flight training adelaide

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NAVIGATION 1

CHAPTER 9 – FLIGHT PLANNING

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FLIGHT PLANNING

9.1 Introduction

The objective of commercial flying operations is to transport passengers and cargo safely and at a profit. Safe operations require that the aircraft is flown at appropriate altitudes and speeds according to its flight manual and with sufficient fuel to reach its destination and alternate airports.

We share the airspace with other aircraft and so that air traffic control can function effectively, there is a need to plan and inform organisations of our airborne intentions.

To meet the profit expectations of the operator, aircraft must be operated in an efficient and cost effective manner. Carrying fuel that is not required, for example, simply adds to the mass of the aircraft and increases the fuel consumption, hence more fuel is used and costs increase. Furthermore, to carry the additional fuel the aircraft may need to fly with reduced payload so reducing the potential profit.

For commercial reasons when flight planning we normally aim to carry **minimum fuel** and **maximum payload**.

9.1.1 Depth of Flight Planning

In general the depth of flight planning required for a particular flight will vary depending on the complexity of the aircraft type being flown, the nature of the task to be completed and the complexity of the environment in which the aircraft is to be employed.

There is a vast difference in the requirements to plan a flight consisting of the aircraft doing a few circuits and landings at its home airfield for training purposes, opposed to an international trip to transport passengers and freight between multiple airports before arriving at a final destination.

Planning a flight also helps the pilot foresee any problems that might be encountered during the flight, so that these problems can be dealt with before the flight and possible solutions found ready to be implemented.

This chapter will focus on the requirements to plan a day VFR flight in accordance with the Flight Training Adelaide Operations Manual.

As a guideline, **the more time spent flight planning on the ground, the easier will be the task of the pilot in the air.**

9.1.2 Organising and Recording Flight Planning Information

To organise all the information required to successfully plan a flight, a standardised flight plan form is used.

The scope of the form is dictated by the depth of planning required and the more complex the planning, the more detailed the form will be in terms of the types of information.

The flight plan form serves as the master reference document for the flight and contains all the information used to both plan and execute the flight in terms of navigation and fuel planning requirements, usually in tabular format:

PIC:	OTHER:	REG:	DATE:		TOTAL FUEL:(HHMM)		DIST:	TOTAL TIME:(HHMM)		END OF DAYLIGHT: UTC/LST		SARTIME:UTC/LST		
POSN	LSALT	ALT	TAS	TR	W/V	HDG	GS	DIST	ETI	PLN EST (HHMM)	ATD ATA (HHMM)	ETA (MM)	REV EST (MM)	FUEL MARG

The flight plan form can be obtained from Flight Operations.

Most columns are completed before the flight during the planning stage and others completed during the flight as information is updated, e.g. recalculating estimates for times over the various waypoints and revising fuel requirements.

9.1.3 Day VFR Flight Planning Sequence

When planning a day VFR flight, the sequence to be followed is:

- Selection of the route.
- Selection of the cruise level(s).
- Planning each phase of the flight.
- Determining the fuel requirements.
- Map preparation.
- Self-briefing or map study.
- Weather briefing.
- Submission of the flight notification.

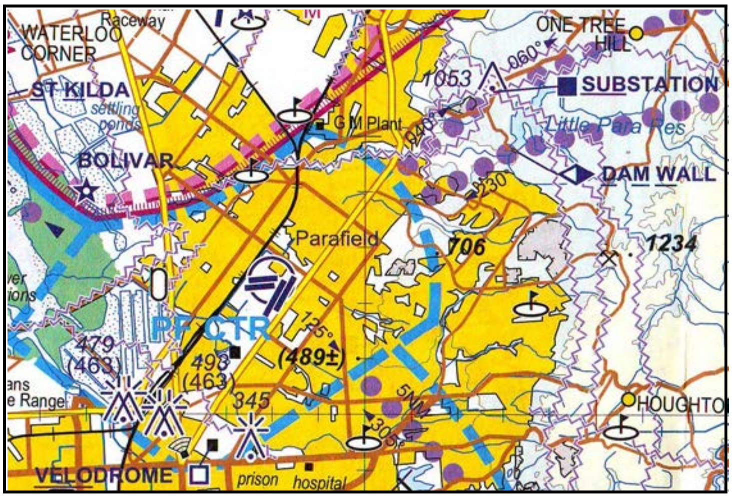
9.2 Route Selection

Initially the waypoints that make up the route will be preselected by the flying instructor with specific exercise objectives in mind. Later on you will need to choose your own waypoints to plan the flight.

A first step would be to find a suitable map or chart and then to locate the departure and destination points. These two points are joined with a straight line and the direction and distance can be measured. The ideal plan would be as simple as possible. However, there will be reasons as to why planning may not be as simple as first thought and why a single straight line route may not be possible.

The straight line may intersect areas that it is not possible to fly in. Danger, restricted or prohibited areas may intersect along this line. Consideration needs to be given to high ground, airspace and airfields.

