BASIC NAVIGATION
for
Sport Aviation

Ver. 20190913

Basic navigation

Table of contents

Introduction

This Manual has been written to provide a basic knowledge of the theoretical and practical aspects of aviation navigation.

The practical techniques are directed towards open-cockpit sport aircraft. The difficulty of carrying and using navigation charts and equipment in some sport aircraft is recognised. Nonetheless, there is a regulatory requirement for charts and flight plans to be carried and used. With practice and guidance, pilots will develop suitable techniques for their use in sport aircraft.

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Abbreviations and definitions

Angle of inclination: the angle between the horizontal and the lines of force associated with the Earth’s magnetic field. At the poles this angle approximates 90°.

Cross-country flight: a flight that extends beyond a 25 NM radius of the departure point.

Elevation: the height of a ground feature above the mean sea level pressure datum.

Equator: an imaginary line on the Earth's surface equidistant from the north and south poles.

Great circle: an imaginary line on the Earth’s surface that represents the shortest distance between those points.

Isoganal: a line connecting points on a chart with equal magnetic variation.

KTS: knots or nautical miles per hour

Lambert Conformal Conic projection: a projection that conceptually seats a cone over the sphere of the Earth and projects the surface conformally onto the cone.

Latitude: a geographic co-ordinate that specifies the north–south position of a point on the Earth’s surface. Often referred to as parallels of latitude.

Longitude: a geographic co-ordinate that specifies the east–west position of a point on the Earth’s surface. Often referred to as meridians of longitude.

Magnetic north: the direction that the north end of a compass needle points corresponding to the direction of the Earth’s magnetic field lines at that point.

Magnetic variation: the angle on the horizontal plane between the direction of magnetic north and true north.

Meridian: an imaginary arc on the Earth's surface from the North Pole to the South Pole.

MIN: minutes

NM: nautical miles

Rhumb line: a line which crosses all meridians of longitude at the same angle.

Transverse Mercator projection: a map projection that delivers high accuracy in zones less than a few degrees in east–west extent.

Terminal area: a terminal control area (TMA) which is defined as a control area normally established at the confluence of air traffic service routes in the vicinity of one or more major aerodromes in which air traffic services are provided by Approach and Departures Control (Manual of Air Traffic Services).

True north (geodetic north): the direction along the Earth's surface towards the geographic North Pole which is the point in the northern hemisphere where the Earth's axis of rotation meets its surface.

° : degrees (e.g. 30°C)

The Basics

The Earth

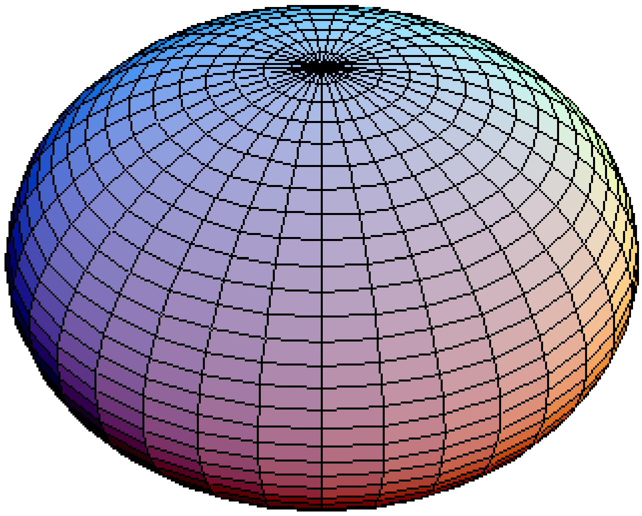


Fig. 1 An oblate spheroid

The shape of the Earth is very close to that of an **oblate spheroid**, a sphere squished along the orientation from pole to pole resulting in a **bulge** around the **equator** (Fig. 1).

To navigate from one point on the Earth to another, it is necessary to know the relative positions of these points and of those around them. A convention was determined and was devised centuries ago by sailors and explorers whose task it was to sail the oceans in search of new territories for trade and other purposes. These conventions survived the test of time and are still used in all aviation-related navigation exercises.

Latitude and longitude

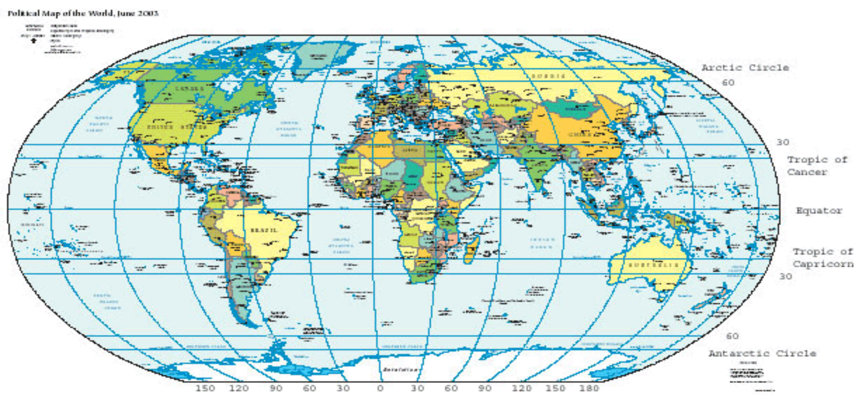


Fig. 2 A map of the Earth showing meridians of longitude and parallels of latitude

The Earth is divided by a series of lines drawn through the poles and another series drawn at right angles to these and parallel to each other. The lines through the poles are known as **meridians of longitude** and those intersecting these meridians are **parallels of latitude** (Fig. 2).

When viewed from space from a position above either of the poles, the outer edge of the Earth can be represented as a circle containing 360*. In order to differentiate one meridian from another, a naming convention was devised such that the 0* meridian passes through Greenwich in the UK. From this **prime meridian**, each degree to the east was annotated sequentially up to 180*. The same applies to the west of the prime meridian.

For the parallel lines drawn intersecting the meridians, the centre of the "bulge" in the spheroid is called the **equator** and parallels spaced 1°(degree) apart are drawn both north and south of the equator and named accordingly, starting at the equator which is the 0° parallel of latitude and ending at the respective poles which are 90° north and south of the equator. Hence, the position of a point on the Earth can be located by referring to its latitude and longitude. Degrees of latitude and longitude are further divided into smaller segments of which there are 60 per degree, these segments being termed **minutes**. One minute of **longitude** represents one nautical mile (NM) **at the equator only.**

Mapping

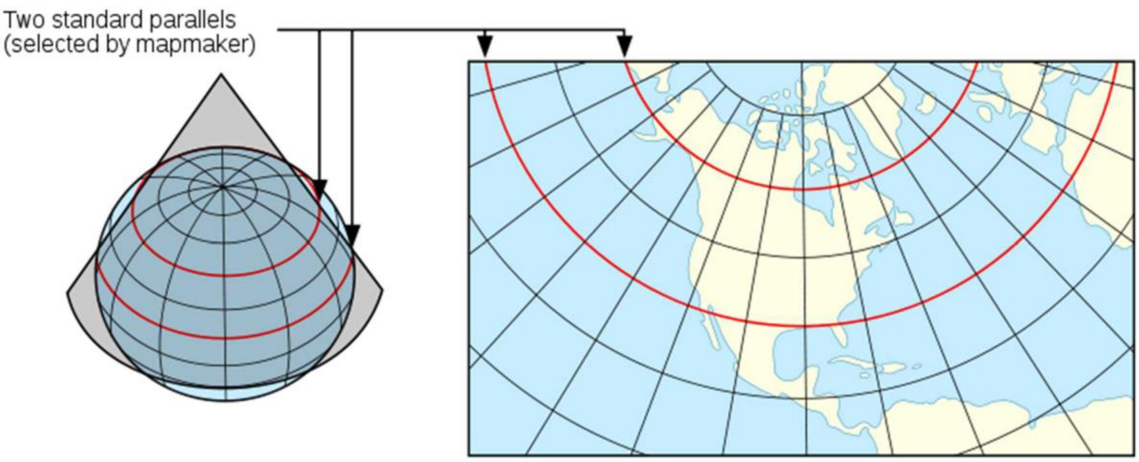


Fig. 3 The distortion created by charts

Charts are made by projecting the Earth's surface onto a flat piece of paper. Distortion of the resulting chart results from the three-dimensional nature of the Earth's surface being flattened onto paper (Fig. 3). Of the many projections available, a **Lambert conformal conic projection** is most often used for the aeronautical charts in visual navigation. In essence, the projection superimposes a cone over the sphere of the Earth, with two **standard parallels** secant to the globe and intersecting it. This minimises the distortion of projecting a three-dimensional surface to a two-dimensional surface. There is no distortion along the standard parallels, but distortion increases the further from the standard parallels one moves. During chart construction, care is taken to ensure that the meridians always represent the actual direction of **true north**. This provides a reference from which to determine direction and the meridians accurately represent distance over the area covered by the chart, with one minute of longitude representing 1NM. Therefore, on aeronautical charts **tracks and distances must always be referenced to the meridians on the chart.**

Pilots favour these charts because a straight line drawn on a Lambert conformal conic projection approximates a great-circle route between endpoints.

A great circle is the shortest distance between two points on the Earth's surface. If drawn on the Earth's surface, a great circle line appears as a straight line, but on a chart it is represented accurately by a curve concave to the equator. However, the scale of the aeronautical charts used for visual navigation is such that for practical purposes, a straight line may be considered to be a great circle.

True north – Magnetic north

From the above, it is known that aeronautical charts are referenced to **true north**. However, for practical basic navigation, a microlight has no way of determining the direction of true north. A practical alternative was needed, and it was found that the direction of **magnetic north** could be determined on or near the Earth's surface by using a compass.

The Earth's magnetic field is created by the molten plasma that forms the centre of the Earth. It terminates in two poles, the **north** and **south magnetic poles**, which are **not** co-incident with the true poles. As such, - the Earth is like a magnet and has a **magnetic field**.

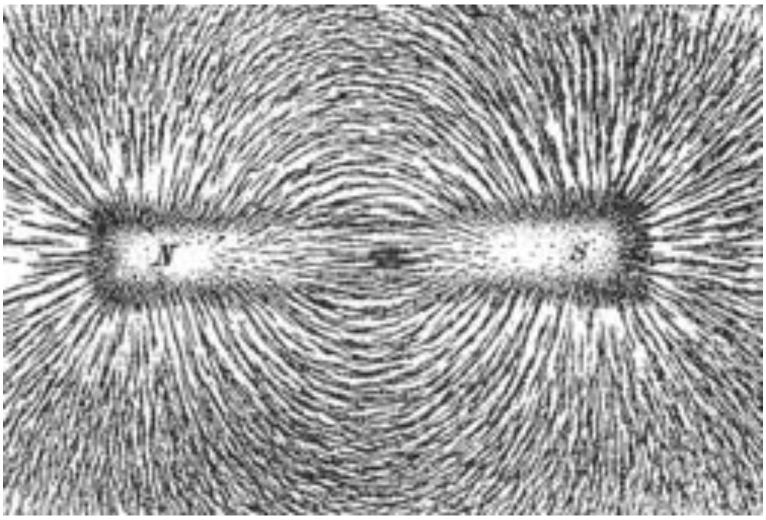


Fig. 4 The magnetic fields generated by a permanent magnet

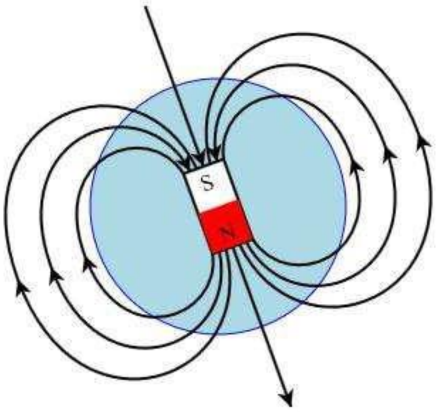


Fig. 5 The magnetic fields generated by the Earth

The above two illustrations show the magnetic fields generated by a permanent magnet (Fig. 4) and the Earth (Fig. 5). The magnetic field of the permanent magnet (Fig. 4) has been highlighted using iron filings.

The lines of force do not run parallel to the surface of the magnet, but form curves that dip down to both magnetic poles. The angle between the horizontal and these lines of force is known as the **angle of inclination**. At the poles, the magnetic field lines are at approximately 90* the surface.

The magnetic fields of force associated with the Earth are very similar. In fact by definition, the Earth's magnetic poles are the points on the Earth's surface where the **angles of inclination** are 90* to the surface (horizontal).

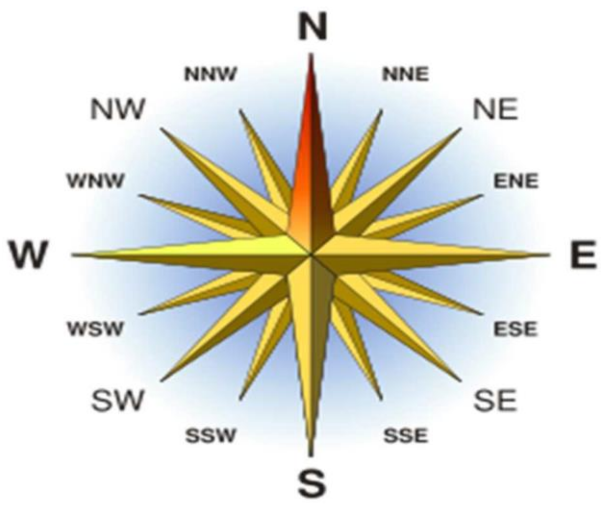


Fig. 6 Points of the compass

The Earth's magnetic field can be detected with a **compass**. Navigation compasses use a **compass card** which incorporates a permanent magnet supported by a jewelled pivot at its centre. The alignment of the permanent magnet is such that a given point on the compass card always points to magnetic north.

From the mapping section above, it is known that the **meridians** are aligned with **true north**, but there is nothing on the charts aligned with **magnetic north**. The angular difference between true north and magnetic north is known as **variation** and is expressed in **degrees. Variation** is not the same at all points on the Earth's surface and shows small but regular changes.

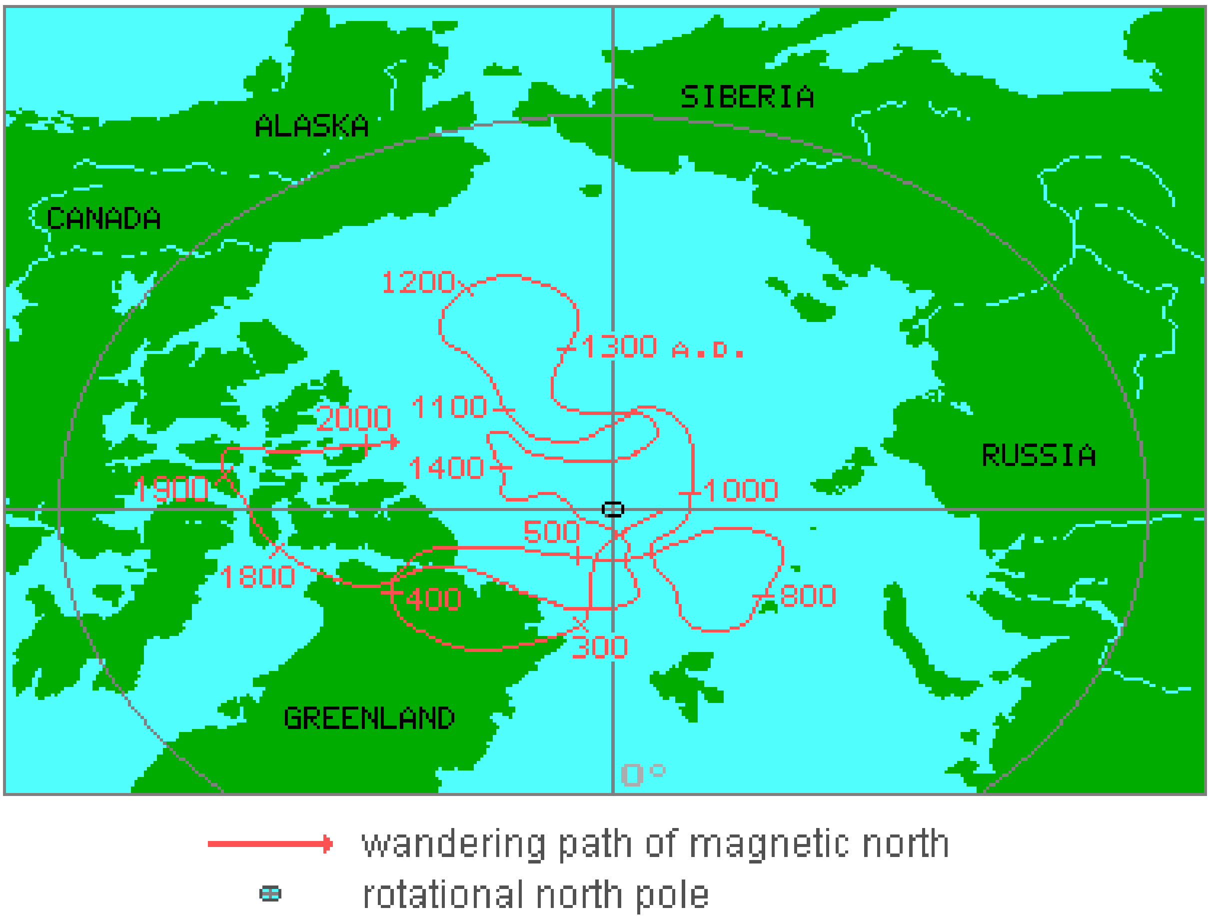


Fig. 7 The movement of the magnetic north pole from before 300 AD until 2000 AD

Fig. 7 is a plot showing the movement of the **magnetic north pole** from before 300 AD until 2000 AD and its relativity to **true north**.

As the term **variation** refers to the difference between **true north** and **magnetic north**, this value must be known before information obtained from a chart and referenced to **true north** can be used on a **compass** that is referenced to **magnetic north**.

