answer
The following answer elements are obtained via the computer:
Ground speed = 414 kt and drift angle correction = – 5°
Answer A.

On recent aircraft, the navigation monitoring is performed using information provided by conventional radio navigation (VOR, ADF, etc.) and RNAV (FMS, GPS, ND, etc.) equipment of the aircraft.

1.1.2 - Flight time monitoring

As previously specified, the flight time is a key parameter for navigation monitoring.
When the wind component and/or wind direction have changed significantly during the flight compared to the planned wind, it is necessary to recalculate the ETA (Estimated Time Arrival) at a given waypoint or at destination. In order to compute the flight time for a specified segment, it is necessary to know the ground distance of the specified segment and the ground speed.

- Reading the ground distance on the en-route chart is already described in the navigation Chapters 033 01 and 033 02. It is also available on the flight plan.
- The ground speed is computed with the actual in-flight parameters (Mach, altitude, effective wind, etc.). The GS could also be computed using the TAS displayed on the flight plan and the actual wind component.

We shall illustrate the ground speed and flight time computation with two examples.

Example 1

Using the information recorded during flight, determine the ground speed:

- cruise: FL370;
- Mach: 0.74;
- outside air temperature: - 47 °C;
- headwind: 30 kt

A) 424 kt B) 404 kt C) 434 kt D) 424 kt

Answer

Applying the following formula: Mach = $\frac{TAS}{a}$

With a = speed of sound = 38.95 x $\sqrt{T}$ with T in °K

= 38.95 x $\sqrt{-47 + 273}$

= 586 kt

Hence, TAS = a x Mach

= 586 x 0.74

= 434 kt

GS = TAS – effective head wind

= 434 – 30

= 404 kt

Answer **B**.

Example 2

Determine the flight time to cover the distance specified below.
CAS: 130 kt.
Outside temperature: 0 °C at 10,000 ft.
Travel distance: 240 NM.
True track: 275°.
Wind: 030/30.

A) 103 min B) 95 min
C) 95 min D) 89 min

Answer

Using the computer, we obtain:

TR(T) = 275°.

Vent 030/30 → TAS = 152 kt, GS = 162 kt

CAS = 130 kt.

Flight time = D_{GROUND} / GS

= 240 / 162

= 1.48 h, or 89 min

Example 3

Refer to the Flight Log excerpt attached.

Reaching WPT2, you are informed that the wind has backed 20°, and the wind speed has decreased by 10 kt. What will be your expected leg time to WPT3?

A) 25 min B) 15 min

C) 21 min D) 29 min

	From: DEP Elevation: Sea level		To: DEST Elevation: Sea level					Call sign: OK-AVI				
	From	To	Altitude	True course	TAS	Wind direction Speed	True HDG	VAR	Mag. HDG	Estimated GS Actual GS	Leg distance	Estimated time Accumulated time
1	DEP	WPT 1	CLB ↑	330°	140 kt	340° 15 kt	330°	2°E	328°	125 kt 125 kt	19 NM	0:09 0:09
2	WPT 1	WPT 2	3500	330°	140 kt	340° 15 kt	330°	2°E	328°	125 kt	30 NM	0:14 0:23
3	WPT 2	WPT 3	3500	260°	140 kt	330° 30 kt					53 NM	
4	WPT 3	DEST	DES ↓	250°	95 kt	230° 30 kt					4 NM	0:04

Answer

The True Course between WPT2 and WPT3 is 260° and the planned TAS is 140 kt.

The updated wind is now 310° / 20 kt instead of 330°/30 kt initially.

The effective wind component = cos (310 – 260) x 20 = 12.8 kt ≈ 13 kt headwind

GS = 140 – 13 = 127 kt

The leg distance between WPT2 and WPT3 is 53 NM.

The duration of this leg is 53 / 127 = 0.42 h or 0.42 x 60 = 25 min

1.2 - In-flight fuel monitoring

As indicated by some incidents reported within the aviation circle, the fuel management requires a strict application of procedures by the pilot.

Beyond the consumption, monitoring due to the travel hazards (degraded weather conditions, air traffic constraints, aircraft performance or aerodynamic degradation due to non-standard configuration etc.), all types of aircraft are potentially subject to gauging uncertainties. As they are rare, risks due to fuel leaks during flight are all the more critical.

These checks should enable:

- the consumption changes to be checked; this is the first obvious reason for doing the in-flight fuel check: real situation against the planned consumption in the operational flight plan and draw conclusions.