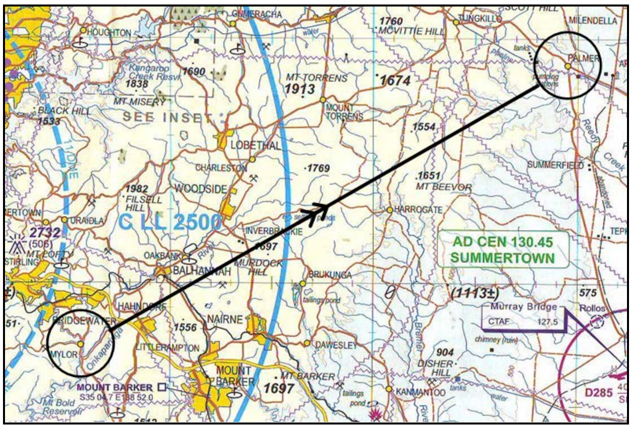
Most airports are surrounded by controlled airspace and have specific VFR departure and arrival procedures that need to be followed to keep uncontrolled air traffic clear of controlled airspace. These VFR departure and arrival routes must be incorporated into the planning.



Ideally the route should include sensible turning points and ground features that will allow the position of the aircraft to be found in a quick and unambiguous manner during the flight. The aim of route and waypoint selection therefore, is also to make navigation as simple as possible. Key principles here are safety, simplicity and efficiency.

NOTAMS also have an important part to play in route selection phase. Events published in the NOTAMS, such as the temporary unavailability of aeronautical facilities, restrictions posed on airspace or the activity within a specific danger area might have an impact on the selection of waypoints along the route.

Once the waypoints have been selected, they are written in sequence on the flight plan form and identified on the map by drawing black circles around each waypoint. The track can also be drawn between each of the waypoints in black ink.



Aside from the basic direction and distance information, the aeronautical topographical chart displays a wealth of information. Much of this information is illustrated through the use of symbols and it is important that the pilot becomes familiar with the symbols commonly used. On many aeronautical charts the symbols are shown in the form of a legend.

9.3 Cruise Level Selection

Deciding on a cruise level (or levels in the case of more complex flight plans) is as important as proper route selection. The cruise level determines not only the performance the aircraft for the largest portion of the flight, but also the length of the climb and descent legs in terms of time, fuel and distance.

From an aircraft performance perspective, piston engine aircraft are most fuel efficient when cruising at sea level. Climb legs are conducted at higher power settings and slower speeds than cruise legs and will generally be much less fuel efficient.

The aim is to keep the climb leg as short as possible by flying as close to sea level as possible to maximise the phase of flight where the aircraft is most efficient.

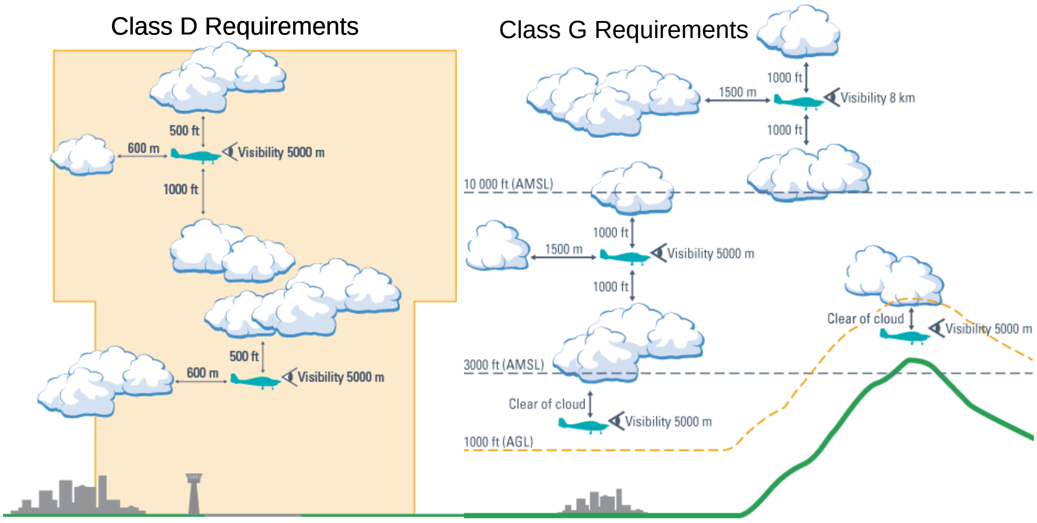
Other factors to consider are:

- Cloud base and other weather phenomenon.
- Terrain (Lowest Safe Altitude).
- Radio reception range.
- Engine failure performance.
- Desired class of airspace (in Class G or Class C airspace).
- Prohibited, Restricted and Danger areas.
- Semi-circular (hemispherical) rule.