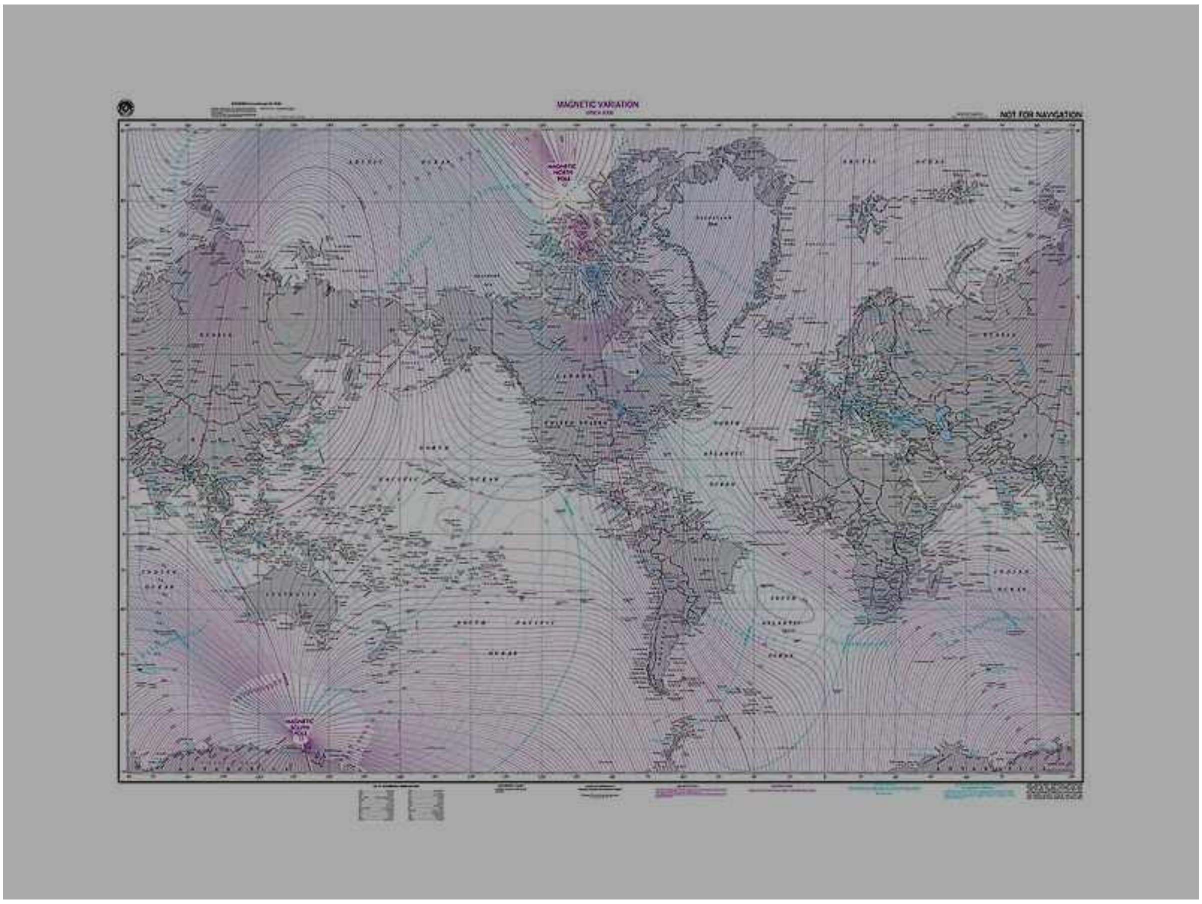


Fig. 8 Lines of equal variation or isoganals on a world map

Fig. 8 depicts a world map showing lines of equal **variation** or **isoganals**. They appear on all aeronautical navigation charts together with the date for which they were valid.
Some charts advise the movement of these **isoganals** annually, but for practical purposes they may be considered accurate over a period of some 20 years or so.

Variation may be **east** or **west**, easterly variation being annotated by the symbol + and westerly variation by –. The following simple expression is used in the application of variation: **Variation east, magnetic least. Variation west, magnetic best.**

In Australia, **variation** is **east** in all areas except for a small area in the south-western region of West Australia.

Aeronautical charts

World Aeronautical Charts (WACs)

Fig. 9 depicts a section of a World Aeronautical Chart **(WAC)** showing how potentially useful information for visual navigation is portrayed in various forms and utilises colours and symbols to differentiate each type of feature. Each WAC contains legends in both the lower and left-hand margins. The lower margin shows the symbol displayed, together with a description of the symbol (e.g. roads, railways, rivers, mountains, airports, towns and cities and other topographical features). The left-hand margin contains a chart of hypsometric and bathymetric tints. Hypsometric means elevations **above** mean sea level and bathymetric means depths **below** mean sea level. Different tints are contained within an area bounded by lines known as contour lines. These contour lines join points on the chart of equal elevation and reflect the boundaries of the tints shown in the legend. The tinted area within the contour boundaries is at or above the elevation represented by the lower contour line itself. As a general rule, the darker the tint, the higher the terrain elevation.

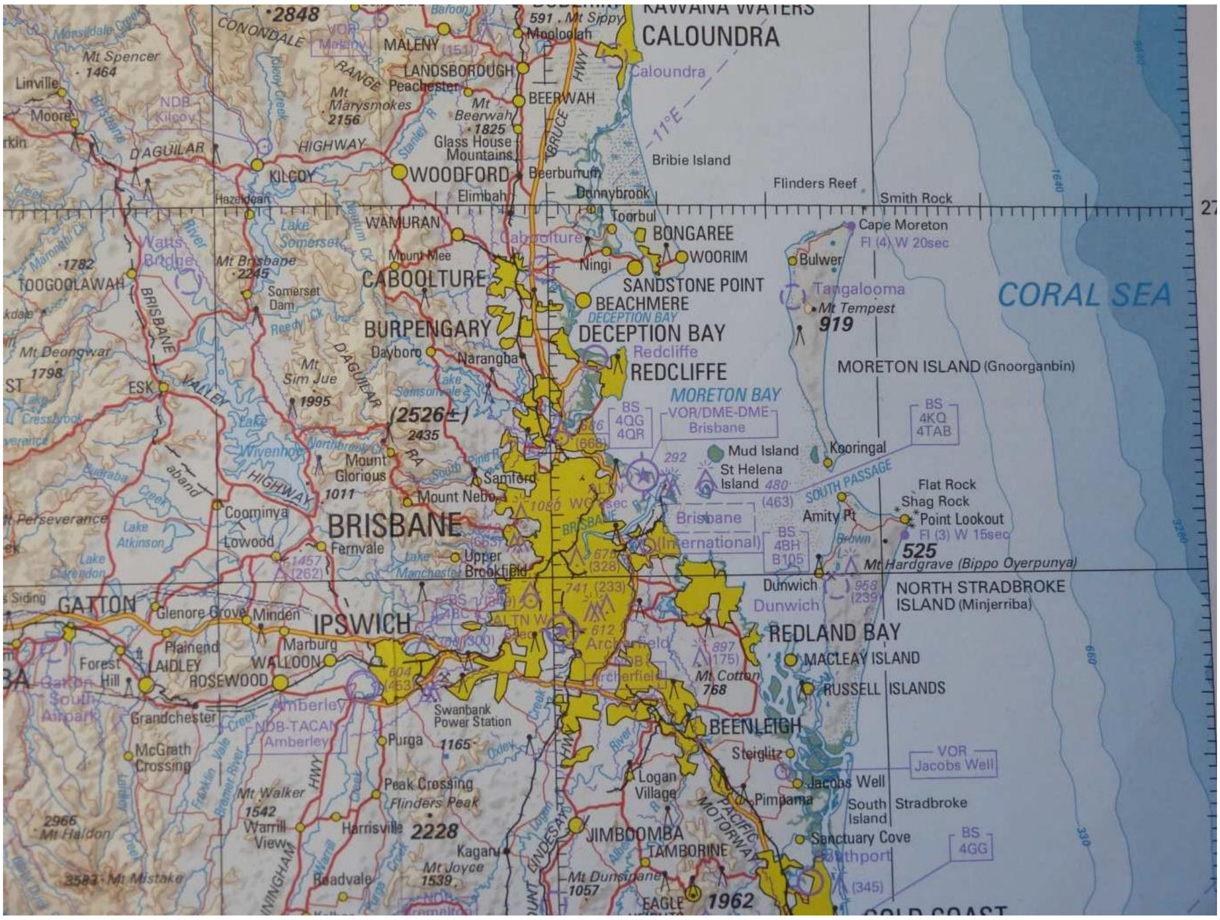


Fig. 9 Information for visual navigation as it appears on a World Aeronautical Chart

Although not obvious due to the size of the section in Fig. 9, the **parallels of latitude** are in fact slightly curved, whereas the **meridians of longitude** are straight lines. The scale of a WAC is 1:1,000,000 or one in a million, meaning that one centimetre on the chart represents 1,000,000 centimetres of the Earth.

Three types of tracks can be drawn on a WAC: straight line, rhumb line and great circle.

A **straight line** on a chart is the shortest distance between two points. However, a straight line cannot be drawn on the Earth's surface since that surface is curved.

A **rhumb** line is a line that crosses every meridian at the same angle. A parallel of latitude is a **rhumb** line. A straight line is not. **Rhumb lines** always have a direct relationship with

true north as they cross the meridians at the same angle.

A **great circle** is a line between two points on the Earth's surface which represents the shortest distance between the points. A meridian is a **great circle,** as is the equator. A **great circle**, drawn other than on the equator does not intersect each meridian at the same angle.

The **WAC** is a **Lambert conformal conic projection** which has the properties of a **straight line** representing an approximate **great circle** and a **rhumb line** over a short distance. The **scale** is almost constant over the chart and can be taken as constant for practical purposes. The meridians are straight lines running north/south to the **true** poles. The charts are constructed such that one minute of **longitude** equals 1 NM and every second meridian on the chart is graduated into one minute or 1 NM graduations. The meridians are not parallel so to measure a bearing, the protractor must be aligned with the middle meridian on the line being measured or plotted.

Track/Bearing measurement

1. Draw a straight line between the departure point and the destination point.

2. Select a meridian approximately halfway along the track.

3. Place the north/south centre-line of the protractor exactly on the meridian with the north cursor aligned to the north of the chart.

4. Place the grommet hole of the protractor exactly on the track line and ensure that the protractor is still aligned accurately on the meridian.

5. Read off the degrees on the **outer** scale of the protractor. Select the nearest whole number as fractions of degrees are not practical. Fig. 10 shows the track from Broome to Derby is 067* **true.**

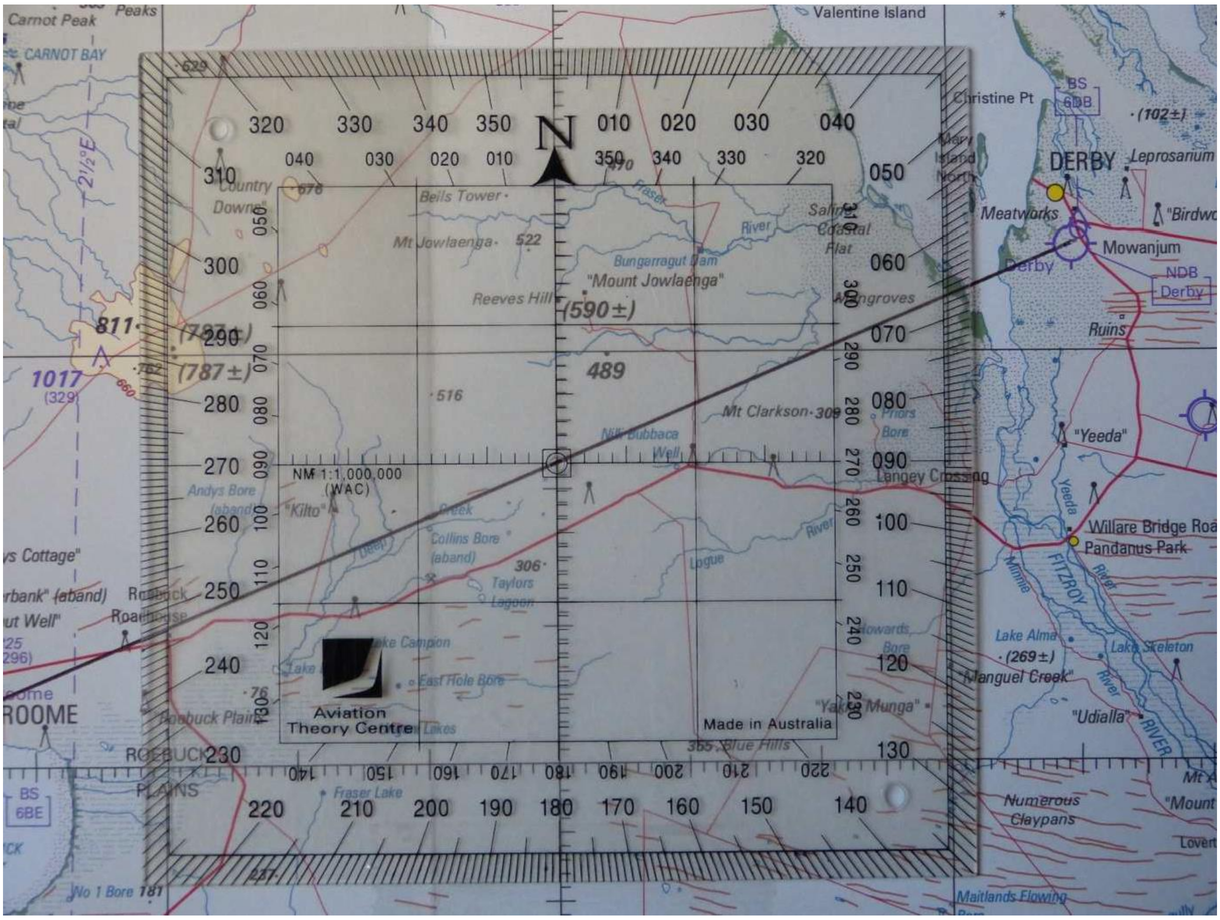


Fig. 10 Measuring a bearing to show the track from Broome to Derby is 067* true

6. Select the isoganal nearest to the centre meridian and read the **magnetic variation** written on it. In Fig. 10, the isoganal is to the left of the protractor (2 ½ * **east**).

7. Apply the variation as indicated earlier (variation east, magnetic least).
067* – 2* = 065* **magnetic**. Note: the ½ degree may be added to or subtracted from the whole degrees obtained from the isoganal as in practical terms, a compass cannot be read to that degree of accuracy during flight.

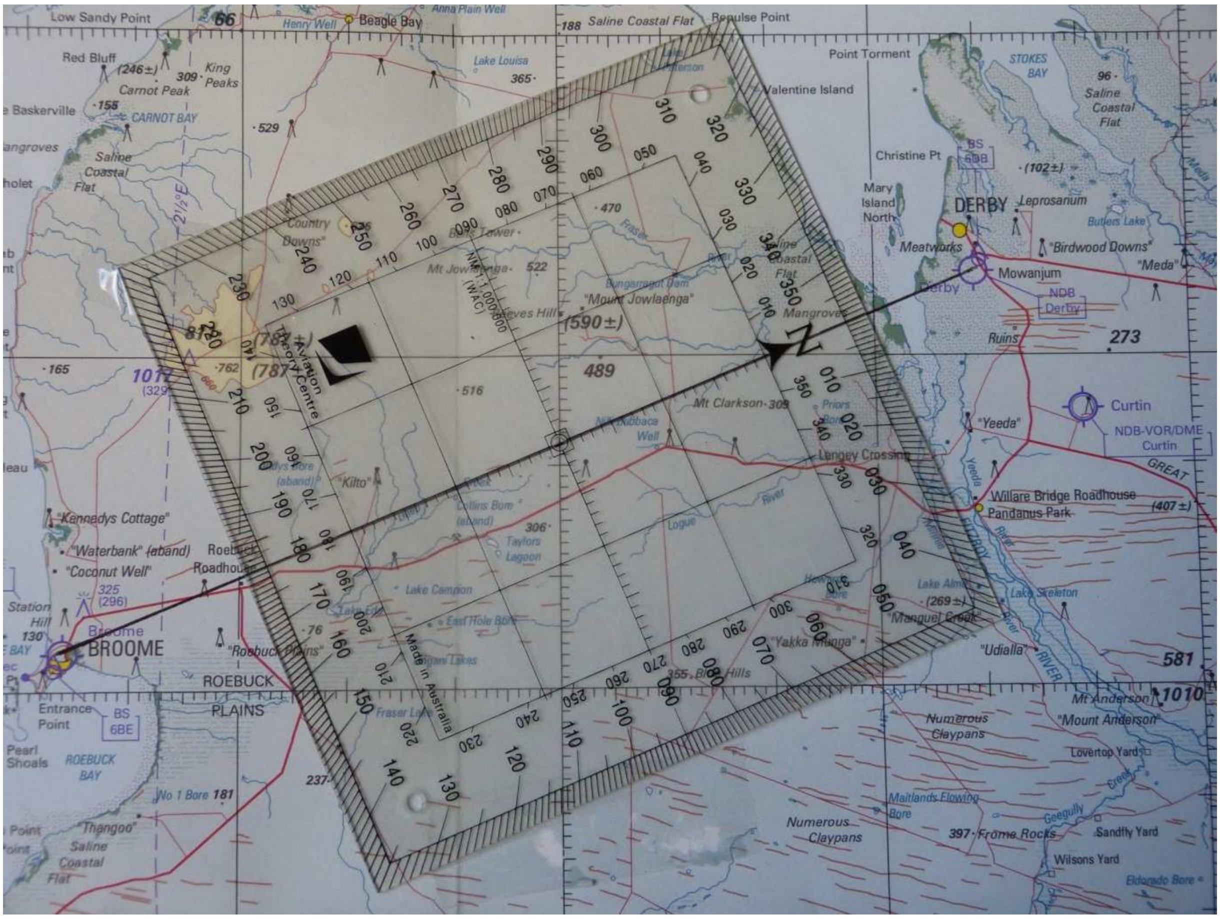


Fig. 11 An alternative way of measuring a track angle

Fig. 11 shows an alternative way of measuring a track angle.

1. Position the protractor such that the north cursor is aligned with the **planned direction of flight**.

2. Move the protractor until the centre grommet hole is centred over a meridian approximately mid track.

3. Recheck alignments and read off the bearing against **meridian** at the **top of the protractor** on the **inner scale**. Take care that the bearing is read starting with the lower printed whole number (60 in Fig. 11).

4. Apply the variation in the same way as described above.

The main advantage of this method is that the north cursor (arrowhead) is pointing in the direction of the planned flight.

Distance measurement

Distances on a WAC may be measured by one of three methods:

1. using a scale ruler
2. using any straight edge or dividers and the scale on the bottom of the chart
3. using any straight edge or dividers and the **minute** divisions on a **meridian** close to the midpoint of the track.

For methods 1 and 2, the correct scale needs to be used. The scale ruler has several scales besides the 1:1,000,000 that must be used on a WAC. The scale on the bottom of the chart shows statute miles, nautical miles and kilometres. The nautical mile scale must be used.