- the remaining fuel over destination to be assessed; this is the purpose of the in-flight fuel management; the goal is to arrive at destination with sufficient remaining fuel, taking into account the conditions of the day;

- the endurance of the flight to be reconsidered; When a non-standard configuration impacting the fuel flow occurs during a flight, it is crucial to assess the endurance of your flight considering the fuel remaining on board and the degraded fuel flow value.

- the instruments to be validated; on the latest generation aircraft as on older aircraft, the fuel gauging is not perfect, especially for long-range aircraft, for which the volumes are large; this is due to the fact that the fuel tanks of an aircraft have complex shapes, require a set of extremely complex fuel gauges and computers, and the reading accuracy is not always linear.

In-flight fuel monitoring is an essential part of the pilot's task. Each operator has to define his own fuel monitoring procedures, which are published in the Flight Manual and are based on regulatory requirements.

The regulation specifies the fuel monitoring procedures during the flight as follows:

- The pilot in command must ensure that the fuel data is periodically checked. Such checks shall be performed at regular intervals and at least once per route segment.
- The remaining fuel must then be recorded and assessments performed.
- The fuel monitoring shall generate a report.

In practice, a strict consumption monitoring consists in recording the fuel burn off, at each waypoint. This operation enables the fuel remaining on board to be determined in order to derive the flight endurance or the maximum distance (range) that may be covered with this amount.

The following formulas will be applied:

Fuel remaining onboard = fuel on departure – fuel burn off

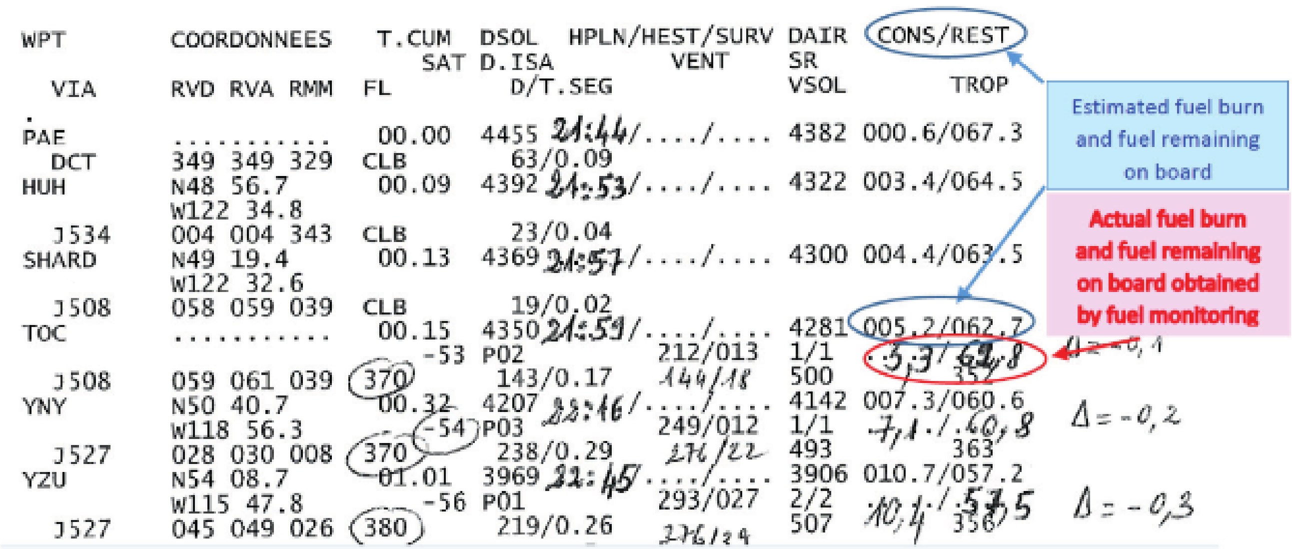
<u>Knowing the Fuel Flow (FF)</u>:
Remaining flight endurance = fuel remaining onboard / FF

<u>Knowing the specific range (SR)</u>:
Range = fuel remaining onboard x SR

<u>Knowing the distance consumption (DC)</u>:
Range = fuel remaining onboard / DC

For information, a facsimile of in-flight fuel monitoring is shown below. A – 0.1 t difference (5.3 t actual consumption against a 5.2 t estimate) at TOC and – 0.2 t (7.5 t against a 7.3 t estimate) on the YNY waypoint can be noted.