9.3.1 Cloud Base

There are specific rules (covered in LAW1) relating to Visual Flight Rules (VFR) aircraft in the different classes of airspace in terms of the visibility requirements and horizontal and vertical distances from cloud. This needs to be taken into consideration when choosing a cruise level.

An explanation of these rules can be found in Jeppesen Air Traffic Control page AU503 and in the CASA Visual Flight Rules Guide (VFRG). An extract from the VFRG for Class D and class G airspace is shown below:



Flying above cloud will decrease the pilot's visibility of the terrain and make map reading during the flight difficult. A cloud may obscure the features required to identify a turning point, increasing the risk of the turning point being missed and the likelihood of becoming unsure of the aircraft's position.

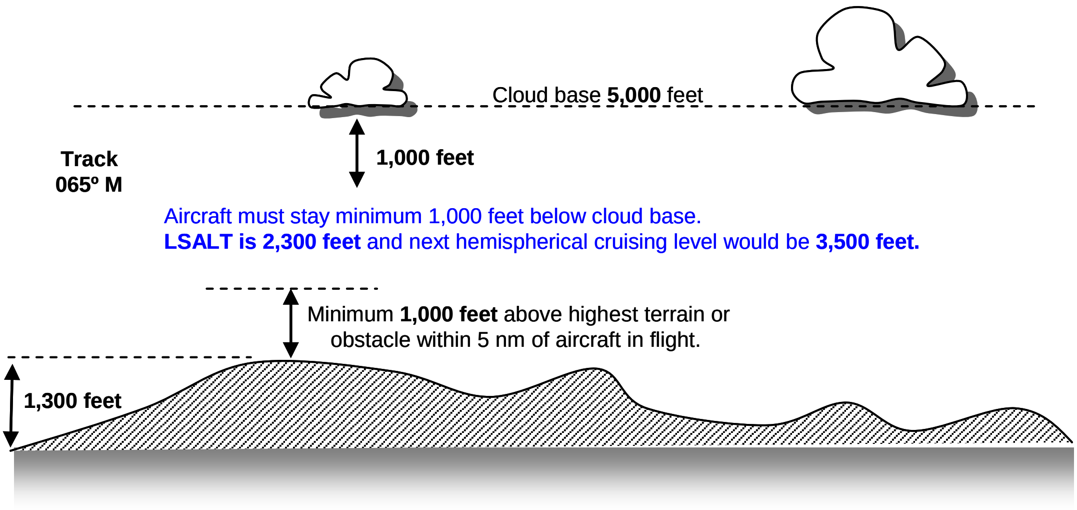
9.3.2 Terrain - Lowest Safe Altitude (LSALT)

A day VFR pilot is not required to enter a LSALT on the flight plan form or cruise above this altitude. It is a CASA requirement for night VFR flying.

Flying operations at FTA requires a LSALT for each leg of a navigational flight. When selecting a cruise level it has to be above LSALT and in accordance with the semi-circular rule.

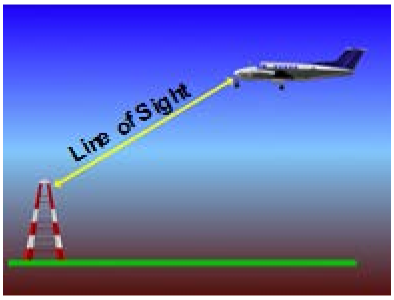
LSALT is used as a guideline in choosing a cruise level as it represents the lowest altitude the aircraft could be operated at, in the vicinity of the track and still remain safely above terrain by a safe margin. This altitude would be used for events such as inadvertent flight into cloud or when unsure of position.

LSALT is calculated using the **VFR criteria**, (CAR 157) i.e. the aircraft is not to be operated below 1,000 feet over populated areas or below 500ft for unpopulated areas, referenced from above the highest obstacle, terrain, or any significant feature within 5nm of the flight plan track, other than for take-off and landing. Round the calculated LSALT **up** to the nearest 50ft.



9.3.3 Radio Reception Range

VHF radio transmissions travel a 'line of sight' path between transmitter and receiver and the higher the aircraft, the greater the VHF reception range. The range of the desired reception should therefore be taken into consideration when choosing a cruise level.



9.3.4 Engine Failure Performance

When flying a single-engine aircraft another consideration is the glide performance of the aircraft when selecting cruising levels. Sufficient height is required to be able to glide to the nearest suitable field or paddock for a forced landing. Flying at a lower height above surrounding terrain decreases your options in the event of an engine failure.

Arrival procedures at some airports might also dictate that you fly at a relatively low altitude over hilly areas, especially if you want to remain outside controlled airspace (OCTA). This could certainly make life interesting in the event of an engine failure.

In some instances it may be better to have a slight increase in workload associated with flying into controlled airspace (CTA) and requesting airways clearances rather than remaining below controlled airspace.