Recall that on a WAC, one minute of longitude equates to 1 NM and the meridians are divided into minutes and therefore nautical miles. For this reason, method 3 is likely to produce the most accurate and consistent results. **Never** use the minute marks on the parallels of latitude to measure distance. This is because in chart construction the marks are drawn such that distances are accurate along the meridians of longitude, but not along the parallels of latitude.

Whilst the above discussion deals specifically with the WAC series, the same methodology can be applied to the other commonly used aeronautical charts.

Visual Terminal Charts (VTCs)

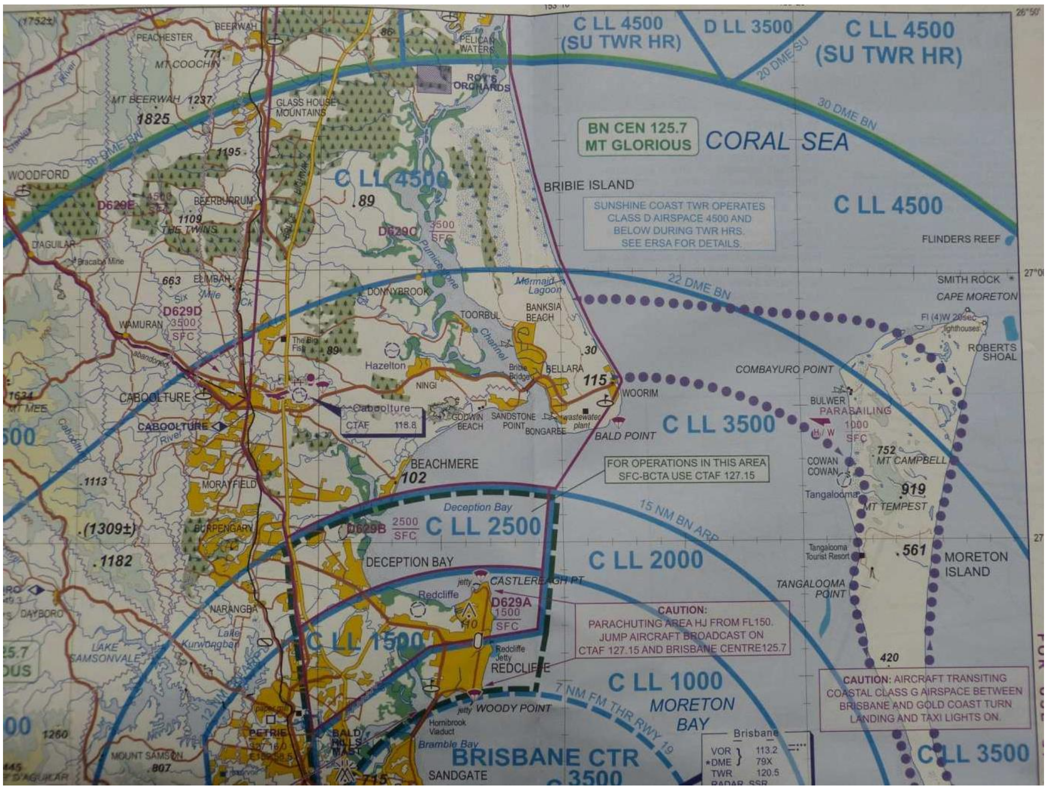


Fig. 12 A Visual Terminal Chart

The Visual Terminal Chart (**VTC)** is a Transverse Mercator projection. This type of chart is drawn with the meridians nearly parallel, but still converging towards the poles. The scale on a **VTC** is 1:250,000, so compared to a **WAC** of the same area, the section of the Earth depicted is only one-quarter of that shown on the WAC. As a result, there is much more detail shown on a VTC including controlled airspace boundaries and altitude limits; radio communication stations and frequencies; prohibited, restricted and danger areas; as well as other aids to visual navigation such as golf courses, mines/quarries, drive-in theatres and large shopping centres. Each type of chart has its own legend of aeronautical information and users should familiarise themselves with the symbology contained in these legends.

The disadvantage of the VTCs is that they are produced to cover only terminal areas, so their effective coverage Australia wide is very limited.

En Route Chart – Low (ERC-L)

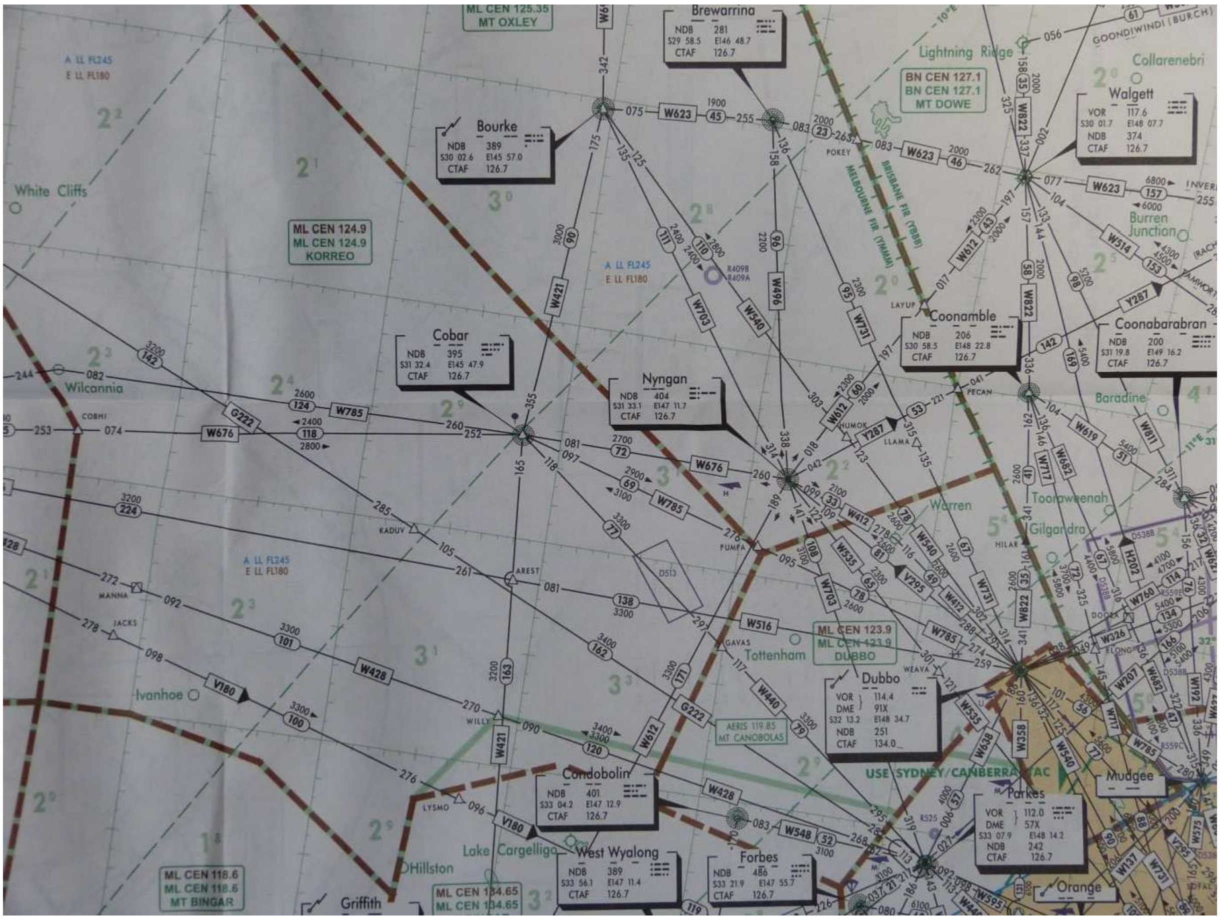


Fig. 13 An en route chart

The En Route Chart (**ERC-L)** is produced primarily for instrument flight rules (**IFR**) operations below 20,000 feet above mean sea level (AMSL). They are **Lambert Conformal Conic projections** presented at various scales and depicting airspace, air routes and radio navigation facilities. The presentation of airspace may have some application in visual navigation and if track bearings and distances are required from an ERC-L, the same procedure as for WACs should be used.

Where operations are conducted in areas that are not covered by **VTCs** or **VNCs**, the **ERC-L** may be used to locate prohibited, restricted and danger areas which may be encountered.

Planning Chart Australia (PCA)

Fig. 14 A section of Planning Chart Australia

As per the name Planning Chart Australia, this chart is used primarily for planning purposes and contains details of area forecast regions, WAC coverage, location names and abbreviations and estimated flight information service (FIS) ground station coverage at 5,000 ft and 10,000 ft AMSL.

Visual Navigation Chart (VNC)

Fig. 15 A section of a Visual Navigation Chart

As with a **WAC**, a Visual Navigation Chart (**VNC)** is a **Lambert Conformal Conic projection** and track and distance measurement techniques are the same as with a **WAC**.

The scale in a **VNC** is 1:500,000, meaning that it contains more detail than a **WAC**, but not as much as a **VTC**. It covers a much larger area than a **VTC**, but coverage is limited to the more populous coastal areas and the adjacent inland areas. This is a more practical chart for microlight navigation as it contains more detail than a **WAC**, covers a greater area than a **VTC** and the scale is more suited to the cruise speeds of microlights. It is however, a much larger chart physically than a **WAC** and will required careful folding or cutting to produce a chart size suited to the limited cockpit space in most microlights.

All the charts detailed above may be purchased online from the Airservices Australia website at www.airservicesaustralia.com/store/

Flight planning

Flight planning is a procedure that must be used on all cross-country flights. Whilst short flights over familiar terrain may not require the same planning input as long flights, a plan must be formulated for every cross-country flight.

Planning involves acquiring the appropriate charts that will cover the proposed flight route, choosing the most appropriate route taking into account no-fly areas, unfavourable terrain and possible alternative airstrips enroute. Weather forecasts and Notices to Airmen (NOTAMs) must also be consulted and depending on the time of day of the planned flight, darkness prediction charts may need to be consulted.

Daylight and darkness

"Night" is the period between the end of evening civil twilight and the beginning of morning civil twilight**. First light should be construed as the beginning of morning civil twilight and last light as the end of evening civil twilight**. The terms "sunrise" and "sunset" have no relevance when calculating daylight operating times.

Pilots of VFR flights must not start operations before first light and must plan to arrive at their destination at least 10 minutes before last light. A means of determining first and last light for pilots is provided from more than one source. The easiest and most accurate method is online from Airservices Australia's NAIPS service at www.airservicesaustralia.com/naips/. After registering (at no cost), locate the First Light- Last Light link and click on it. Enter the information requested and first and last light will be displayed in UTC. Convert to local time if required. These times are available upon request from FLIGHTWATCH via the area frequency for the local area and also from the AIP Australia and ERSA. The AIP and ERSA use graphs and tables to determine first and last light via a rather complicated process that requires practice to master. Below is an example of the graphs used. Instruction on using these graphs and tables is provided and must be referred to in order to ensure an accurate result.

The times obtained from any source do not include allowances for the nature of the terrain surrounding a location, or the presence of other than a cloudless sky and unlimited visibility at that location. The presence of cloud cover, poor visibility or high terrain to the west of an aerodrome will cause daylight to end at a time earlier than that obtained and allowance must be made for these factors when planning a flight.

Online resources exist for determining the calculated morning civil twilight (first light) and evening civil twilight (last light) eg : -

https://Suncalc.net

https://sunrisesunset.willyweather.com.au/

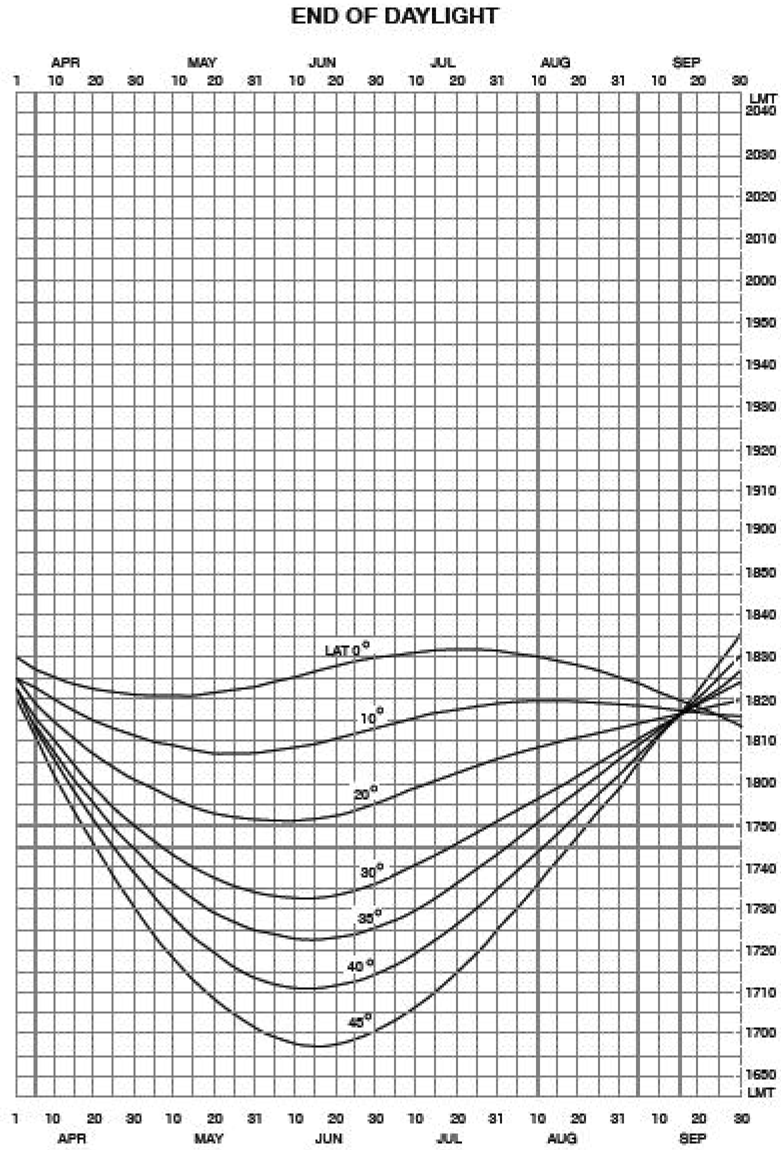


Fig 16. End of Daylight Chart

Planning should also include the completion of a flight plan form (Fig. 16) and/or other documentation that can be used in flight to assist with navigation and the checking of flight progress.

Flight plan form

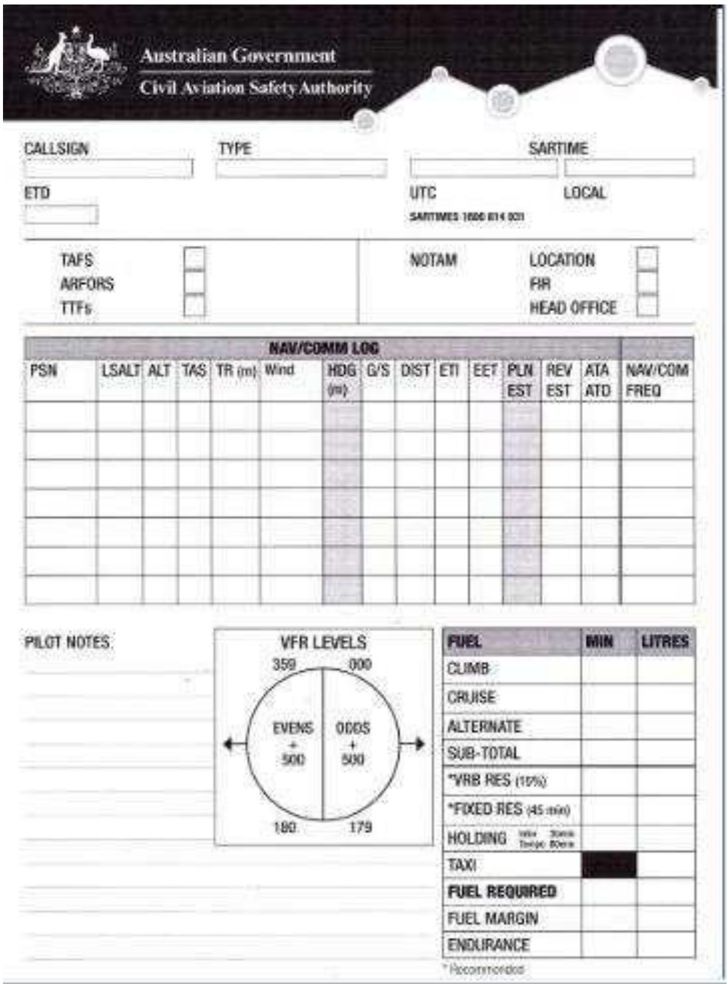


Fig. 17 A flight plan form

Following is an explanation of the fields and abbreviations used on the flight plan form:

Callsign: the registration numbers of the microlight.

Type: microlight.

SARTIME: a time nominated by the pilot to an air traffic flight service unit, before which the pilot expects to arrive at his destination. If the nominated **SARTIME** passes and the pilot has not contacted the flight service unit, search and rescue procedures will be instigated. Whilst it is not mandatory for microlights to use the **SARWATCH** service, it is strongly recommended. An alternative is to use a responsible person as a SARWATCH time keeper.

UTC/Local: the datum for the **SARTIME**. All aviation times are expressed in terms of **Universal Coordinated Time (UTC)** and this datum should be used at all times.

ETD: estimated time of departure.

The next section on the form is a checklist to ensure that all the pertinent information has been received prior to departure.

TAF: **terminal aerodrome forecast(s)** – a weather forecast specific for a particular aerodrome and the area within 5 miles of the aerodrome. Wind direction in a **TAF** is expressed in degrees **true** and cloud heights are above **airfield elevation**.

ARFOR: **area forecast** – the forecast weather for a specific area. The areas covered by these forecasts are depicted on the **PCA**. Wind direction in an **ARFOR** is expressed in degrees **true**

and cloud heights are **above mean sea level (AMSL)**.

TTF: **trend type forecast** – a **TAF** that has a trend attached to it (e.g. From 0230, wind ....), this type of forecast is normally issued for controlled aerodromes.

NOTAM: **Notice to Airmen** – notices available pre-flight to advise of certain conditions that may affect the safety of a flight into a specific area. **NOTAMs** can cover a specific **location** and may advise of runway closures or other such restrictions; or a **flight information region (FIR)** where certain airspace restrictions may be in force; or **head office** which would publish information regarding temporary or permanent amendments to publications, rules and regulations. **NOTAMs** are available from Airservices Australia via the internet. Please see "Aviation Weather Forecast and NOTAMs" below for details.