Facsimile of a flight monitoring



Example 1: computing the fuel remaining at next waypoint following a direct flight to this waypoint

The estimated and actual remaining fuel amounts are indicated in an extract of the following flight plan.

On arrival at the Charlie waypoint, the ATC authorizes you to fly straight to the Echo waypoint. Knowing that the flight time for a straight flight between these 2 waypoints is 30 minutes and that the weather conditions remain unchanged, what would be the amount of fuel remaining onboard at the Echo waypoint?

A) 3870 kg B) 3260 kg
C) 3630 kg D) 4250 kg

Waypoint	TAS (kt)	GS (kt)	Distance between 2 wpts	Estimated time	Actual time	Remaining fuel estimate (kg)	Actual remaining fuel (kg)
Alpha	150	140	40	1:05	1:05	5200	5200
Bravo	150	150	25	1:27	1:27	4820	4830
Charlie	150	150	20	1:45	1:45	4450	4470
Delta	150	140	30	2:17		3850	
Echo	150	140	15	2:30		3555	

Answer

The solution consists in computing the Fuel Flow (FF) with the latest actual data (i.e. between Bravo and Charlie), then using this Fuel Flow value to estimate the amount of fuel remaining onboard at the Echo waypoint.

Computing the FF:
Actual time between Bravo and Charlie: 1:45 – 1:27 = 18 min
Actual remaining fuel between Bravo and Charlie: 4830 – 4470 = 360 kg
The FF is then derived
FF = 360 / 18 = 20 kg/min

Computing the trip fuel between Charlie and Echo:
Trip fuel = flight time x FF
= 30 x 20 = 600 kg

Fuel remaining onboard at the Echo waypoint
Remaining fuel at Echo = 4470 – 600 = 3870 kg
Answer A

Example 2: computing the endurance following a non-standard configuration
Consider an aeroplane with 3 fuel tanks: left, right and centre. Left and right fuel tank capacity = 205 kg each, centre = 600 kg.
The left fuel tank is connected to the left engine and the right fuel tank to the right engine. A pump connected to the centre tank is feeding the left and right fuel tank.
At take-off, there were 600 kg of fuel. The consumption is 125 kg/h per engine and after 35 min of flight, the pump fails. What is the endurance from that moment?

A) 5 h 23 min
B) 1 h 38 min
C) 3 h 37 min
D) 4 h 13 min

Answer
At take-off, the fuel distribution is the following:
- 2 wing tanks left and right = 2 x 205 kg = 410 kg (as we feed the wing tanks first)
- Centre tank = FOB – 410 = 600 – 410 = 190 kg

During flight, we burn fuel in centre tank first because of the bending moment.
After 35 min of flight (or 0.58 h), we have burnt = 250 kg/h (2 engines) x 0.58 = 145 kg
Fuel remaining in the centre tank that we cannot used it anymore as the centre pump has failed = 190 – 145 = 45 kg

After 35 min of flight, the fuel in the wing tanks remains intact and only this amount of fuel could be used to compute the endurance
Endurance from the time the pump fails = 410 / 250 = 1.64 h = 1 h 38 min.

02 MANAGEMENT AND IN-FLIGHT RE-PLANNING

2.1 - In-flight fuel management

If the fuel monitoring shows that the estimated amount of fuel remaining on arrival at the destination airport is less than the regulatory fuel requirement, the pilot must assess the situation and make the appropriate decisions in order to best manage the fuel in flight.

He may decide to continue to the destination airport, using the following methods to modulate the fuel consumption if a difference is shown between the estimated consumption and the actual consumption measured on the total fuel quantity indicators:

- switch to another, more economical, cruising speed;
- modify the cruise altitude, in order to benefit from a more favourable wind;
- or decide to diver to a diversion airport, in order to land with at least the required reserve fuel.