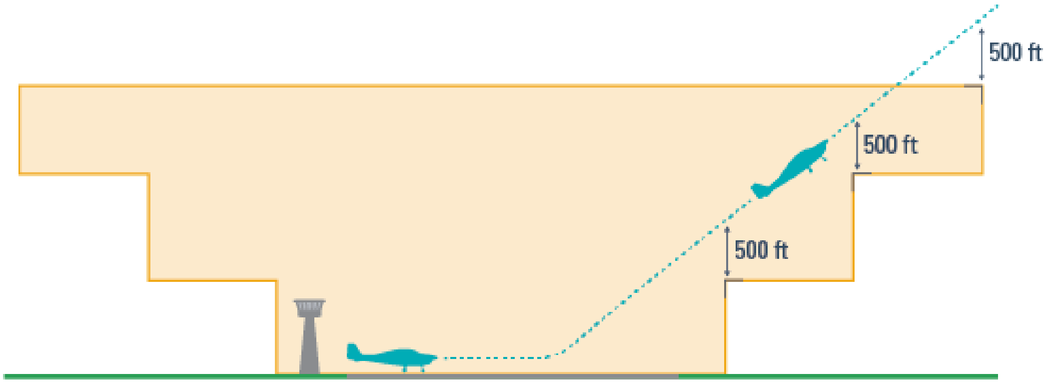
Flying at a slightly higher altitude could provide extra time to select a more suitable field and will extend the glide range and potentially a greater choice of where to do a forced landing.

Modern aircraft engines are reliable and engine failures are not such a common occurrence. Flying a well maintained aircraft this may not be the most important consideration, but a professional pilot will consider as many variables as possible to ensure that the flight can be conducted safely, whilst having options in case of potential problems that may arise during the flight.

9.3.5 Desired Class of Airspace

There are specific rules (covered in LAW1) relating to the operation of VFR aircraft in the different classes of airspace. Not all airspace types allow VFR flying and some classes of airspace require special permission upon entry.

For example, when operating in Class C or Class D airspace, aircraft are required to remain 500ft above the lower limit of the airspace, which will affect the choice of cruise level.



An explanation of these rules can be found in Jeppesen Air Traffic Control page AU704 and in the CASA Visual Flight Rules Guide (VFRG).

9.3.6 Prohibited, Restricted and Danger Areas

Prohibited, restricted and danger areas may affect the choice of cruise level. For instance, if the airspace is active (closed) the aircraft will need to fly above or below it.

- <u>Prohibited area</u> – Airspace within which the flight of aircraft is prohibited.
- <u>Restricted area</u> – Airspace within which the flight of aircraft is restricted in accordance with specified conditions.
- <u>Danger area</u> – Airspace within which activities dangerous to the flight of aircraft may exist at specified times.

Details regarding the lateral and vertical dimensions of prohibited, restricted and danger areas can be found on VTC, VNC and radio navigation charts.

When these areas are active it will be listed in the NOTAMS or AIP ENR 1.4. The AIP and VFRG also define the types of restricted airspace that can be flown through, the conditions and airspace types to be avoided.

9.3.7 Semi-Circular (hemispherical) Rule

The semi-circular rule is based on **magnetic track** and provides a minimum of 1,000ft separation between VFR traffic travelling in opposite directions.

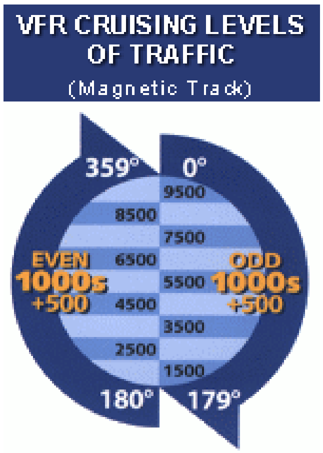
Aircraft operating at 5,000ft or higher (Australia) must comply with the semi-circular rule and when practicable the semi-circular rule must be used when flying below 5,000ft (CAR 173).

For operations at FTA, all VFR flights shall be planned at levels selected in accordance with the hemispherical/semi-circular rule as shown in the Jeppesen Air Traffic Control Section, page AU804.

When the magnetic track is between 000°M and 179°M, the level selected shall be odd thousands plus 500 feet. i.e. 1,500ft, 3,500ft, 5,500ft, 7,500ft etc.

When the magnetic track is between 180°M and 359°M, the level selected shall be even thousands plus 500 feet. i.e. 2,500ft, 4,500ft, 6,500ft, 8,500ft etc.

VFR aircraft operating outside controlled airspace may be operating at levels different to those specified in the semi-circular rule when flying below 5,000ft AMSL.