NAV/COMM: **navigation and communications**. This section is used to record planned information and also to record certain aspects of flight progress.

PSN: position

LSALT: lowest safe altitude. This is used for IFR operations and has no function in visual navigation.

ALT: altitude. The altitudes above 5,000 ft AMSL to be planned and flown must comply with the VFR LEVELS diagram in the lower centre of the form, provided that flight in VMC is possible at the chosen level and VHF radio is carried and used. It is strongly recommended that all cruise altitudes comply with these rules provided that VMC can be maintained and radio communications are in accordance with the requirements.

TAS: true air speed. TAS is usually obtained by applying a correction for altitude and temperature to the indicated airspeed (IAS) read directly from the ASI. However, the speed and altitudes at which microlights operate are such that for practical purposes, the TAS is approximately the same as IAS.

TR (m): track magnetic

Wind: wind velocity in degrees **magnetic** and speed in **knots**. (1 knot means 1 nautical mile per hour).

HDG(m): heading magnetic. Note that this column is greyed. This is to provide a quick reference to this column that contains information that will most likely be regularly accessed in flight.

G/S: ground speed

DIST: distance

ETI: estimated time interval

EET: estimated elapsed time

PLN EST: planned estimated time of arrival

REV EST: revised estimated time of arrival

ATA ATD: actual time of arrival or actual time of departure

NAV/COM FREQ: navigation or communication frequency to be used.

PILOT NOTES: notes that the pilot makes to assist him with the flight. This would be the appropriate area to record the frequency of the flight service unit with which the pilot would communicate for

SARTIME purposes and in an emergency. The frequencies are printed on ERC-L, VTC and VNC together with the call sign of the ground station.

FUEL: This section is used to calculate how much fuel is required for the proposed flight plus a margin or reserve, and how much extra fuel is likely to be left at the completion of the flight. The "Climb" and "Cruise" rows will most likely be combined due to the relatively short climb segment compared to the cruise portion. Alternate fuel may or may not be carried depending on the forecast for the planned destination. If the destination aerodrome is forecast to be below VMC at the planned arrival time, then alternate fuel must be carried. If a forecast is not available for the destination aerodrome at the planned arrival time, alternate fuel must be carried. In both cases, the alternate aerodrome must be forecast to be at or above VMC for the planned arrival time.
Microlights are not required to carry a variable reserve and the normal recommended fixed reserve is 30 minutes at normal cruise consumption. Taxi fuel is usually not a factor. The FUEL REQUIRED then is the sum of the fuel to destination plus fuel to alternate plus fixed reserve. Endurance refers to the total usable fuel on board at the time of departure and the FUEL MARGIN is the difference between fuel required and endurance.

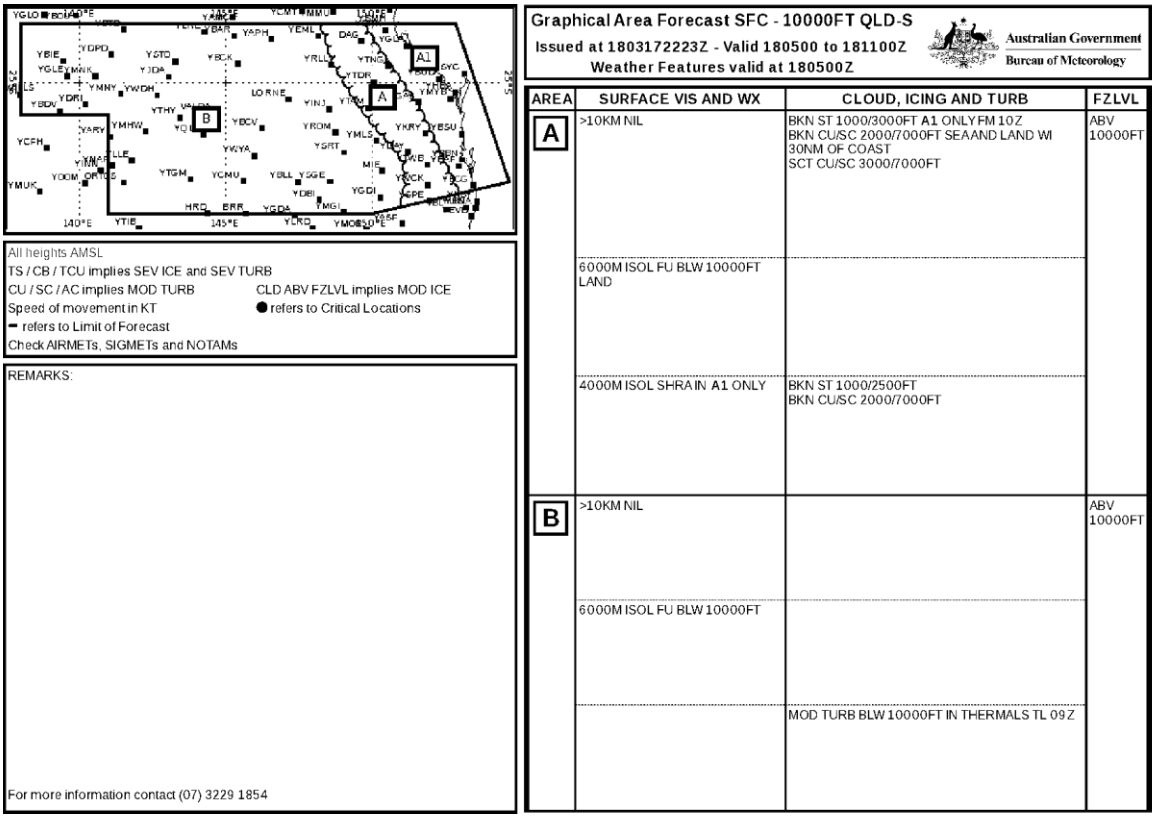
In order to complete a flight plan form such as the one above, certain resources need to be referenced to obtain the necessary information.

The method for obtaining the magnetic track and distance between two points on aeronautical charts was covered earlier in this manual, so the track and distances columns can be completed. From the same aeronautical charts, an appreciation of the elevation of the terrain beneath and close to the proposed flight path can be obtained and a suitable cruise altitude selected according to the VFR levels diagram on the flight plan form. Although the VFR levels diagram is only mandatory above 5000' AMSL, ASRA strongly recommends that the diagram be used for all altitude selections. It remains then to obtain a wind that will affect the microlight in flight and use that to calculate: (i) an appropriate heading to fly to follow the desired track, and (ii) a groundspeed to calculate how much time the flight will take and how much fuel will be needed. The wind and other information can be obtained from an aviation weather forecast.

Aviation weather forecast and NOTAMs

An aviation weather forecast can be obtained from Airservices Australia via the link: https://www.airservicesaustralia.com/naips/Account/Logon. You need to register to use this service but there are no charges involved. Once logged in, the HOME page provides access to location and area briefings including weather forecasts and NOTAM services. Some time may be necessary for the user to become familiar with the information available from this source and how to navigate to it.

The following information was downloaded from the above site for Area 40 which was selected from an interactive screen. It is an actual ARFOR valid for the times specified. The graphical nature of the forecast charts allow the selected area to be further divided, thus providing a more accurate forecast for the total area.



Graphical Area Forecast SFC - 10000FT QLD-S

Issued at 1803172223Z - Valid 180500 to 181100Z

Weather Features valid at 180500Z

Australian Government

Bureau of Meteorology

AREA	SURFACE VIS AND WX	CLOUD, ICING AND TURB	FZLVL
A	>10KM NIL	BKN ST 1000/3000FT A1 ONLY FM 10Z BKN CU/SC 2000/7000FT SEA AND LAND WI 30NM OF COAST SCT CU/SC 3000/7000FT	ABV 10000FT
	6000M ISOL FU BLW 10000FT LAND		
	4000M ISOL SHRA IN A1 ONLY	BKN ST 1000/2500FT BKN CU/SC 2000/7000FT	
B	>10KM NIL		ABV 10000FT
	6000M ISOL FU BLW 10000FT		
		MOD TURB BLW 10000FT IN THERMALS TL 09Z	

All heights AMSL

TS / CB / TCU implies SEV ICE and SEV TURB

CU / SC / AC implies MOD TURB

CLD ABV FZLVL implies MOD ICE

Speed of movement in KT

● refers to Critical Locations

━ refers to Limit of Forecast

Check AIRMETs, SIGMETs and NOTAMs

REMARKS:

For more information contact (07) 3229 1854

Fig 18. Grid Area Forecast (GAF) An

explanation of each section of the grid follows.

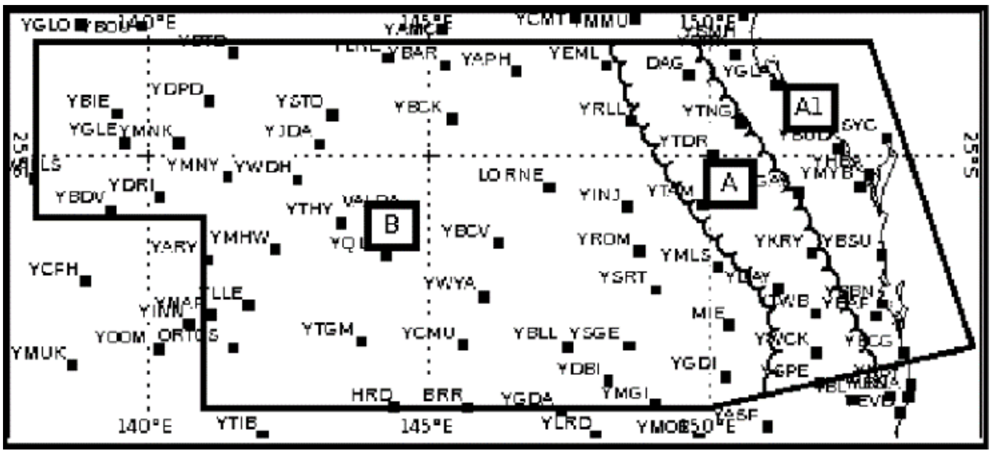


Fig 19. GAF Sub-sections

This section shows that area 40 has been further divided into three subsections, forecast conditions for which are explained in the right hand boxes shown in Fig 18 above.

Fig 20. Validity Information

Note that the forecast is valid for altitudes between the surface and 10,000 feet AMSL.

1803172223Z means that the above forecast was issued at 2223 on the 17th of March, 2018 UTC.

Valid 180500 to 181100 Z means it is valid from 0500 on March 18th until 1400 on March 18th UTC.

Note. Because within a forecast the coverage period commences at the time indicated and is valid for the next 3 hours. Hence the appearance of 1400 in the above explanation.

Weather Features valid at 180500 Z means that any weather features such as dust, mist, smoke etc are valid from 0500 on March 18th UTC. A full decode of Weather Features are available in AIP GEN 3.5 – 36 para.13.

NOTE: Abbreviations for cloud coverage in the following Figure are as follows: SKC =

Sky Clear = nil cloud

FEW = Few = 1 to 2 OKTAS

SCT = Scattered = 3 to 4 OKTAS BKN =

Broken = 5 to 7 OKTAS

OVC = Overcast = 8 OKTAS

AREA	SURFACE VIS AND WX	CLOUD, ICING AND TURB	FZLVL
A	>10KM NIL	BKN ST 1000/3000FT **A1** ONLY FM 10Z BKN CU/SC 2000/7000FT SEA AND LAND WI 30NM OF COAST SCT CU/SC 3000/7000FT	ABV 10000FT
	6000M ISOL FU BLW 10000FT LAND		
	4000M ISOL SHRA IN **A1** ONLY	BKN ST 1000/2500FT BKN CU/SC 2000/7000FT	

Fig 21. Visibility, cloud Forecast

The boxed **A** refers to the whole of subsection A shown in Fig.18 with sub-subsection A1 referred to in the text. Note that the centre vertical boxes are divided into 3 horizontal boxes. Each horizontal box forecasts the weather for each 3 hours of the period, starting at 0500.

>10KM NIL means visibility in excess of 10 kilometres and nil or no significant weather.

BKN ST 1000/3000FT A1 ONLY FM 10Z BKN CU/SC 2000/7000FT SEA AND LAND

WI 30NM OF COAST SCT CU/SC 3000/7000FT means broken stratus cloud, base 1000 feet AMSL, tops 3000 feet AMSL. In area A1 only, from 1000 UTC, broken cumulus and stratocumulus base 2000 feet AMSL, tops 7000 feet AMSL over the sea and land within 30 nautical miles of the coast, scattered cumulus and stratocumulus base 3000 feet AMSL, tops 7000 feet AMSL.

ABV 10000FT means that the freezing level is above 10,000 feet AMSL.

6000M ISOL FU BLW 10000 LAND means visibility in some isolated areas is reduced to 6,000 metres in smoke below 10,000 feet AMSL over land.

4000M ISOL SHRA IN A1 ONLY means that the visibility will be reduced to 4,000 metres in isolated showers of rain in sub-subarea A1 only.

BKN ST 1000/2500FT BKN CU/SC 2000/7000FT means broken stratus base 1,000 feet AMSL, tops 2,500 feet AMSL and broken cumulus and stratocumulus base 2,000 feet AMSL, tops 7,000 feet AMSL.

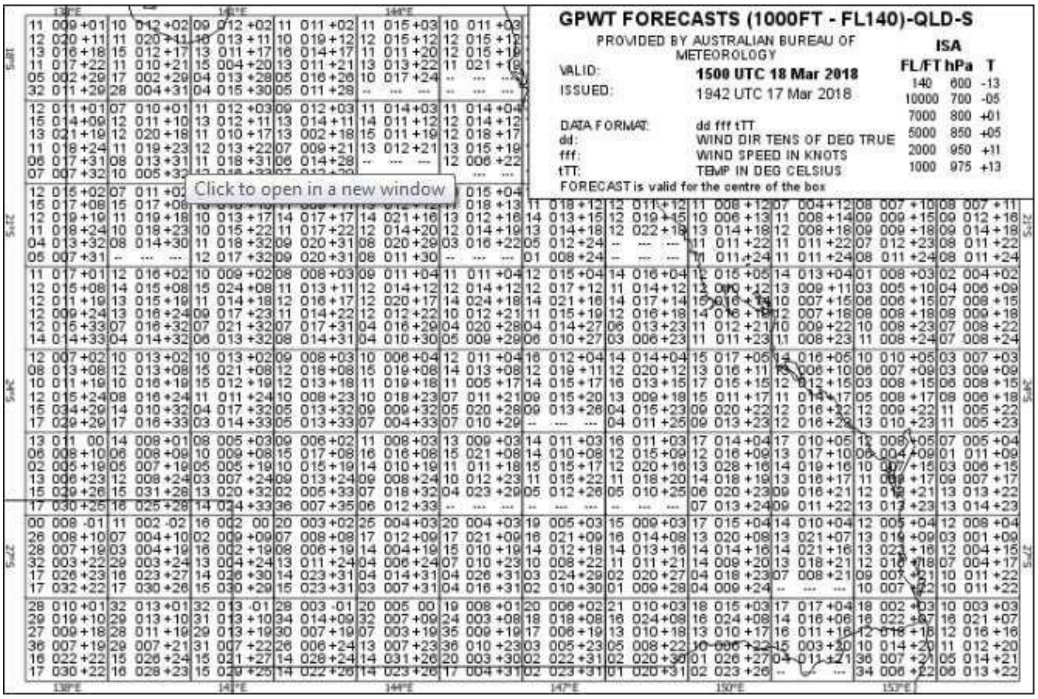


Fig 22. Grid Point Wind and Temperature Forecast Chart (GPWT)

Wind and temperature forecasts are presented in a graphical format as shown in Fig 22. Each square represents 5* of latitude and longitude. The forecast is valid for the centre of each individual square but may be considered accurate for the whole of that square.

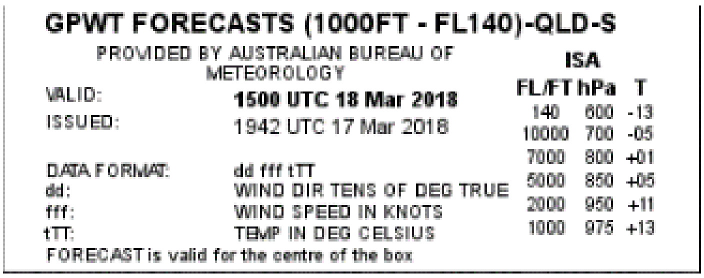
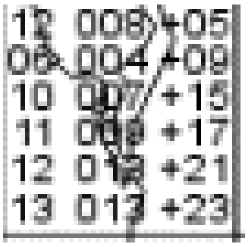


Fig 23. Header Box

The title indicates that the forecast is provided for levels from 1,000 feet AMSL up to Flight Level 140 which is 14,000 feet above the standard sea level pressure of 1013 millibars. Note. Flight Levels in Australia must be used from FL 110 upwards.

The remainder of the header box is self-explanatory. The ISA figures to the right are the standard temperatures and pressures at each level indicated. This is primarily used as a quick reference, mainly for standard temperatures, for aircraft that use an ISA deviation for performance calculations. It is not commonly used in microlight operations.



12	008	+05
06	004	+09
10	007	+15
11	008	+17
12	012	+21
13	013	+23

Fig 24. GPWT Square

This randomly selected square shows the wind direction and speed together with the temperature at the levels described in the header box. Considering the 1,000 feet AMSL line note that the wind direction is 130* TRUE and the speed is 13 knots. The temperature is expected to be plus 23* Celsius which, when compared with the ISA table in the header box is ISA + 10.

A complete list of meteorological abbreviations can be found in the Aeronautical Information Package Australia (AIP) which is accessed through the Airservices website at: http://www.airservicesaustralia.com/publications/ Navigate to GEN 3.5 – 1, Meteorological Services.

NOTAMS

The following are examples of NOTAMs that were downloaded from the Airservices Australia NAIPS website. They are actual NOTAMs that are or were valid during the times indicated.

UNMANNED ACFT OPS FM CALOUNDRA AD (YCDR) WI
2.5NM RADIUS OF PSN S26 48.2 E153 06.3 DURING VMC
CONDITIONS ONLY
SFC TO 400FT AGL
FROM 12 082200 TO 02 090600 HJ

UNMANNED ACFT OPS FM CALOUNDRA AD (YCDR) means unmanned Aircraft Operations from Caloundra Aerodrome (YCDR). YCDR is the ICAO code for this aerodrome.