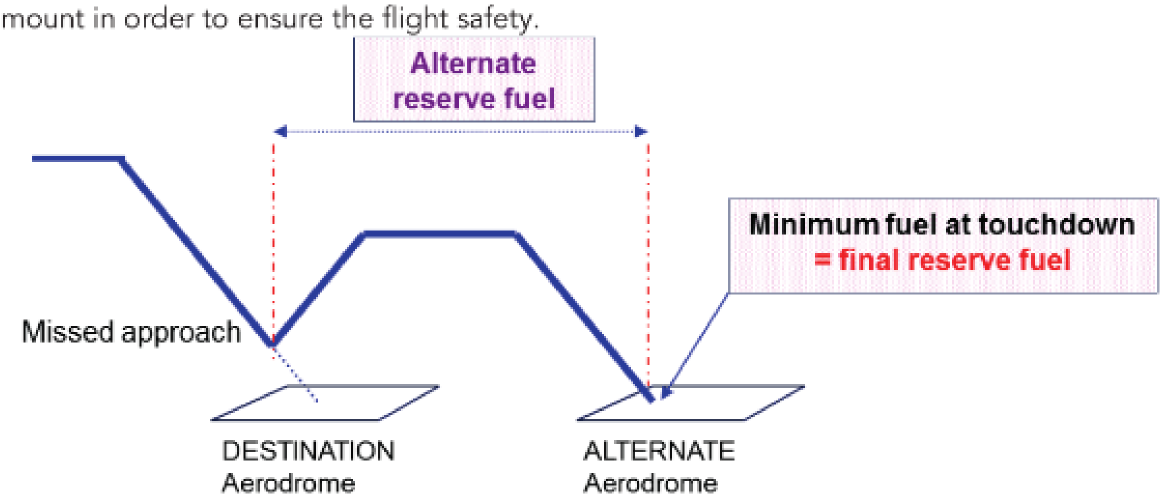
In terms of regulations, the text of the applicable regulation imposes compliance with the following in-flight fuel management rule.

2.1.1 - Minimum fuel at touchdown

Regardless of the flight conditions, the remaining fuel on-board must be managed by the crew so that the minimum fuel amount at touchdown remains higher than or equal to the final reserve fuel. This rule applies both to a destination airport and an alternate or diversion airport.

2.1.2 - Minimum fuel at the destination airport

The in-flight fuel monitoring should allow the crew to reach the destination airport with a minimum fuel amount in order to ensure the flight safety.



In accordance with the regulatory requirements, the minimum fuel amount above the destination airport threshold must be sufficient to reach the alternate airport. It is defined as follows:

Minimum fuel over destination (with alternate*)

=

Alternate fuel + final reserve fuel

*With no alternate airport:

Minimum fuel over destination = final reserve fuel

Thus, if the in-flight fuel monitoring indicates that the estimated amount of remaining fuel on arrival at the destination airport is less than the sum of the alternate fuel and the final reserve fuel, the crew must consider the traffic and the existing operational conditions:

- at the destination airport;
- on the trip to the alternate airport and at the alternate airport, before deciding, either to continue the flight to the destination airport, or a diversion, in order to land with at least the fuel amount corresponding to the final reserve fuel.

In parallel with the in-flight fuel monitoring, the meteorological monitoring is also essential; indeed, in order to ease the decision-making in case of diversion, the crew must perform a meteorological condition monitoring for the appropriate airports likely to be used as diversion airports (TAF, METAR, etc.).

Example 1: computing the endurance depending on the on-board remaining fuel

During an IFR flight on-board a Beech Bonanza, the fuel gauges indicate that the remaining fuel amount is 100 lb after a 38 minutes flight.

Knowing that:

- the total fuel amount at take-off is 160 lb;
- the fuel required for alternate is 30 lb;
- the fuel estimate for taxiing is 13 lb;
- the final reserve fuel is estimated as 50 lb.

If the Fuel Flow remains constant, how long can the aircraft fly to the destination with the remaining fuel?

A) 12 minutes B) 63 minutes

C) 44 minutes D) 4 minutes

Answer

After a 38 minutes flight, the fuel burn off amount is 160 – 100 = 60 lb; this corresponds to a Fuel Flow of 60/38 = 1.579 lb/min. This flow rate is considered as being constant for the remainder of the flight, as specified in the question.

The onboard remaining fuel is 100 lb, from which the alternate reserve fuel and the final reserve fuel must be deducted as required by the regulation, i.e.:

100 – 30 – 50 = 20 lb

This amount of onboard remaining fuel thus corresponds to the following endurance:

20 / 1.579 ≈ 12 min

Answer **A**.

Example 2: computation of the estimated landing mass at destination alternate aerodrome with landing gear blocked down.

Planned and actual data are shown in the Flight Log excerpt.

After a balked landing at the destination airport, you have to divert to the alternate airport with the landing gear extended. The re-calculated flight time to alternate due to the reduced speed is 1h 30min and the fuel flow will be 600 kg/h. Final reserve fuel remains unchanged. What will be the estimated landing mass at the alternate airport?