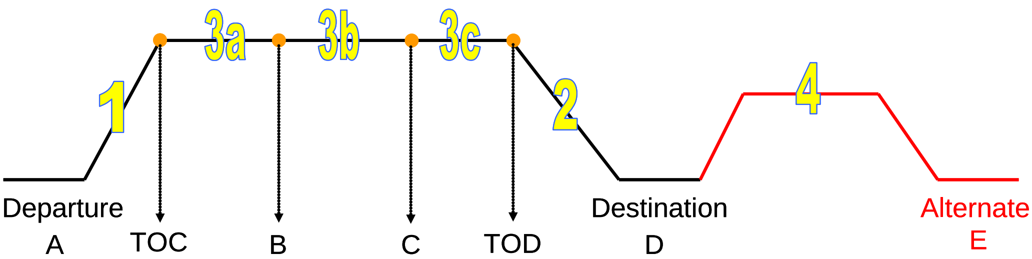


9.4 Planning Each Phase of Flight

With the route and cruise level defined, the detailed planning of each leg/phase of the flight is completed. The aim is to calculate the total time and fuel the flight will require.

A typical navigational flight for a light aircraft will consist of three phases:

- Climb – High power setting and slower airspeed than the cruise.
- Cruise – Most efficient power setting and best range speed.
- Descent – Idle thrust setting and nearly the same as cruise speeds.



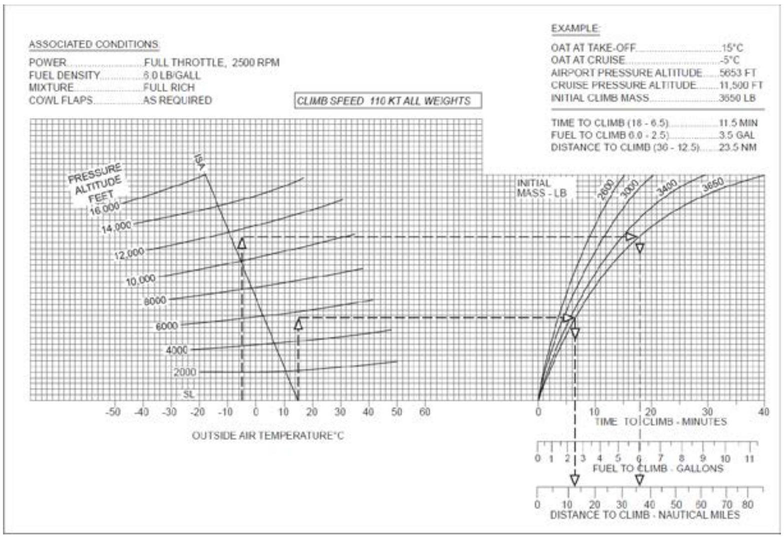
The performance of the aircraft is different in each phase of flight, therefore planned separately to determine the time, fuel and distance of each phase.

The detailed planning is started by measuring the total distance along the route. Climb leg planning is done first (1), followed by descent leg (2) planning. The cruise sector planning is done at the end (3a, 3b and 3c).

When the climb distance is known, the Top of Climb (TOC) position can be determined and is the point where the cruise phase will begin. When the descent distance is known, the Top of Descent (TOD) position can be determined and will be the point where the cruise phase ends.

When an alternate is required, the route from the destination to the alternate is planned in the same manner.

An accurate (but time consuming) approach to take when planning the flight is to use performance graphs designed for the specific aircraft type and phase of flight.



These graphs or tables take into account the exact weight, altitude, temperature and power settings involved during that particular phase of flight, providing the user with accurate values for time, fuel and still air distance.

Alternatively, a slightly less accurate approach would be to plan the flight as a cruise sector and afterwards adjust the total time and fuel for the differences between climb, cruise and descent performance. This is the process currently used when flight planning.

Each leg’s magnetic track and distance is measured on the map and entered in the flight plan form. Wind and temperature information from the latest weather forecast would also be consulted, so that the magnetic heading and groundspeed of each leg can be determined as if it were a cruise leg. Note that the winds used during the climb and descent legs must be the average wind for each climb and descent leg.

9.4.1 Climb Sector Planning

When climbing, the aircraft will fly slower and require more fuel compared to cruising the same distance, due to the climb being conducted at a higher power setting.

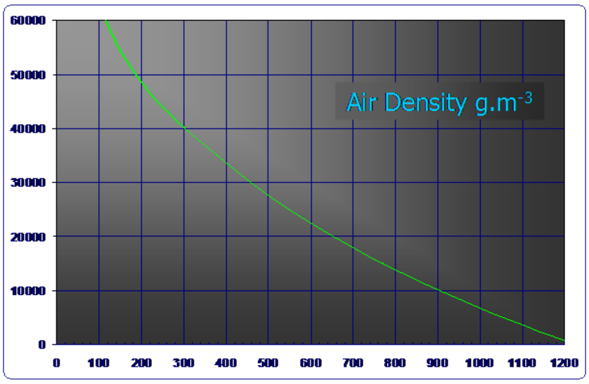
An additional amount of time and fuel needs to be added to correct the flight plan for the portions of the flight that the aircraft will be climbing. These climb adjustments are noted in the operations manual and are aircraft type specific.