WI 2.5NM RADIUS OF PSN S26 48.2 E153 06.3 means within a 2.5 nautical mile radius of the position indicated.

DURING VMC CONDITIONS ONLY means during visual meteorological conditions only.

SFC TO 400FT AGL means from ground level to 400' above ground level.

FROM 12 082200 TO 02 090600 means from December 8th at 2200 UTC (0800 local time) until February 9th at 0600 UTC (1600 local time).

HJ means during daylight hours.

The following for Goondiwindi (YGDI) actually contains two NOTAMs, the first numbered C31/14 and the second numbered C38/14.

GOONDIWINDI (YGDI)
C31/14 REVIEW C30/14
KANGAROO HAZARD EXISTS (ALL MOV AREAS) FROM
09 240156 TO 12 220200 EST

KANGAROO HAZARD EXISTS (ALL MOV AREAS) means kangaroo hazard exists on all the movement areas of the aerodrome.

FROM 09 240156 TO 12 220200 EST means from 24th September at 0156 eastern standard time until 22nd December at 0200 eastern standard time.

C38/14

RWY 12/30 AND ALL UNSEALED AREAS NOT AVBL DUE SOFT WET SFC FROM 12 082151 TO 12 110500 EST

Self explanatory with SFC meaning surface. Times are month, date and time in Eastern Standard Time.

When requesting and downloading NOTAMs, be sure to tick the box for “Head Office”, as this will ensure that temporary airspace restrictions and prohibited, restricted and danger area information will be provided.

Prohibited, restricted and danger areas

Airspace in which a potential hazard to aircraft operations may exist and all areas over which the operation of civil aircraft may be restricted are promulgated as follows:

Prohibited area refers to airspace within which flight of aircraft is prohibited.

Restricted area refers to airspace within which the flight of aircraft is restricted in accordance with specified conditions.

Danger area refers to airspace within which activities dangerous to the flight of aircraft may exist at specified times.

These areas are shown on aeronautical charts by boundaries outlined in magenta and containing the identification of the area as a letter and a number. The letters allocated are P for a prohibited area, R for a restricted area and D for a danger area. Collectively, these areas are known as PRD areas. Unless otherwise specified, vertical limits are promulgated as AMSL. The abbreviation “SFC” means the surface of the ground or water. “NOTAM” indicates that the vertical limits or hours of activation will be notified by NOTAM.

Flight within a prohibited area is not permitted in any circumstances.

Flight within a restricted area is subject to the conditions published in ERSA and NOTAM. When active, restricted airspace must be considered to be controlled airspace.

For **hang glider / Paraglider operations** under CAO 95.8 -

[para 7.6] An aircraft to which this Order applies may be flown in Class C or Class D airspace if the pilot:

(a) holds a pilot licence issued under Part 61 of CASR 1998 with an aeroplane category rating that allows the holder to fly in that airspace; and

(b) has a valid flight review for the class rating in accordance with Part 61 of CASR 1998.

For microlight operations under CAO 95.32 –

[Para 7.3] An aeroplane may be flown inside Class A, B, C or D airspace only if all of the following conditions are complied with:

(a) the aeroplane is certificated to the design standards specified in regulation 21.186 of CASR 1998 or is approved under regulation 262AP of CAR 1988 in regard to flights over closely-settled areas;

(b) the aeroplane is fitted with an engine of a kind to which paragraph 6.1 of Civil Aviation Order 101.55 applies, or that CASA has approved as being suitable for use in an aircraft to which this Order applies, and is not subject to any conditions that would prevent the flight;

(c) the aeroplane is fitted with a radio capable of two-way communication with air traffic control;

(d) the aeroplane is flown by the holder of a pilot licence with an aeroplane category rating:

(i) issued under Part 61 of CASR 1998; and

(ii) that allows the holder to fly inside the controlled airspace;

(e) the pilot has a valid flight review for the class rating in accordance with Part 61 of CASR 1998;

(f) if the controlled airspace in which the aeroplane is operating requires a transponder to be fitted — the aeroplane is fitted with a transponder suitable for use in the airspace.

Note Operations in Class A airspace in V.F.R. are only possible in accordance with a permission issued by CASA under regulation 99AA of CAR 1988.

Access to a restricted area may be available if the activity for which it has been activated has ceased (early deactivation). It is a pilot's responsibility to check the current status with Air Traffic Services.
Approval for a flight within an active danger area outside controlled airspace is not required, however it is the responsibility of the pilot in command to be aware of the dangerous activity and take appropriate precautions. PRD areas may be activated or deactivated at short notice.

Controlled airspace

Whilst some microlights are approved for and some pilots are qualified for operations within controlled airspace, as a general rule, **microlights, paragliders and hang gliders may only operate in uncontrolled Class G airspace. Operations in Class E airspace are possible provided that certain equipment is fitted to the aircraft. Controlled areas A,B,C and D must be avoided at all times and to ensure that this airspace is not infringed**.

Manual calculations

The text above has shown how to measure tracks and distances on aeronautical charts and how to obtain the winds and other information from an aviation weather forecast.
The following section will explain how this information is used in a practical navigation scenario.

Dead reckoning (manual) computers as well as electronic devices are available to simplify this planning task. However, it is necessary to understand the logic used by these devices in order to ensure that the results obtained are "reasonable". For example, if the wind is blowing from the right and ahead of the microlight in flight, the heading must be to the right of the track and the groundspeed must be less than the true airspeed.

The proposed flight is between Alpha and Bravo in a microlight that carries 60 litres of usable fuel and cruises at a true airspeed of 50 KTS with a fuel consumption of 20 litres per hour (l/hr).

From a WAC, the track is measured at 071 degrees true. Variation is 11 degrees east so the track is 060 degrees magnetic. Note that bearings are always expressed using three digits from 001 through to 360 around the compass rose. The forecast wind at the proposed cruising altitude of 3500 is 100/15. Recall that this is a true direction, so to use this practically it must be converted to a magnetic direction by applying the 11 degrees easterly variation. The wind to be used then is 089/15. With the above data, it is possible to calculate the heading required in flight to follow the measured track over the ground, together with the speed over the ground that the microlight will achieve (groundspeed). You need a blank sheet of paper, square protractor and a set of dividers or other distance measuring device.

In order to achieve accurate plotting, the protractor must be aligned with the same datum during all measurements (e.g. the edge of the sheet of paper or perhaps a vertical line representing magnetic north could be drawn).

Refer to Fig. 25. Aligning the protractor, mark and draw a line in the direction **from** which the forecast wind blows. Choosing a suitable scale (minute/mile scale on the WAC), mark off 15 along the wind line Fig. 25. A to B. From the **end** of the wind line B, draw another line in the **reciprocal** (opposite) direction of the measured track. In this case, the line will start at the end of the wind line B, and proceed in the direction of 240 degrees (Fig. 25).

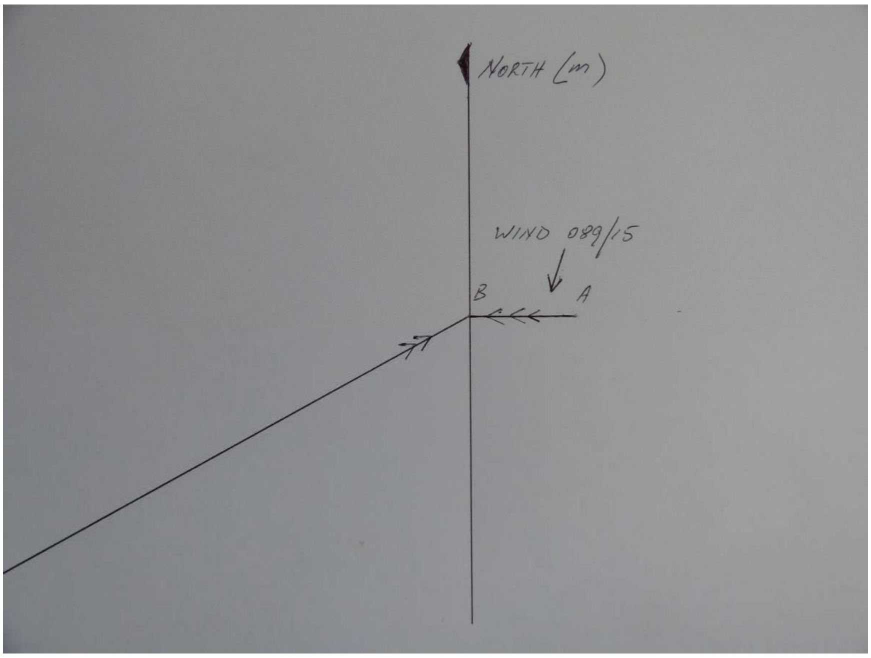


Fig. 25

Conventional symbols include one arrow head for heading, two for track and three for wind. Using the same scale as that used for the wind speed, take the dividers and span a distance equal to the **true airspeed** of the microlight, in this case 50 KTS. Place a divider tip on the **start** of the wind line A, and mark the track line with the other divider tip (Fig. 26).

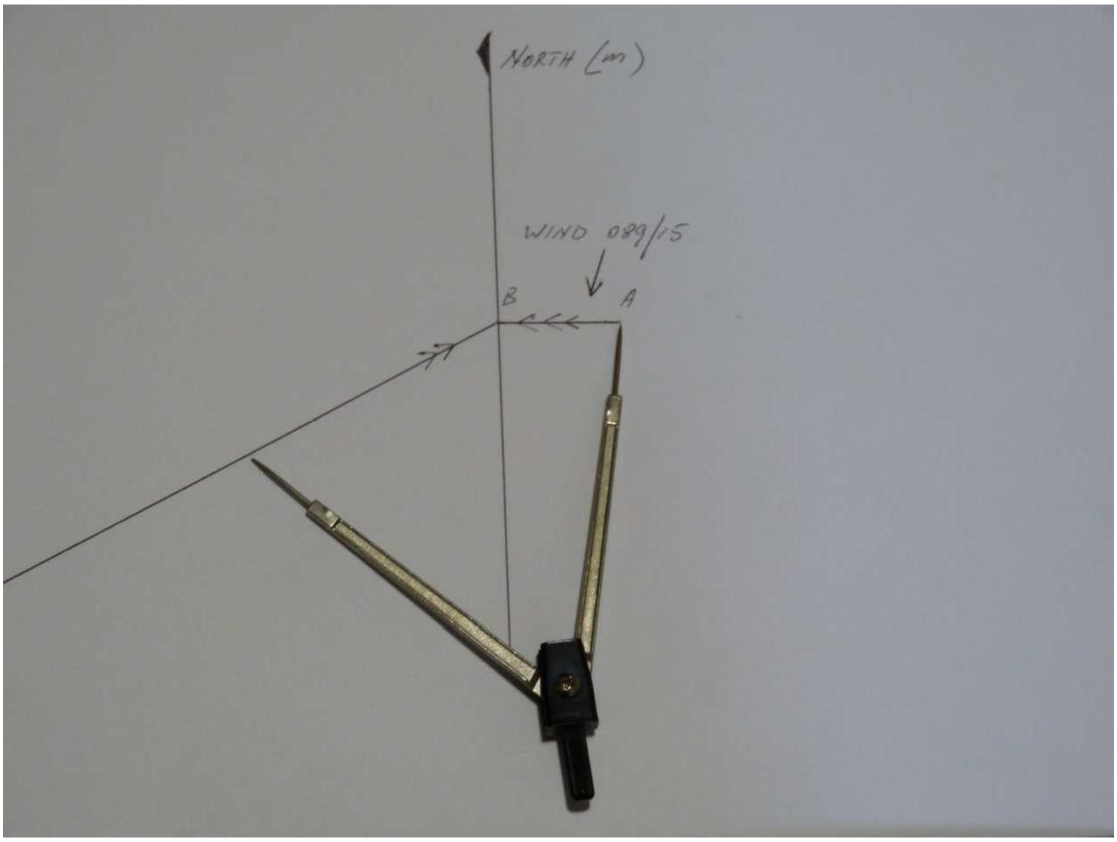


Fig. 26

By joining these two points, a triangle of velocities has been drawn to scale and the required practical information can now be obtained from this triangle (Fig. 27).

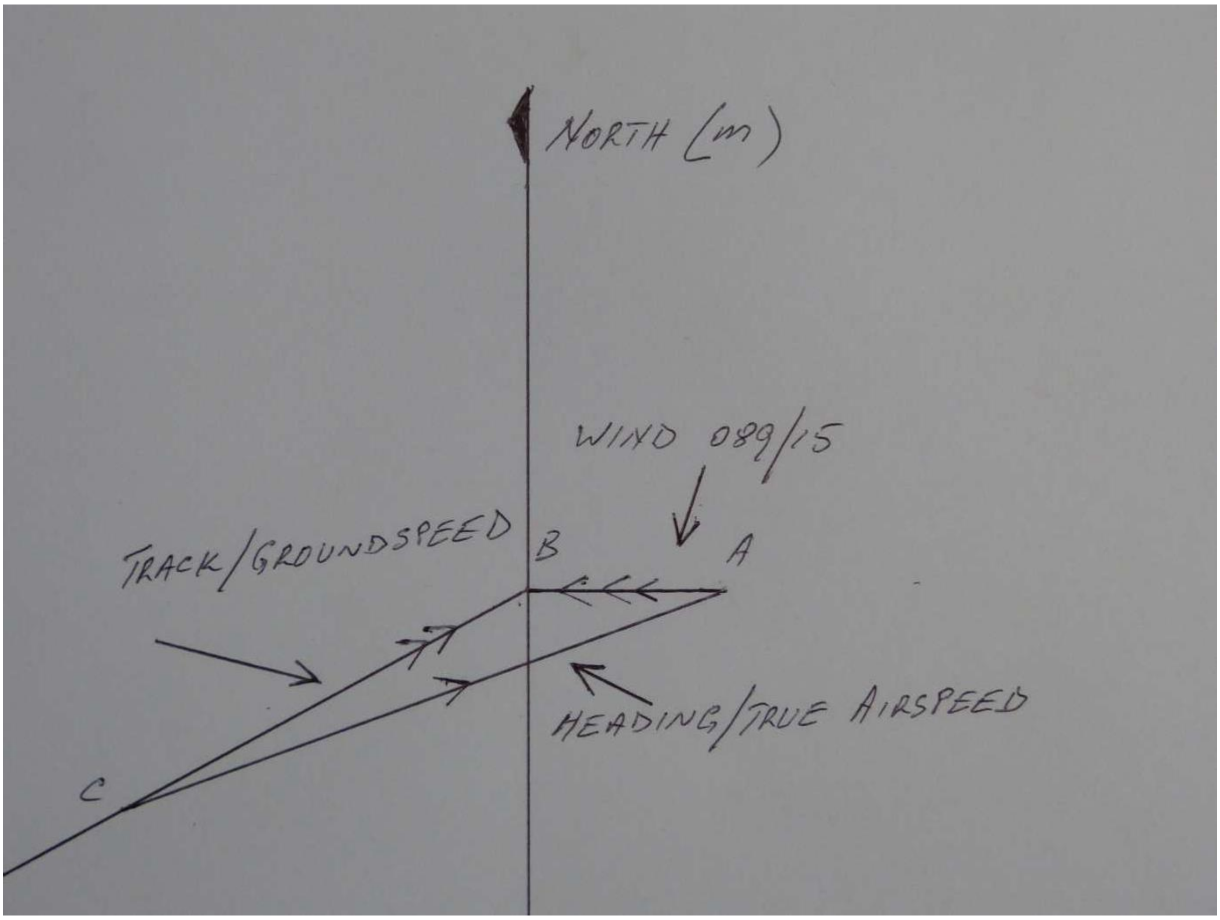


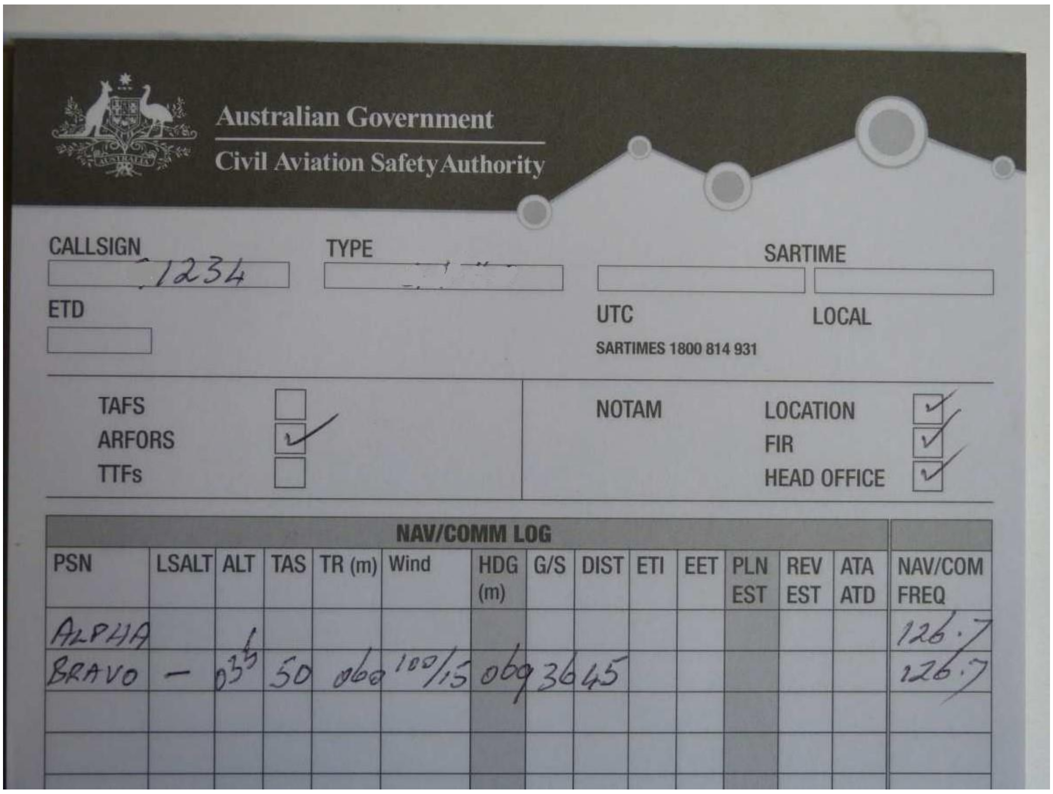
Fig. 27

The required heading to be flown can now be measured by placing the centre grommet of the protractor over the end of the heading line farthest from the wind line C, aligning it and reading off the heading against the outer scale on the protractor (in this case 069* m). Groundspeed is found by measuring the length of the track line using the same distance scale as that for the wind speed and true airspeed, B to C (36 KTS).