A) 6017 kg B) 5177 kg
C) 7672 kg D) 5642 kg

FLIGHT LOG EXCERPT

FUEL	Time	Kg
Trip	4:50	2030
Contingency	0:15	105
Alternate	1:00	420
Final reserve	0:30	150
Minimum take-off fuel	6:35	2705
Extra	2:00	840
Take-off fuel	8:35	3545
Taxi		50
Ramp		3595

MASS		Kg
DOM		4567
Payload		460
ZFM		5027
Take-off fuel		3545
TOM		8572
Trip fuel		2030
Estimated landing mass (at destination)		6542

Answer

Computing the fuel amount with landing gear extended:

FF = 600 kg/h

Time to alternate = 1h30 = 1.5 h

Fuel to alternate with LG extended = 600 x 1,5 = 900 kg

Do we have enough fuel to fly to alternate?

FOB = 420 (alternate) + 150 (Final R) + 840 (extra) = 1410 kg > 900 kg

So OK, we have enough fuel to alternate

Computing the landing mass at alternate
LM at alternate = LM at Destination – Fuel to alternate
= 6542 – 900 = 5642 kg

2.2 - In-flight re-planning

Certain circumstances or technical incidents during the flight imperatively impose an en-route diversion; this covers:

- engine failure;
- depressurization;
- ETOPS flight, with a technical problem impacting the flight continuation in ETOPS conditions.

In such conditions, the pilot must perform an in-flight re-planning, according to:

- the amount of on-board remaining fuel after the in-flight fuel monitoring balance;
- the fuel and the time required for diversion; the latter is obtained via the data provided by the manufacturer on graphs; this section will discuss both cases of engine failure and depressurization, using the B737 graphs.

2.2.1 - Engine failure

The graph on the following page enables the quick determination of, either the fuel and flight time required to join the diversion airport from the engine failure point, or the maximum range according to the on-board remaining fuel.
This graph was designed at the Long Range speed for the one engine inoperative cruise and a M.74/250 kt descent.
The concept and the use of this type of graph have already been mentioned in Chapter 033 03 "Fuel".

Example
Use the graph on the next page to determine the maximum distance and the diversion time following the en-route engine failure.

It indicates:

- available diversion fuel: 8,500 kg;
- diversion cruise altitude: 10,000 ft;
- weight at diversion point: 62,500 kg;
- head wind: 50 kt
- temperature: ISA – 5 °C.

A) 760 NM; 4 hr 30 min   B) 1 130 NM; 3 hr 30 min
C) 860 NM; 3 hr 20 min   D) 1 000 NM; 3 hr 40 min

Answer
See the correction on the graph.
The maximum distance is 860 NM and the diversion time is 3.35 hr; i.e. 3 hr 20 min.
Answer **C**.