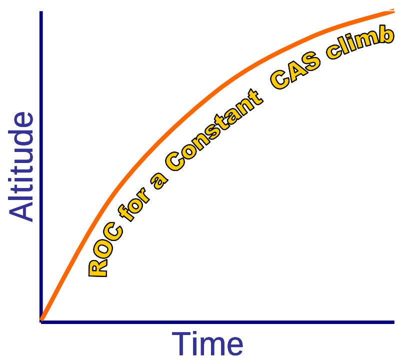
For example, the climb adjustment for the Tobago TB-10 is performed by adding one minute to the leg time and one litre to the leg fuel for each 2,000ft of the planned climb.

The climb adjustment for the Diamond DA40CS is similar and is performed by adding one minute to the leg time and 0.3 US Gallons to the leg fuel for each 2,000ft climb that is planned.

9.4.1.1 Average Wind and Temperature in the Climb

The density of air reduces with altitude and this affects the performance of an aircraft in that engine power reduces with altitude. Air density reduces at a non-linear rate.





The climb profile is conducted at a constant Calibrated Airspeed (CAS), which will result in a variable rate of climb as density reduces and altitude is gained. The rate of climb will reduce at a non-linear rate as altitude is gained until a point is reached where the aircraft can climb no further on the power setting, weight and temperature, i.e. the aircraft's maximum altitude is reached.

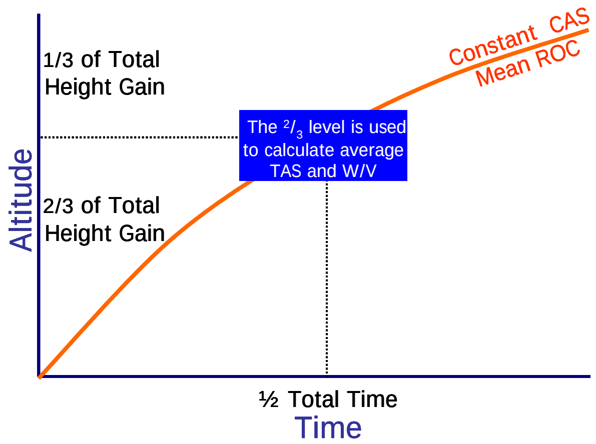
Throughout the climb the wind velocity and temperature would also be changing with altitude. Temperature reduces with altitude and in general, wind velocity will increase as altitude is gained.

In climb planning the average temperature is needed to determine the average True Airspeed (TAS) to apply the average wind velocity to the track on the navigation computer and determining drift, heading and groundspeed.

With light aircraft the TAS does not vary significantly during a typical climb leg and to simplify the planning process a constant TAS value is used in the planning. For higher performance aircraft types the average TAS must be determined by using the average temperature and altitude for the climb.

It is necessary to identify the average wind velocity affecting the aircraft during the climb in order to determine drift, heading and average groundspeed. The average wind and temperature is obtained from a weather forecast by identifying the average altitude for the climb leg.

The average altitude for the climb will occur at the halfway point in time for the climb. This point occurs at two-thirds altitude, due to the non-linear rate of climb, resulting from a constant CAS climb speed.



9.4.1.2 Calculating the Two-Thirds Altitude for the Climb

The two-thirds altitude can be calculated with the following formula:

$$\tfrac{2}{3}\,\text{Altitude} = [(\text{End Altitude} - \text{Start Altitude}) \times \tfrac{2}{3}] + \text{Start Altitude}$$

Example: An aircraft needs to climb from an airfield at 280ft elevation, to a cruising altitude of 5,500ft AMSL. Find the average altitude for the climb.

$$\begin{aligned}\tfrac{2}{3}\,\text{Altitude} &= [(\text{End Altitude} - \text{Start Altitude}) \times \tfrac{2}{3}] + \text{Start Altitude}\\ &= [(5500\text{ft} - 280\text{ft}) \times \tfrac{2}{3}] + 280\text{ft}\\ &= [(5220\text{ft}) \times \tfrac{2}{3}] + 280\text{ft}\\ &= [3480\text{ft}] + 280\text{ft}\\ &= 3760\text{ft AMSL}\end{aligned}$$

This average altitude is used to interpolate a wind velocity from the weather forecast.

9.4.1.3 Interpolating the Weather Forecast for Average Wind Velocity

Consult the weather forecast as close to the time of the flight as possible, as the predicted winds in the forecast should then better match actual conditions at altitude. Using an outdated weather forecast will result in inaccurate planning and is also unsafe.

Sometimes the average altitude calculated will be similar to the standard forecast altitudes and it will not be necessary to interpolate the wind velocity. In other cases the procedure discussed below can be used.

Example: Refer to the Grid Point Wind and Temperature (GPWT) forecast extract below and interpolate the wind velocity at an average altitude of 3,760ft AMSL.