A logic check should now be carried out to determine if the answers found are reasonable. From the triangle of velocities, it can be seen that the wind is blowing from the right side and from the front of the microlight. Therefore in order to achieve the track line, the microlight must head to the right of the track line and the required heading must be to the right of the track. Track is 060* and heading is 069*, so the answer is reasonable. Similarly, the wind is coming from the front, so the groundspeed must be less that the true airspeed. True airspeed is 50 KTS and groundspeed is 36 KTS, so again, the answer is reasonable.

It can be appreciated that this method of calculating heading and groundspeed is laborious and tedious especially for multi-leg flights. Pilots wishing to use manual computers or electronic devices for this purpose must ensure that they are completely familiar with the equipment they intend to use and should apply the same logic test as that described in the previous paragraph to check the answers.

The information calculated above can now be transferred to the flight plan form and the final calculations completed (Fig. 28).


Australian Government
Civil Aviation Safety Authority

CALLSIGN 1234
TYPE
ETD
SARTIME
UTC
LOCAL
SARTIMES 1800 814 931

TAFS
ARFORS
TTFs

NOTAM
LOCATION
FIR
HEAD OFFICE

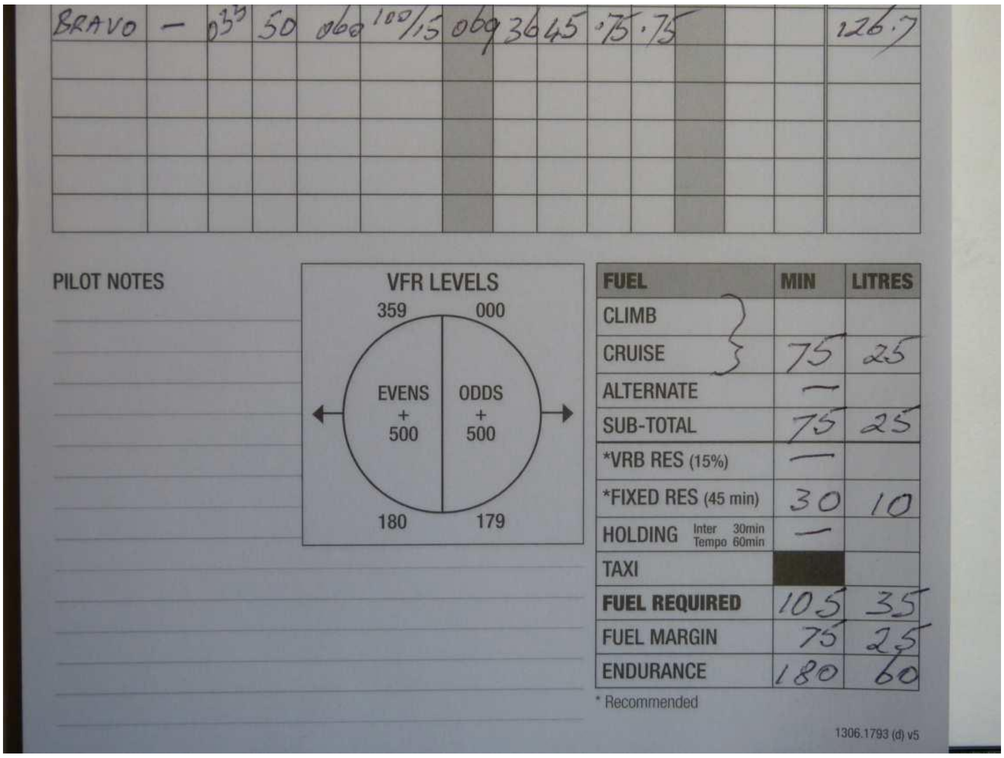
NAV/COMM LOG

PSN	LSALT	ALT	TAS	TR (m)	Wind	HDG (m)	G/S	DIST	ETI	EET	PLN EST	REV EST	ATA ATD	NAV/COM FREQ
ALPHA														126.7
BRAVO	—	035	50	060	100/15	069	36	45						126.7

Fig. 28 Calculations entered onto a flight plan

Note that the ETD and SARTIME fields are blank because that information is unknown at this time. It is most common to nominate a SARTIME to the responsible Flight Service Unit once airborne. SARTIME can be amended whilst in flight. As neither airstrip has a weather forecast service associated with it, no TAFs or TTFs were available. The estimated time interval for the flight has yet to be calculated and once that is known, the fuel plan can be completed as well.

The ground speed is expected to be 36 KTS and the distance to be flown is 45 NM. To find the time interval, take the distance to be flown and divide this by the ground speed planned (45/36). This gives flight duration in number of hours and fraction thereof. To obtain minutes, multiply the answer by 60 (45/36 = 1 ¼ x 60 = 75). Again, a logic check should be made. The groundspeed is less than the distance to be flown so it will take longer than one hour for the flight. The difference between the two is not that great, so the answer needs to be a bit more than one hour but not approaching two hours. In this case, 75 minutes is reasonable. This can now be used to complete the flight plan form (Fig. 29).



BRAVO	—	033	50	060	100/15	069	36	45	·75	·75				126.7

PILOT NOTES

VFR LEVELS

359 000

EVENS + 500

ODDS + 500

180 179

FUEL	MIN	LITRES
CLIMB		
CRUISE	75	25
ALTERNATE	—	
SUB-TOTAL	75	25
*VRB RES (15%)	—	
*FIXED RES (45 min)	30	10
HOLDING Inter 30min Tempo 60min	—	
TAXI		
FUEL REQUIRED	105	35
FUEL MARGIN	75	25
ENDURANCE	180	60

* Recommended

1306.1793 (d) v5

Fig. 29 Flight plan details

Basic navigation computer

Fig. 30 shows the side of the computer that is used to determine heading and ground speed having been given the track and forecast wind velocity.

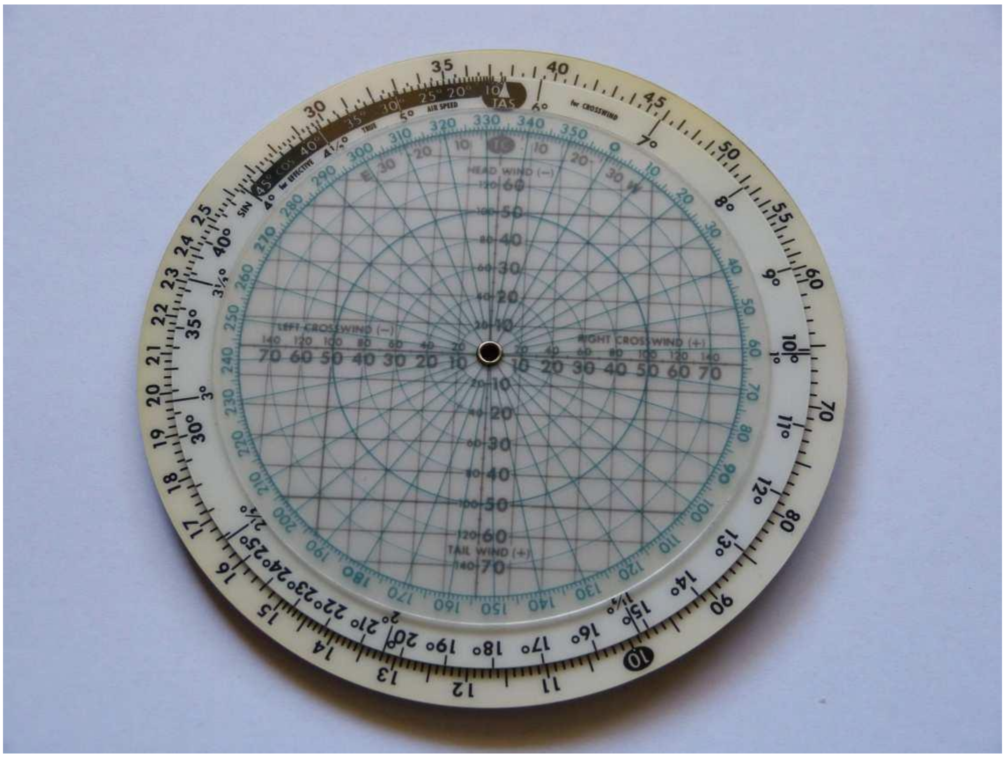


Fig. 30 The side of the computer used to determine heading and ground speed

This side of the computer and its functions will differ between brands and models of computer. It is the user's responsibility to study the documentation that accompanies the computer in order to become familiar with the techniques that are to be used to achieve the desired result.

Fig. 31 shows the slide rule side of the computer. This side is common to all computers and its use is the same in all cases.

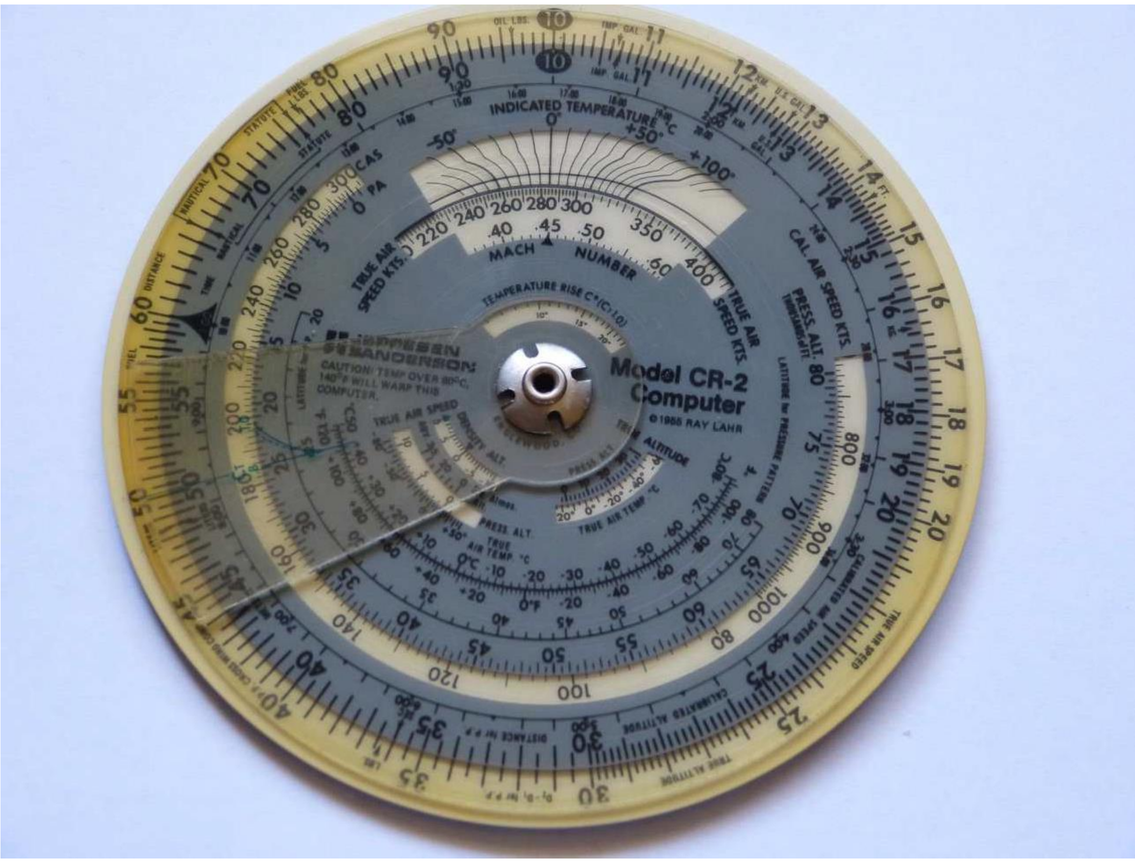


Fig. 31 Slide rule side of the computer

There are two discs that are marked with identical scales. In Fig. 31, the outer or fixed disc can be seen as the discoloured white outer scale, while the inner moveable disc and scale has a grey background. Also included is a clear, moveable plastic tab that contains a cursor line, marked on it in green in this case. There are many scales and functions associated with this side of the computer, however the outer two scales are the most commonly used for basic calculations. The primary use of these scales is to determine the time interval between points on a flight plan and to calculate fuel required for a particular flight. When used for these purposes, remember that the **inner** scale is always associated with time and the **outer** scale with distance or fuel. The scales are marked accordingly, adjacent to the 60 on the outer scale and 60 on the inner scale. On the inner scale, the 60 is replaced by an arrowhead. The following examples will help you understand how to use the slide rule.

Exercise (a). Our planned ground speed is 50 KTS and the distance between two waypoints is 37 NM, how long will it take to travel between these points? Remember that 50 KTS also means 50 NM per hour or 50 NM per 60 MIN.

Locate 50 on the outer distance scale and rotate the inner scale until the arrowhead (60) is below it. This represents a speed of 50 KTS. Now, adjacent to the distance between the two waypoints on the **outer** scale (say 37 NM) read off the time interval on the **inner** scale: 44 MIN (Fig. 32). Use the closest whole number of minutes. Fractions of minutes can be ignored.

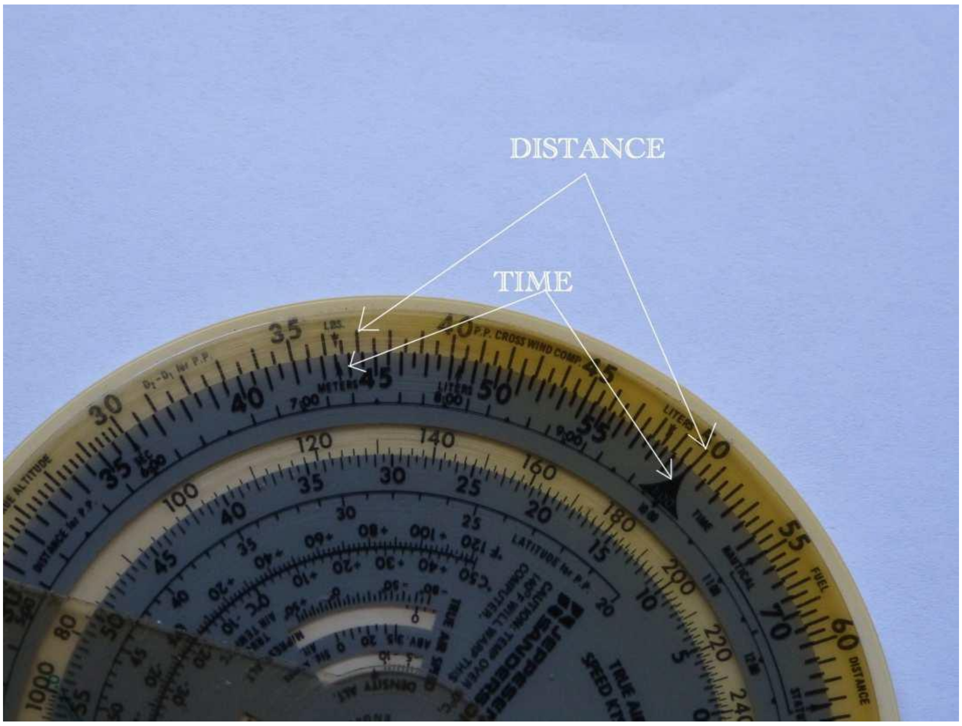


Fig. 32 Reading the slide rule (a)

Although we are using slow speeds in these exercises to reflect actual microlight performance, this exercise could have applied to a jet airliner except that the distance scale would be multiplied by 10 giving a ground speed of 500 KT, a distance between waypoints of 370 NM and a time interval of 44 MIN. Note also that it is **only** the **outer** scale that can multiplied or divided.

Exercise (b). Here's another exercise: ground speed 73 KT, distance 94NM, time interval 77 MIN or 1 hour and 17 MIN (Fig. 33).

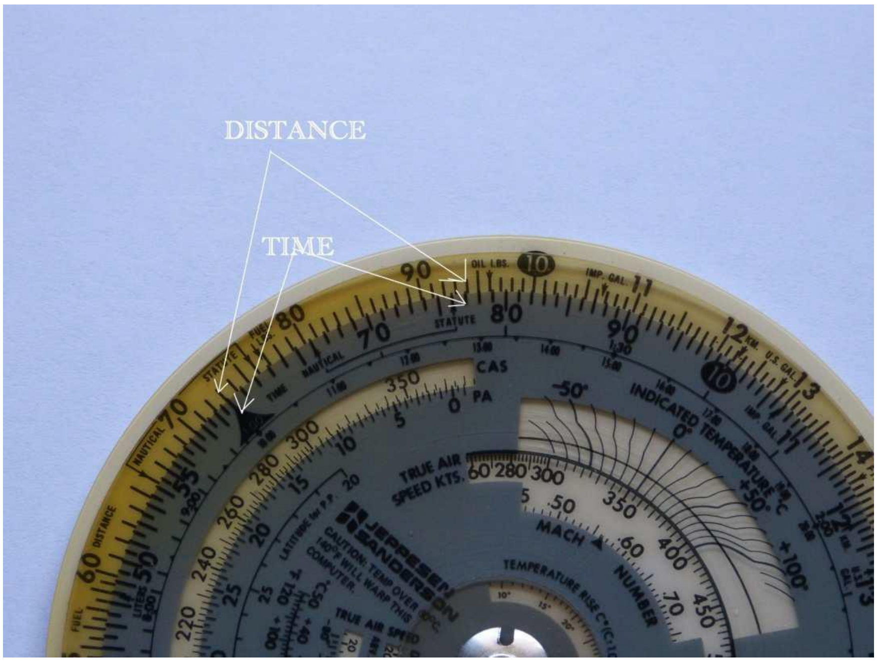


Fig. 33 Reading the slide rule (b)

Exercise (c). These scales can also be used to calculate ground speeds in flight. For example, two positive fixes were obtained enroute and the distance between the fixes was measured at 18 NM. The time interval between the fixes was 20 MIN. What is the ground speed? We use the same variables on the same scales, that is, distance on the outer and time on the inner. So, against the distance of 18 NM on the outer, we place the time of 20 MIN. Now, on the inner scale, locate the 60 MIN marker (arrowhead) and against it on the outer scale, read the ground speed, 54 KTS (Fig. 34).