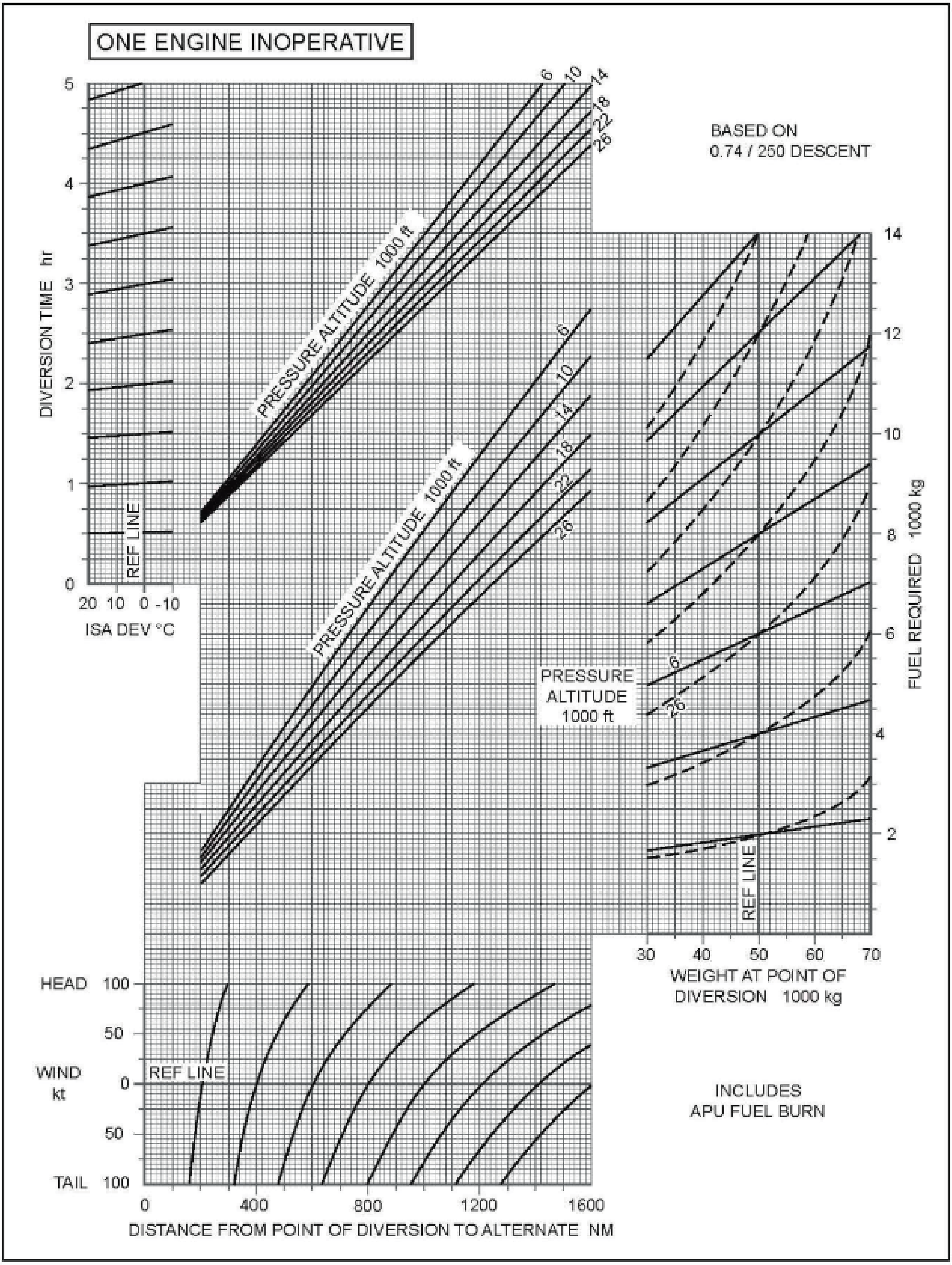


Figure 4.7.3 In-Flight Diversion (LRC) One Engine Inoperative

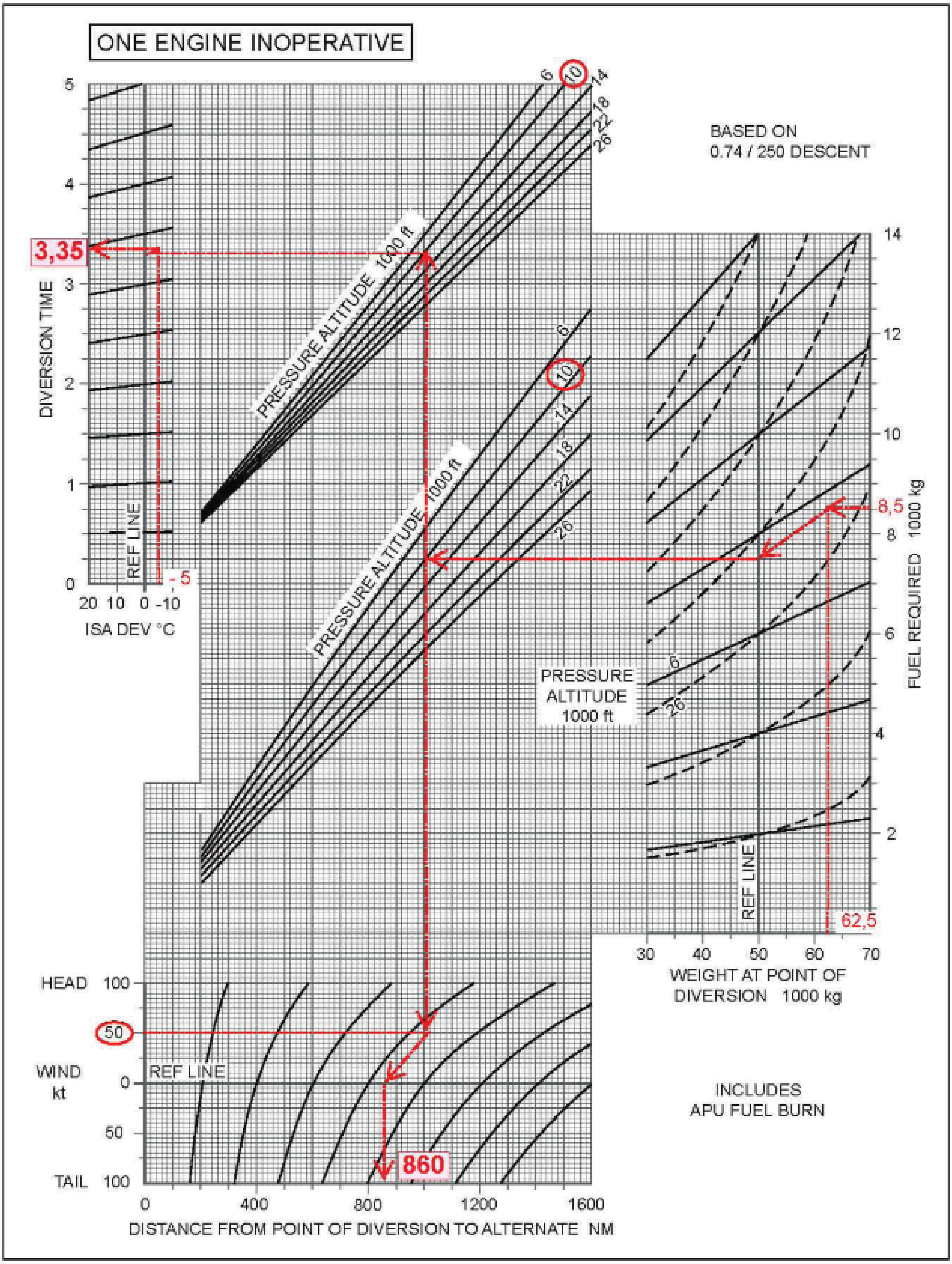


Figure 4.7.3 In-Flight Diversion (LRC) One Engine Inoperative

2.2.2 - Depressurization

The following graphs enable the fuel burn to be determined in order to join the diversion airport in case of depressurization. Two cases may occur:

- depressurization with all engines operating: the required fuel is computed using graph 4.7.1b below.
- depressurization with one engine inoperative: in this case, the manufacturer recommends computing the fuel required with one engine inoperative (graph 4.7.1a) and all engines operating (graph 4.7.1b) to select the lowest value.

The example below shows the fuel computation in the second case, with simultaneous depressurization and one engine inoperative.

Example

You simultaneously undergo an engine failure and depressurization. What would be the fuel required to conduct the diversion with the following data:

- tailwind: 25 kt;
- distance to the diversion airport: 820 NM;
- temperature: ISA + 10 °C;
- estimated weight at depressurization point: 55,000 kg;
- icing conditions: yes.

A) 8,300 kg B) 7,035 kg
C) 7,000 kg D) 8,414 kg

Answer