GPWT FORECASTS (1000FT - FL140) - AUS

PROVIDED BY AUSTRALIAN BUREAU OF METEOROLOGY

VALID:	**0000 UTC 24 May 2017**
ISSUED:	0505 UTC 25 May 2017
DATA FORMAT:	dd fff tTT
dd:	WIND DIR TENS OF DEG TRUE
fff:	WIND SPEED IN KNOTS
tTT:	TEMP IN DEG CELSIUS

FORECAST is valid for the centre of the box

ISA FL/FT	hPa	T	dd	fff	tTT
140	600	-13	15	065	-05
10000	700	-05	12	055	+03
7000	800	+01	10	055	+08
5000	850	+05	05	040	+15
2000	950	+11	28	020	+20
1000	975	+13	29	015	+24

The interpolated wind will lie between the winds forecast for 2,000ft and 5,000ft:

- For the wind direction, calculate the total amount the wind changes direction between the two levels, i.e. (shortest way) from 280°T to 050°T is 130° change.
- Calculate the total difference between the forecast levels in feet. 5,000ft – 2,000ft = 3,000ft change.
- Calculate the rate of change of degrees per foot of altitude. 130° change across 3,000ft = 130° ÷ 3,000ft = 0.043° per foot.
- Find how far the given two-thirds level is above or below one of the forecast levels. In this case the interpolation will be done upwards from the 2,000ft forecast level. 3,760ft – 2,000ft = 1,760ft away from 2,000ft.
- Based on the rate of change per degree calculated before, determine the direction change between 2,000 and 3,760ft. 0.043° × 1,760ft = 76.27° ≈ 76° change.
- Find the interpolated wind direction by applying the direction change to the base value being interpolated from. The wind direction at 2,000ft is 280° and it was determined that the change up to the two-thirds level is a change of 76°. By examining the forecast it can be observed that the wind direction increases

from 280° at 2,000ft towards 050° at 5,000ft and therefore the 76° change should be added to the 280°. 280° + 76° = 356°T.

- The wind speed is interpolated in the same manner and would be 31.733kts ≈ 32kts.

The interpolated wind for the two-thirds level would therefore be 356°/32. This wind velocity would now be incorporated into the planning done on the flight plan form.

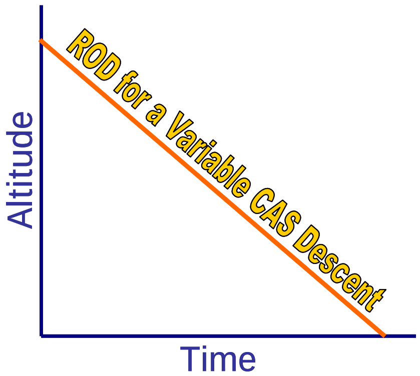
9.4.2 Descent Sector Planning

For light aircraft the descent performance is very similar to cruise performance in terms of time and fuel requirements over the same distance and hence it is not necessary to adjust the planning by making allowance for the decent leg.

In actual flying conditions, the aircraft will use slightly less fuel during the descent compared to the cruise, as the descent is conducted at idle thrust. Instead of reducing the fuel required for the descent leg from the cruise planning, the "surplus fuel" is consumed on the ground as landing taxi and shutdown fuel. Any other remaining fuel is not deducted and viewed as a safety buffer.

9.4.2.1 Average Wind and Temperature in the Descent

The descent profile is conducted at constant rate of descent, which will result in a variable CAS, as density increases and altitude is reduced, whilst descending towards sea level. This means that the rate of descent will reduce at a linear rate as altitude is reduced over time.

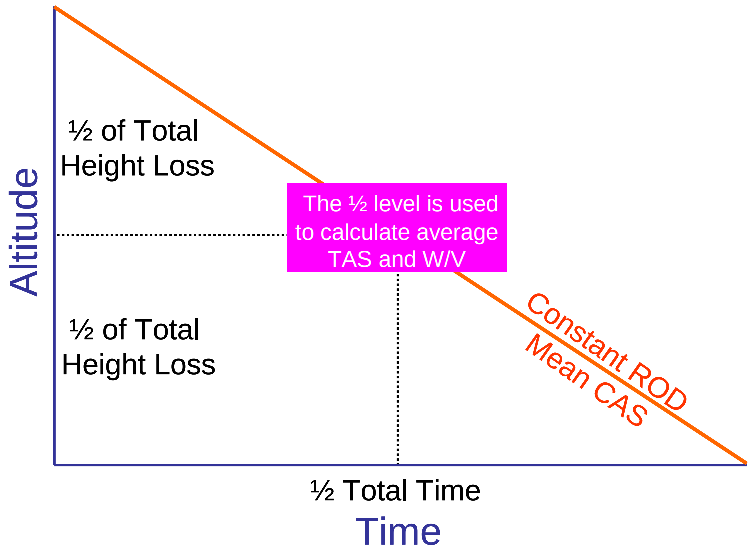


Similar to the climb, the changes in wind and temperature need to be taken into account to determine average TAS, drift, heading and groundspeed for the descent profile.