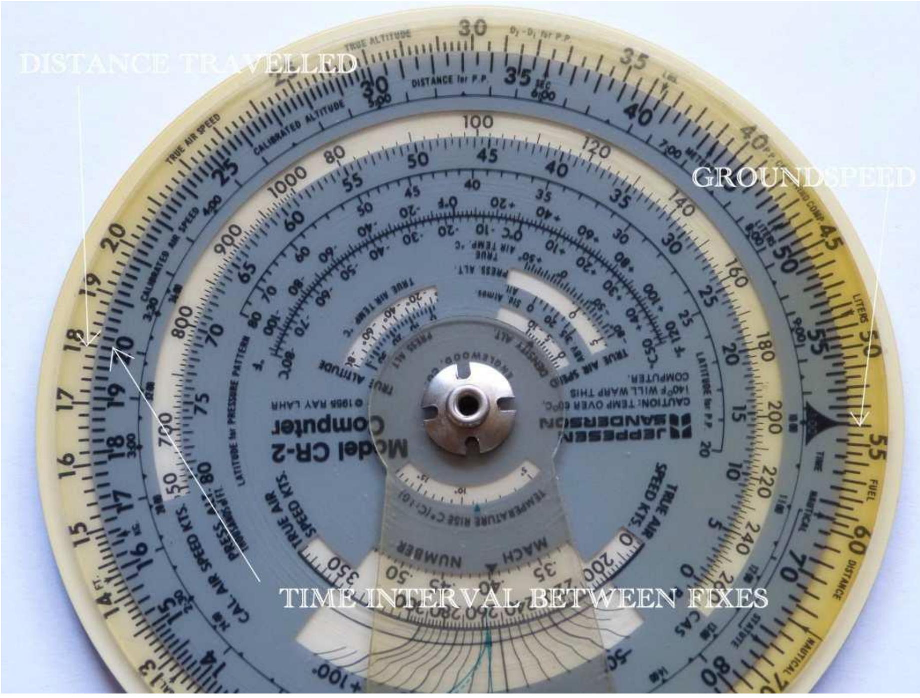


Fig. 34 Using the slide rule to calculate ground speeds

Fuel consumption and endurance are calculated in the same way except fuel replaces distance as the unit on the outer scale. Try this example: Fuel consumption is 18 litres per hour, (setup 18 on the outer over the 60 arrowhead on the inner), usable fuel on board is 40 litres, (against 40 on the outer, read off the endurance in minutes on the inner), endurance is 133 minutes or 2 hours and 13 minutes. Note: when transmitting fuel figures to Air Traffic Services, always use minutes and not hours and minutes.

Example: Fuel consumption is 23 litres per hour and the planned flight time is 1 hour and 19 minutes. How much flight fuel is required? Set up 23 on the outer over the 60 arrowhead on the inner. Against 1 hour and 19 minutes (79 minutes, remember always use minutes only on the inner scale) on the inner scale, read off the flight fuel required on the outer scale: 31 litres. In this case, the answer is rounded up to the nearest whole litre. Rounding down would mean that the calculated flight fuel is less than the actual would be, so for all fuel quantity calculations, round up to the nearest whole number.

As with all calculations, be they by manual, computer or electronic means, a logic test should be applied to the answer to check that it is reasonable in the circumstances. For example, if the ground speed is 50 KTS and the distance to travel is 40 NM, then the time interval must be less than 60 MIN but more than 30 MIN. This is because 40 is less than 50 which would take 60 MIN and more than 25 NM which would take 30 MIN. Now, 40 is closer to 50 than it is to 25, so an answer of 48 MIN would be reasonable.

Another useful tool incorporated into this side of the computer is a series of conversions. Obtaining the equivalent of litres in imperial or US gallons, for example, is a simple one- step process. Similarly, nautical miles to statute miles to kilometres.

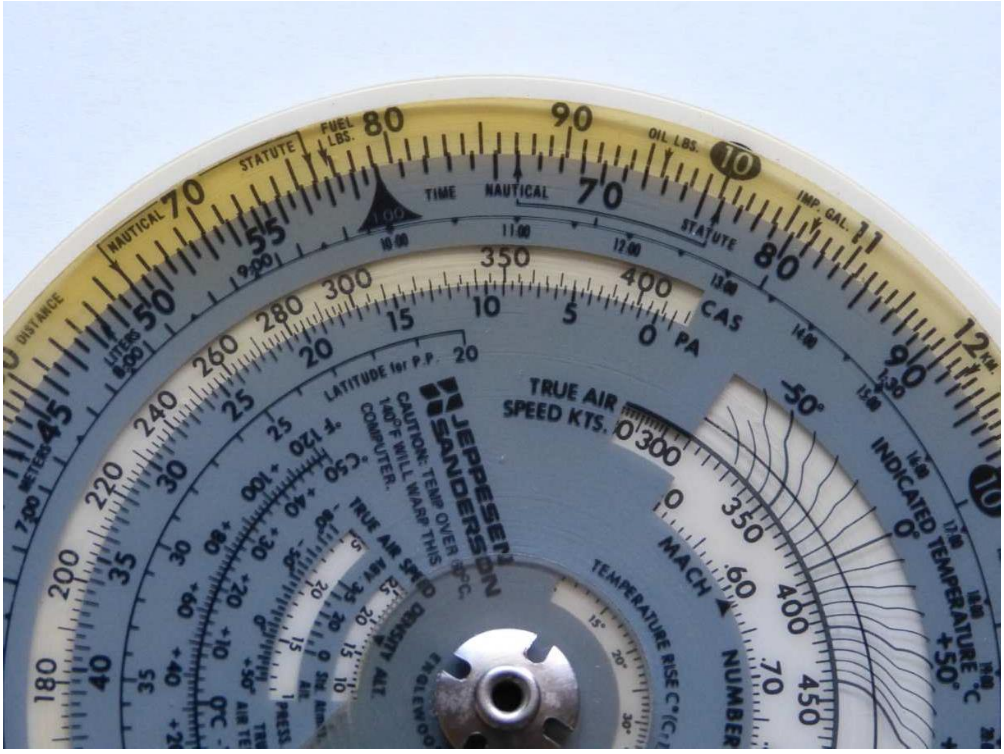


Fig. 35 Using the slide rule for unit conversions

Refer to Fig. 35 above. Against 66 on the outer scale is a small arrow with the word NAUTICAL printed to its right. Against 76 on the outer scale is another arrow with the word STATUTE above it to the left. Against 122.2 on the outer scale is another arrow with the abbreviation KM. on top of it. These represent conversion factors and by placing the value to be converted against the appropriate arrow, the corresponding conversions are read against the other arrows. For example, in Fig. 35, 50 on the inner scale is against the NAUTICAL arrow so we are converting 50 NM to statute miles and also kilometres. The corresponding values are read on the inner scale against the appropriate arrows and in this case result in 50 NM equals 57.5 statute miles and 92.5 kilometres.

Many other functions are available on this side of the computer, many of which are not applicable to microlight navigation. The user should consult the user guides provided with the computer to ascertain if any of these functions are usable.

Other planning resources

En Route Supplement Australia (ERSA)

An excellent source of pre-flight planning information lies within the En Route Supplement Australia (ERSA). It is available by subscription and the information can be accessed through the internet at http://www.airservicesaustralia.com/aip/aip.asp?pg=40&vdate=29-May-2014&ver=1. The online information can be downloaded and printed and as the service is free, is a viable option for the latest version of ERSA.

The aerodrome data section is useful guide from ERSA. It contains data sheets on many of the larger aerodromes in Australia which indicate information such as aerodrome elevation, runway directions location of the primary windsock and prominent taxiways (Fig. 28). ERSA contains around 30 pages of information explaining what each field on these sheets means. Some time will be required for the first-time user to become familiar with the presentation of the information and its meaning. Where ERSA does not list an aerodrome, the pilot must contact the owner or operator of the aerodrome to determine its characteristics and operating limitations, if any.

Other information on pre-flight briefings available is contained in ERSA together with methods of accessing the information.

ALPHA **ELEV 1255**
AVFAX CODE 4110

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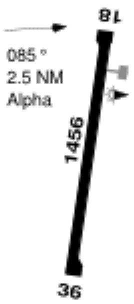

AD OPR Barcaldine Regional Council, PO Box 11, Alpha, QLD, 4724. PH 07 4985 1166, PH AH 0429 851 109, ARO 0429 851 109, ARO AH 4985 1425.

PASSENGER FACILITIES
PT

PHYSICAL CHARACTERISTICS
18/36 180 48a PCN 5 /F /B /580 (84PSI) /U WID 30 RWS 90

AERODROME AND APPROACH LIGHTING
RWY 18/36 LIRL (1) PAL 122.8 SDBY PWR AVBL
RWY 18/36 PTBL
(1) SDBY PWR 20MIN MAN Switching
1. Prior permission REQ for all itinerant OPS HN. AH 0429 851 109.
2. RWY serviceability inspection is required prior to take-off and landing - HN.

ATS COMMUNICATIONS FACILITIES
FIA BRISBANE CENTRE 122.3 8500FT

CTAF 126.7

ADDITIONAL INFORMATION
Possibility of animals on AD.

CHARTS RELATED TO THE AERODROME
WAC 3234

Fig. 36 Aerodrome and Facilities data sheet

The magnetic compass

The magnetic compass consists of a magnetised pointer that is free to align itself with the Earth's magnetic field. For use in aviation, the compass pointer is usually incorporated into a card with sides; this is reminiscent of an upside-down shallow can. The sides are used to inscribe direction or bearing information. The complete unit is suspended on a jewelled spindle and encased in fluid inside a sealed unit. A viewing window is built in such that the bearing information is readily viewable by the user (Fig. 37).

Fig. 37 A magnetic compass

The magnetised pointer will always point to magnetic north provided that it is not significantly affected by metallic material or electromagnetic currents. Any discrepancy between the indicated direction and the actual direction is known as deviation.

Most microlights are fitted with simple compasses that will probably suffer from deviation to some degree. This may be permanent due to the magnetic influences of the microlight itself and its systems and if it is significant (more than 3* on any heading), the compass should be swung and a deviation correction card drawn up that allows an indicated heading to be flown to achieve the actual heading required.

Provided that the compass reads correctly, it is still sound practice to align the microlight with a known magnetic bearing (a runway centre-line bearing). Allow the compass to settle down then check whether the indicated compass bearing is at or very near the known bearing. This should be done before every cross-country flight and if a discrepancy is noted, you should check for any magnetic material that has accidently or inadvertently been placed in close proximity to the compass.

In flight, the compass is subject to errors other than deviation. Turning through north will result in the compass over-reading and turning through south will result in the compass under-reading. This is because of a counterweight fitted in the vicinity of the north pointer of the compass that is designed to keep the compass card level rather than align itself with the curve of the magnetic field lines. Due to the inertia of this weight, the card lags behind the actual heading resulting in an overshoot of the target.
The mnemonic ONUS for Overshoot North, Undershoot South is often used as a memory aid for this phenomenon. Practically, in a microlight the compass cards move under the influence of many external factors that cannot be eliminated. Pilots should bear this potential error in mind so

as not to “chase” the compass during a turn.

Similarly, when accelerating on easterly and westerly headings, the compass will show an apparent turn to the south and during deceleration the apparent turn will be to the north. The mnemonic SAND is used in this case, South Acceleration, North Deceleration. The likelihood of a aircraft being influenced by long and significant accelerations and decelerations is not large, so although these acceleration errors may be largely ignored, they should still be borne in mind.

The most practical way to alter heading an a microlight in flight is to calculate the number of degrees and direction of the heading change required and look in that direction noting a feature on the ground in the general direction. Turn towards the feature you have chosen, then fine tune the heading once the compass has settled down.

Pilots are often confused by the relative location of the heading marks visible in the viewing window of a compass. In Fig. 37, the heading showing, allowing for parallax error is about 185*. As the 210* heading mark on the compass is to the left of the lubber line, uninitiated pilots will turn left to turn onto a heading of 210*. This is incorrect. The easiest way to remember which direction to turn is to recognise that if the required heading is numerically larger than the current heading, then a right turn is required.
Similarly, if the required heading is numerically less than the current heading, then a left turn is required.

Practical navigation and map reading

Navigation log

A navigation log should be kept for each flight. On the flight plan form, you can use the two columns immediately before the NAV/COM FREQ column. When it becomes obvious that the planned estimated time (EST) or estimate time of arrival (ETA) is incorrect due to an inaccurate wind forecast, calculate the new ETA and put it in the REV EST column. In a flight plan containing more than one leg, only do this for the current leg. When the current leg is completed, the revised EST, which has been calculated using the error from the first leg, is completed for the next leg only.

By logging the times and calculating the time intervals for the next leg, it will be possible to then estimate with a fair degree of accuracy, the time when a place or feature on the map should appear rather than having to guess what place you are seeing when it does appear. Should a turn back be necessary due to deteriorating weather for example, a return heading and ground speed can be calculated by referring to the flight plan and the navigation log.

A close check on this log will help determine if there is sufficient fuel remaining to complete the flight or if a diversion to a closer destination is necessary. A significant change in the ETA for the destination may also require that the nominated SARTIME be amended.

At this time, there is no requirement for the flight plan form and log to be kept once the flight is completed. However, pilots should be aware that CASA has the regulatory power to direct that flight plan forms and logs be kept for a specific time period.

Navigating and map reading

The chart to be used in flight can be folded such that it can easily be flipped to the section required for the current flight leg. A knee board is a useful piece of equipment if space permits its carriage. A viable alternative is to fold the chart and insert it into a clear plastic sheet protector and tape this to the pilot's trousers in the region of the thigh.

The chart should be orientated such that the track direction required is pointing away from the pilot. This may require the chart to be upside down which may result in difficulty in reading some place names. Practice will ensure familiarity with using a chart in this manner. The main advantage is that ground features on the chart will be orientated relative to the track in the same direction as they will appear on the ground relative to the microlight.

The most accurate way to set heading is to take off and climb out in the normal manner until able to return to overhead the airfield, then turn onto the first leg heading and note the time of departure on the log. This has the disadvantage of consuming extra time and fuel. The more usual manner of setting heading is by departing from a suitable leg of the circuit and heading to intercept the outbound track close to the airport and then turn onto the planned heading. At that point it is necessary to estimate the distance of this interception from the airfield and calculate how long it would have taken to fly direct from overhead the airfield to that point (e.g. planned ground speed is 36 KTS and the track was intercepted 3 NM from the airfield). Flying direct this would have taken 3/36 x 60 minutes, about 6 minutes. From the time of interception, take off 6 minutes to use as the actual time of departure (ATD), and then note this time in the log. At a convenient time, calculate the

ETAs for each turning point if there is more than one leg.

Having set heading, it is absolutely critical to ensure that the microlight is heading in the direction intended. The heading column on the flight form has been highlighted in an attempt to prevent the pilot from selecting other numbers by mistake and flying that as heading. It is also know that numbers within numbers have been swapped around to the detriment of the operation (e.g. 230* instead of the correct 320*). An early fix should be prepared before departure, ideally within about 15 minutes of departure. If a fix is not available, then a line feature may be available and can be used. A line feature refers to a river, dam, reservoir, railway line, highway, transmission line etc. A careful check should be made to ensure that the fix or feature is unique to the desired track (e.g. a river of approximately the same size is not a good check if there is another river about the same distance away as the one on track, but in the opposite direction).

Some pilots find it useful to place marks along the track at 5 or 10 NM intervals. This can assist with checking the actual ground speed and adjusting ETAs if necessary (e.g. passing one such mark, note the time and then note the distance covered in the next 6 minutes). Let's say the distance was 5 NM. Six minutes is one-tenth of an hour (60 minutes), so if the distance travelled in one-tenth of an hour is 5 NM, then the groundspeed is 5 x 10 = 50 KTS. Adjust the ETA for the next fix or turning point accordingly.

Read from the map to the ground. The type of chart being used will determine how many ground features are depicted on it. Therefore not all the ground features visible to the pilot will be marked on the chart. Care must also be taken with streams, creeks, lakes, dams etc., especially after a period of wet or dry weather. After significant rainfall, these water features may have overflowed and their shape may not match those on the chart. Similarly, after a dry spell, there may be no water at all in the feature. However, it is most likely that there will be a line of shrubs or trees along the water feature that will follow the winds and bends of a stream or creek and delineate the orientation of the feature and its twists and turns.

Where there is doubt that the feature being crossing is the correct one, try to use other features more distant to assist (e.g. a spot height at an angle of say 30* to the right of the nose and a definite peak on the horizon 90* to the left). If these features are in fact where they are expected to be, the position has been fixed. Some pilots would mark this position and note the time of passage next to it on the chart. This type of fix can also be used to assess ground speed. Say a particular fix is about one-third of the distance along track to the next turning point or the destination. By calculating the elapsed time to this point from departure, the approximate ETA for the next turning point will be the fix time plus twice the elapsed time from departure to the fix.

A change in the forecast wind rarely affects ground speed alone. More often than not, the heading that has been flown will have been incorrect as well resulting in the aircraft being off track to one side or the other. If this is the case, estimate how far off track the aircraft currently is and then calculate a heading to get back on track at a convenient point. Assume that the aircraft's position has been fixed and it is 3 NM left of track after travelling 20 NM. Obviously, if this situation is not corrected, the aircraft will never arrive at its intended destination. By using the 1 in 60 rule, it is possible to estimate the track error in degrees and adjust the heading to re-intercept track at the convenient point.

The 1 in 60 rule states that 1 mile will subtend 1 degree at 60 miles. Taking this further, 2 miles will subtend 2 degrees at 60 miles etc., and 5 miles will subtend 10 degrees at 30 NM (Fig. 38). The simple formula is angle = dist off track/distance gone or distance to go x 60. In the example above, 3 miles off track in 20 miles gone = 3/20 x 60 =

9 degrees.

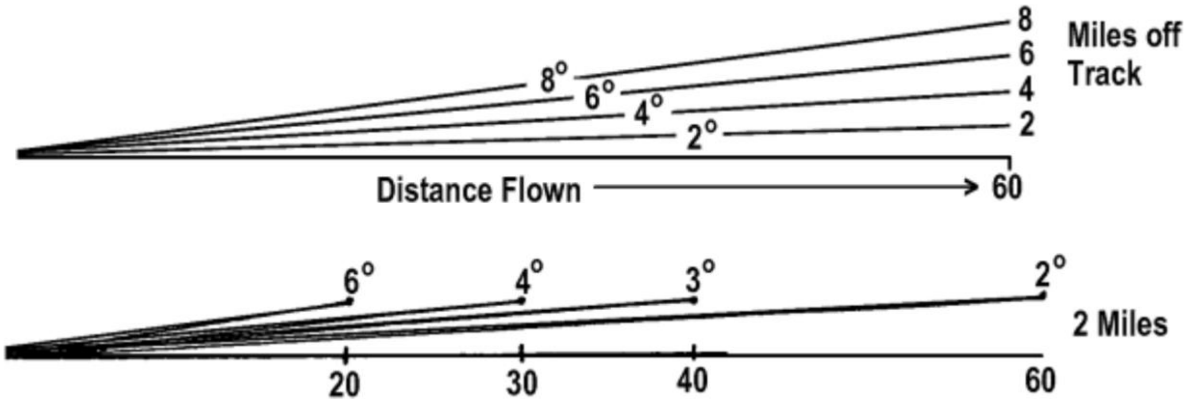

Fig. 38

Now assume that there is ahead on track, a place where a highway crosses a river. This fix is 30 miles ahead and would be an ideal place to ensure that the microlight is back on track. Using the 1 in 60 rule, it is possible to calculate the amount by which the original heading needs to be adjusted to achieve the goal.