It should be noted that the last sentence in the inset at the bottom of both graphs states that it is necessary to compare the computation result with one engine inoperative with the result with all engines operating, in order to select the highest fuel burn of both cases ("compare the fuel required from this chart with critical fuel reserves").

Fuel burn with one engine inoperative (graph 4.7.1a)

Using the specified data, the diversion fuel is equal to 6,800 kg (see correction on the graph). The fuel burn value thus obtained is applicable in standard conditions with no icing conditions; therefore, the following corrections should be applied:

- at ISA + 10 °C, the fuel correction stated at the bottom of the graph should be applied, i.e. 0.5 % for a 10 °C standard temperature difference, thus: 6,800 x 0.5 % = 34 kg;
- in icing conditions, the correction is 20 %, i.e. 6,800 x 20 % = 1,360 kg; therefore, the fuel burn with depressurization and one engine inoperative is:
- 6,800 + 34 + 1,360 = 8,104 kg

Fuel burn with all engines operating (graph 4.7.1b)

The diversion fuel obtained with this graph is 7,100 kg (see correction).
Temperature correction and icing conditions:

- at ISA + 10 °C, the fuel correction is 0.5 %; i.e. 7,100 x 0.5 % = 36 kg; in icing conditions, the correction is 18 %, i.e. 7,100 x 18 % = 1,278 kg;
- the fuel burn in case of depressurization with all engines operating is: 7,100 + 36 + 1,278 = 8,414 kg

The highest diversion fuel among both above computations will be selected, i.e. 8,414 kg.
Answer D.