Applying the 1 in 60 rule for the distance to go, the formula becomes 3/30 x 60 = 6 degrees. If it was desired to parallel the original track whilst remaining 3 NM left, the original heading would need to be adjusted by 9 degrees to the right. It has been decided to re-intercept the track and the estimated closing angle is a further 6 degrees to the right. Therefore the heading must be adjusted to the right by 9 + 6 = 15 degrees. Upon arrival at the fix and once established on track again, alter the heading to the left by 6 degrees. This new heading should maintain the planned track provided that the wind now remains constant.

Track crawling

The above is largely theoretical for a Microlight. It assumes that the compass being used is accurate, the heading can be accurately maintained for the duration of the flight, the actual wind will remain constant for the duration of the flight and that there are adequate ground features to accurately determine position. In a microlight, these factors are not often the reality and therefore this idealistic method of navigation may not be appropriate in all cases. It has been said that the process of “track crawling” is unprofessional, sloppy and shows a lack of appreciation for the finer points of navigating an aircraft. In reality, microlights are so slow relatively speaking, that a small change in wind speed and/or direction can have a major impact on track made good and actual ground speed. For this reason, in many circumstances track crawling may be the best method for a microlight.

Track crawling refers to the technique of drawing the track on a chart then crawling along that track by choosing a feature from the chart that is a short distance away along track, then flying directly to that feature. Approaching this first “fix” another feature along track is chosen, identified and tracked towards at an appropriate time. This in-flight technique does not preclude proper pre-flight planning and does not relieve the pilot of the responsibility of obtaining a weather forecast or completing a flight plan prior to departure. It is merely the in-flight technique that is different and ensures that you are not blown off course by varying winds which cannot be accurately accounted for when planning your flight.

When flying at low levels or in areas where there are few features to be identified, it may not be possible to see the feature which is on the chart to fly towards. An additional method can assist with track crawling in these situations. When leaving the departure location or last identified feature on the chart, fly for a short time with the nose of the microlight pointed in the direction of the calculated track, irrespective of the drift caused by a wind. At this time take note of a recognisable feature that can be seen as far away as possible, which is in the direction that the microlight is pointing and therefore on the planned track. This may be a group of trees on an open plain or a large shed which stands out from the surrounding background. Having identified this marker on the track, adjust the heading so as to pass over this point. If there is a strong and variable wind, the nose of the microlight may be pointing at varying headings which are a lot different to required track, but the microlight will still be flying directly towards the destination. When approaching the first marker, repeat this procedure as often as necessary until it is possible to identify a feature on the chart that is visible ahead. Once the microlight has been located over this feature, an accurate position is now available from which to calculate an actual groundspeed for future ETA calculations.

Diversions

Diversions can be necessary for any number of reasons: bad weather, running short on fuel, approaching end of daylight, original destination no longer available etc. It is understood that in a microlight in flight, it is not practical to draw a diversion track, then measure the track bearing and distance and then construct a triangle of velocities to determine a new heading and ground speed to use. The diversion details will need to be estimated to get some idea of the heading to steer and the time interval for the new track.

It is best to divert from a known position so as to eliminate one approximation. By identifying a diversion point ahead of the microlight, it is possible to have all the estimations completed before arriving at the diversion point thus reducing the pilot workload after the diversion begins.

Whilst it may not be possible to accurately draw the diversion track, it will be possible to draw in an approximate straight line by freehand to represent the diversion track. Once this has been completed, the bearing can be estimated by referring to a meridian (remember these reference true north, not magnetic) or the original track. If difficulty is experienced in estimating the angular difference, it may be helpful to draw a line at 90* to the original track starting at the diversion point. By mentally dividing this 90* segment into halves, thirds or even quarters, the diversion track may be estimated. Apply the difference between the original track and the estimated diversion track to the original heading and use that heading as a starting point. Note that if the diversion track is to the right of the original track, the new heading will be numerically greater that the original and vice versa if it is to the left. The wind that has been affecting the flight has been estimated and the starting heading must be adjusted to take into account this wind which will have a different effect on the diversion track than it did on the original. If the diversion is more into the wind, the ground speed will decrease as will the drift. Conversely, if the diversion is more out of the wind, the ground speed will increase as will the drift.

The diversion distance may be estimated by eye using the length of the original track, the meridian mile scale, the length of a pencil or part thereof in miles. A new ETA will be calculated using the new estimated ground speed and the estimated diversion distance. Having calculated the ETA, check to see that it can still be accommodated by the SARTIME originally nominated. If not, a new SARTIME will need to be nominated to a flight service unit by radio. Even if the original SARTIME does not need to be changed, flight service should be notified of the diversion.

The above is a very rough approximation and a fix shortly after diverting will be necessary to confirm all the previous estimations. Again, read map to ground and once a positive fix is obtained, adjust the heading accordingly to track crawl towards the new destination.

Unsure of position

If the pilot becomes unsure of the position of the microlight (i.e. lost!), it becomes necessary to change technique and read from the ground to the map in an attempt to identify a feature common to both. This feature could be a town or village, river with unusual bends, reservoir, lake or road etc. If the microlight has been maintaining a constant heading, check the elapsed time from the last positive fix and mentally convert this time to distance using the last known ground speed, then mark this distance along track with an X or some other suitable method. Draw a freehand circle around this point with a radius of about half the distance travelled. This is the most probable position of the microlight. The ground should now be searched visually for a significant feature and when one is

located, search the chart within the drawn circle for the same feature.
Should this prove unsatisfactory and a fix cannot be found, calculate how much flight time remains before reserve fuel starts to be consumed. This is the time remaining to locate a suitable area for a precautionary landing and plan that manoeuvre. The time should be used wisely to select the best possible site with the best possible chance of making contact with others once on the ground.

If random headings were flown prior to becoming lost for whatever reason, a line feature ahead of the microlight should be selected that the pilot is sure has not been crossed and the microlight flown to that feature. If attempts to locate the aircraft's position on the line feature is unsuccessful and fuel is not yet critical, turn along the feature in one direction or the other and proceed until a positive fix is made, or fuel supply dictates that a precautionary landing is necessary. Should there be no suitable line feature, a precautionary landing must be planned and executed.

Low-level navigation

It may become necessary to conduct all or part of a flight at levels lower than normal. Recall that microlights are permitted to operate at a minimum height of 300 ft AGL. At levels such as this, navigation techniques need to be adapted accordingly and other hazards that were not evident at much higher levels need to be considered.

It is obvious that a pilot's field of vision at 300 ft will be far less than that at say 3000 ft. Features that can be seen very clearly at 3000 ft will not become visible until the aircraft is nearly on top of them. A good example is a lake or a large dam. Because the water body's surface is flat and it is likely surrounded by higher ground, the aircraft may well be flying over the water before the pilot becomes aware of it. The rapidity with which the feature was encountered together with the aircrafts height results in the shape and expanse of the water body not being assessable. For this reason, if tracking towards such a feature, use it for track and ground speed checks as opposed to pinpoint fixing. The situation becomes worse if there are several such water features in the area.

Hills present special navigation problems at low level. Even relatively small hills appear larger from a height below their tops. In a manner similar to the water features, the shape of a hill becomes unclear unless the hill is a monolith. Should there be a number of peaks near the track but only a few are marked on the chart with spot heights, it may be almost impossible to define which is which at low level especially if the hill tops are obscured by cloud. From a higher altitude, the tallest peaks stand out quite clearly. A straight track at 2000 ft above terrain becomes a torturous path at 300 ft AGL when flying along valleys and trying to dodge ridges.

If forced to fly into a valley in the hope of finding escape at the other end, ensure that the aircraft is flown up one side of the valley or the other. Which side is chosen is for the pilot to decide, but in a two-place side-by-side aircraft, the flight path should be on the side of the valley which is opposite to the side on which the pilot sits in the aircraft (e.g. if the pilot sits on the left, the aircraft should fly up the right-hand side of the valley). This gives the pilot the maximum amount of visibility and turn radius to not only check on the weather behind the aircraft, but also to manoeuvre the aircraft should the path ahead become impassable.
Powerlines become a major concern when flying in such locations at low level. It is not so much the major transmission lines that are normally marked on a chart, but the smaller spur lines that are often single wires that can span long distances. If the tops of the valley ridges are obscured, it may not be possible to pick out the power poles and therefore the wire(s). Flying up a valley where the ridges are obscured, the likelihood of the end of the valley being clear is not great and a safer option may be to turn out of the valley and divert around the terrain or terminate the flight.

Perchance the aircraft proceeds to the head of the valley and finds that there appears to be a gap through which the aircraft could pass, NEVER, NEVER cross the ridge at 90* until the area on the other side has been confirmed as clear and any turbulence through the gap has been assessed. Should the gap be attacked at 90* to the ridge line and it becomes necessary to turn back at low level, a 180* turn will be necessary. A poorly executed turn may well see the aircraft descending towards the terrain or climbing into the cloud base. The proper approach is to fly the aircraft along the ridge, parallel to and close to it. This allows the area on the other side to be assessed and also tests for the presence of turbulence. If there is no or little turbulence and the area through the gap is clear, a 90* turn is all that is required to slip through the gap. If conditions are not satisfactory, an opposite direction 90* turn sees the aircraft back in the valley.

Almost all other features that normally appear well in advance at normal heights can suddenly appear when flying at low level. This is especially true when the feature crosses the track at or near right angles. If the chart indicates that a feature (highway, railway line, stream etc.) will be crossed at some distance ahead, calculate an ETA for the passage and start searching for it well ahead of the ETA. Similarly, if the track will pass over a populated area which must be avoided, commence the visual search well before the area is encountered so that it can be avoided by an appropriate amount.

Rising ground

Rising ground can cause problems when operating at low levels. The climb performance of the aircraft may not be sufficient to out climb the rising ground ahead. This is more likely when operating with a tailwind. The lack of performance must be recognised early and the aircraft should be turned around and a climb to a higher altitude achieved before the crossing is attempted again. Whilst a headwind when operating towards rising ground will reduce the ground speed and assist the angle of climb, the general sink created by the descending air could negate the climb angle advantage and preclude a safe result. Again, the aircraft should be turned around and climbed to a higher altitude for the crossing. During this turn, the pilot must be aware of the hazards associated with turning into a tailwind, the dreaded downwind turn.

Turbulence

Low-level flight in any sort of wind will encounter turbulence in the form of mechanical turbulence. This is caused by the wind flowing over uneven terrain, trees and hills, through gullies and valleys and other such obstacles. This turbulence is directly proportional to the wind speed. Therefore, when operating in strong winds at low level severe updrafts, downdrafts and rotors should be anticipated particularly in the lee of any substantial obstacle such as an isolated hill or ridge line and operations in these area avoided (Fig. 39).

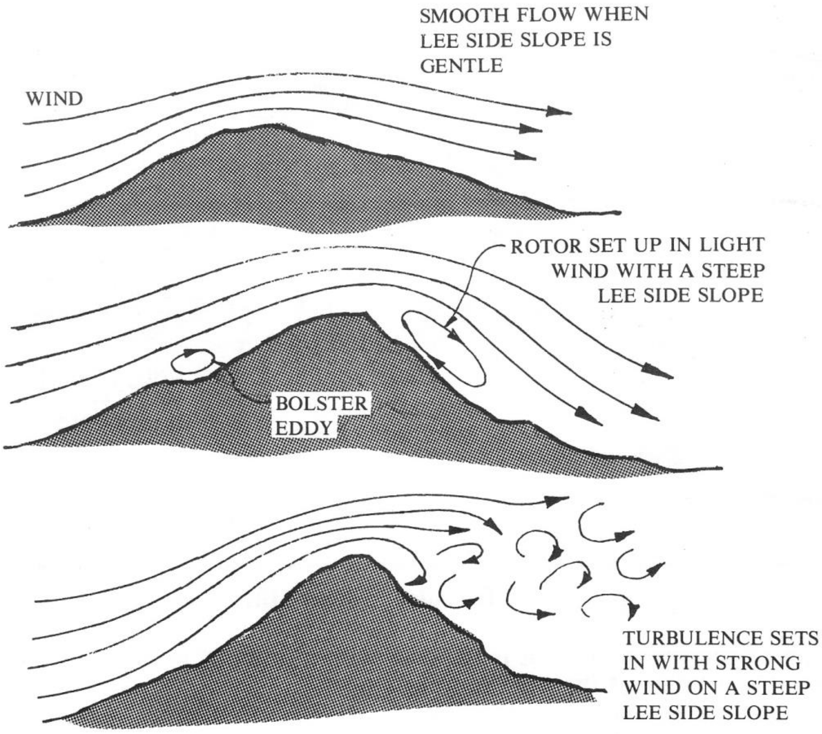

Fig. 39 Turbulence

Convective turbulence can be particularly evident if the aircraft is operating close to an active thunderstorm. Strong vertical airflows are possible near thunderstorms particularly in or around heavy precipitation. If heavy rain showers are observed, the aircraft should be flown well clear of the area. The convection updrafts feeding large cumulus clouds may be so strong that a microlight can be carried upwards into the cloud base despite being configured for descent. There are recorded incidences of gliders and parachutists being carried to great heights by such currents. Large cumulus clouds should be avoided by a significant margin.

Not as severe but certainly noticeable is the convective turbulence encountered when flying over hot, dry unvegetated areas. The sun heats these areas and the convection causes the air above to rise, sometimes quite rapidly. In this turbulence, the aircraft will be carried vertically aloft, sometimes for several hundred feet. Once the aircraft flies out of the rising air current, recovery can be initiated. Over areas where there is significant vegetation, the air currents act in the opposite direction with the cooler, less heated air descending and moving to replace the risen hot air. Again, at lower levels this can prejudice terrain clearance (Fig. 40).

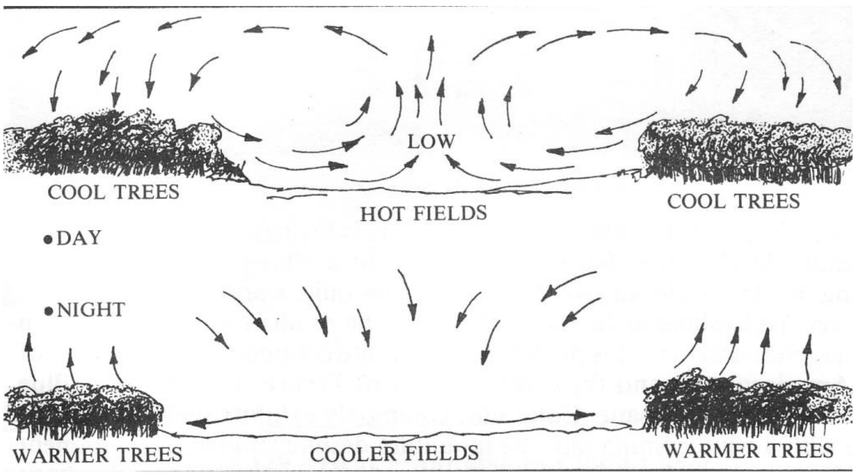

Fig. 40 Convective turbulence

Windshear

Windshear is a sudden change in wind speed and/or direction in either the horizontal or vertical plane. An encounter with horizontal windshear will have an effect on the navigational problems associated with maintaining track and calculating ground speeds. In the vertical plane, the results of windshear can be more profound, especially for low performance microlights operating at low level. Assume that the microlight is operating at low level into a 30 KTS headwind and encounters a 20 KTS negative windshear. The indicated airspeed (IAS) will immediately reduce by 20 KTS and so will the performance. A descent will commence and in extreme circumstances full power may not be sufficient to accelerate the aircraft enough to arrest the descent. In this case, the nose must be lowered in an attempt to gain the required speed and at low level, terrain clearance may be prejudiced. In an extreme case, the aircraft will strike the ground or an obstacle. There is little or no warning of windshear so altitudes should be chosen to take into account the worst possible scenario (Fig. 41).

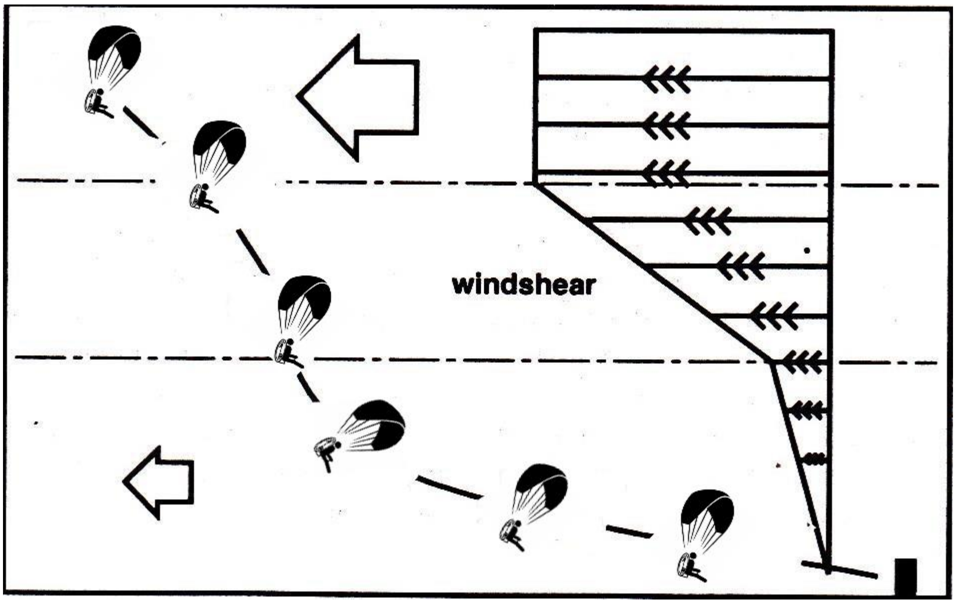

Fig. 41 The effect of windshear on a PPG

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