Depressurization with one engine inoperative graph

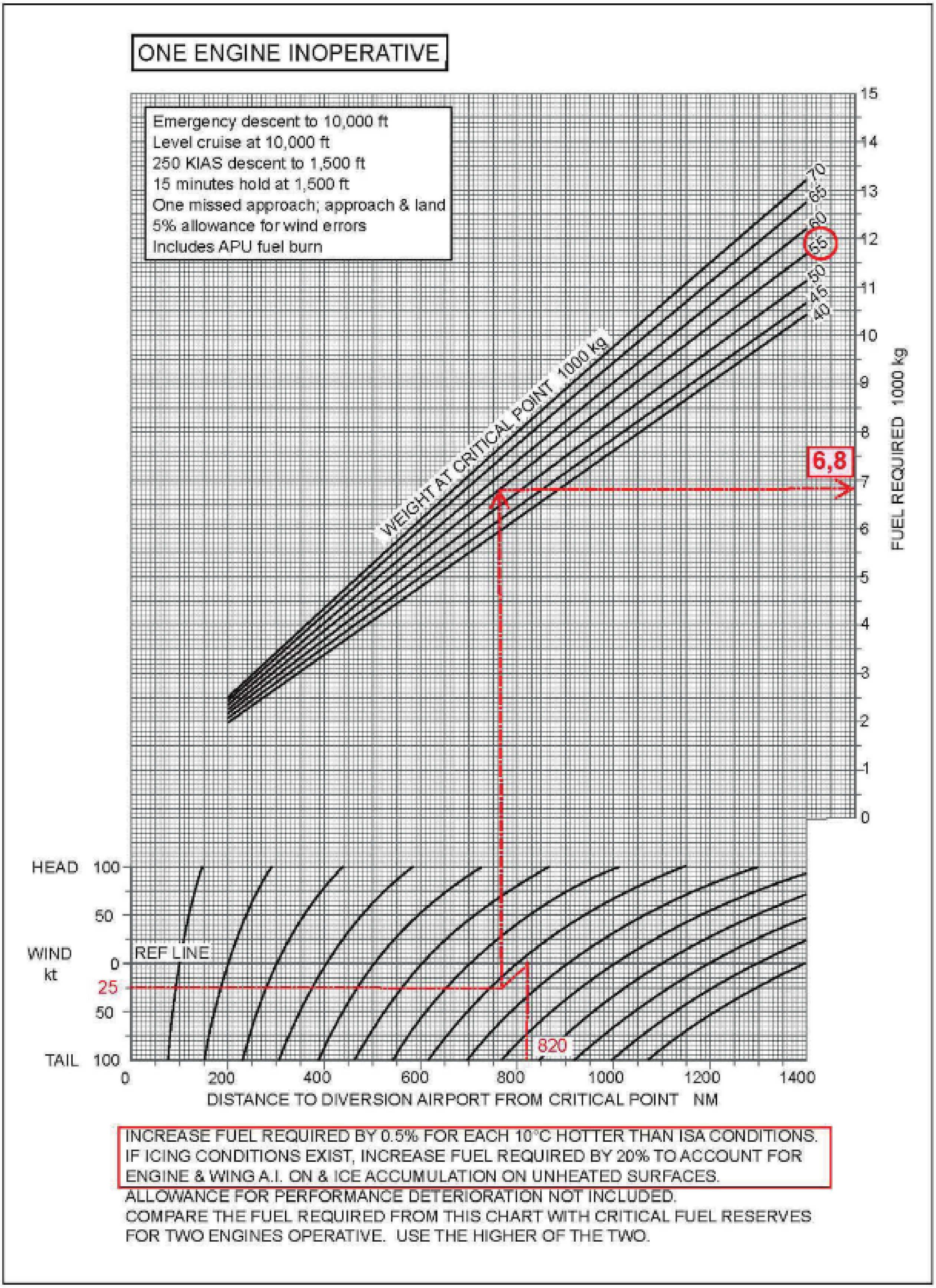


Figure 4.7.1a Critical Fuel Reserve – One Engine Inoperative

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The complete set of manuals has been conceived under the joint direction of the CTKI (Chief Theoretical Knowledge Instructor) of the ENAC and the HT (Head of Training) of the MERMOZ Institute.

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Book covers designed by Jérôme ESPENAN – ENAC – photography credits AIRBUS

ISBN : 978-2-86248-240-8
Legal deposit : 1st Quarter 2021