For light aircraft the TAS does not vary that much during a typical climb or descent leg and to simplify the planning process a constant TAS value is used in the planning. For higher performance aircraft types the average TAS must be determined by using the average temperature and altitude for the descent.

It is necessary to identify the average wind velocity affecting the aircraft during the descent in order to determine drift, heading and average groundspeed. The average wind and temperature can be obtained from a weather forecast by identifying the average altitude for the descent leg.

The average altitude for the descent will occur at the halfway point in time. This occurs halfway between the altitude from which the descent is commenced and the altitude to which the aircraft is planned to descent.



9.4.2.2 Calculating the Halfway Altitude for the Descent

The halfway altitude can be calculated with the following formula:

$$\frac{1}{2}\text{Altitude} = \frac{(\text{Start Altitude} + \text{End Altitude})}{2}$$

Example: An aircraft needs to descend from 8,500ft AMSL to an airfield at 1180ft elevation. Find the average altitude for the descent.

$$\begin{aligned}\frac{1}{2}\text{Altitude} &= \frac{(\text{Start Altitude} + \text{End Altitude})}{2}\\ &= \frac{(8{,}500\text{ft} + 1{,}180\text{ft})}{2}\\ &= \frac{9{,}680\text{ft}}{2}\\ &= 4{,}840\text{ft}\end{aligned}$$

The average altitude can be used to interpolate a wind velocity from the weather forecast in a similar manner as for the climb. Once the wind velocity has been determined it can be incorporated into the planning for the descent leg on the flight plan form.

9.4.3 Cruise Sector Planning

In detailed planning involving performance graphs, the cruise sector will only be planned once the climb and descent distances are known and can be subtracted from the total distance in order to calculate the cruise sector distance.

The planning approach at FTA is a faster and slightly less accurate approach to flight planning, where the entire flight is planned as a cruise sector first and then adjustments are made for the climb legs.

Cruise planning is accomplished through completing the various columns in the navigation part of the flight plan form. The partially completed form should by now contain the list of waypoints along the route as well as the various cruise levels to be used throughout the route.

PIC:	OTHER:	REG:	DATE:	TOTAL FUEL:(HHMM)	DIST:	TOTAL TIME:(HHMM)	END OF DAYLIGHT: UTC/LST	SARTIME:UTC/LST

POSN	LSALT	ALT	TAS	TR	W/V	HDG	GS	DIST	ETI	PLN EST (HHMM)	ATD ATA (HHMM)	ETA (MM)	REV EST (MM)	FUEL MARG

Once the cruise levels for each of the cruise legs have been determined, the TAS can be calculated by means of the navigation computer from known values of CAS, pressure altitude and Outside Air Temperature (OAT).

The CAS is chosen based on the desired power setting in the cruise (maximum speed, best range- or endurance speed). The cruise level is defined based on the considerations discussed earlier and the OAT would be obtained from the weather forecast.

Sometimes the actual cruise TAS of the aircraft does not change that much during the cruise sector and it is acceptable to plan on a constant TAS value to further simplify the planning. This may further slightly decrease the accuracy of the overall plan.

Each leg's track is measured and converted into degrees magnetic using the variation applicable to that leg. Leg distances are also measured and recorded on the flight plan form. The total distance can also be calculated.

Using the wind side of the navigation computer, each leg's heading and groundspeed is calculated. Use magnetic wind together with the magnetic track to the calculations. The wind applicable to each leg is obtained from the weather forecast at the level the aircraft will cruise. Average winds for climb and descent legs must be calculated as discussed earlier in the chapter.

With the leg distance and groundspeed known, the leg times in minutes are calculated and recorded on the flight plan form.

The fuel flow applicable to the cruise sector can be obtained from the aircraft's performance manual and will depend on the speed profile chosen. In general, faster cruise speeds equate to higher fuel flows. The operations manual contains detailed information on the various fuel flows to be used in navigation planning for the different aircraft types.

The fuel flow is applied to the leg time to determine the leg fuel requirements. The total cruise time and cruise fuel requirement is then calculated and recorded on the flight plan form.

With the entire flight planned as a cruise sector, the adjustments for the climb leg in terms of time and fuel can be applied.

These adjustments are detailed in the operations manual and are different for the various aircraft types flown.

The climb time adjustments are incorporated into the appropriate leg times calculated before and the climb fuel adjustments are kept separate on the flight plan form from the leg fuel amounts calculated earlier. These cruise and climb only fuel amounts will be combined when the fuel plan is completed.

9.4.4 Alternate Leg Planning

Alternate Aerodrome means aerodromes specified in the flight plan to which a flight may proceed when it becomes inadvisable to land at or continue towards the aerodrome of intended landing.

If the flight requires an alternate (discussed in CPL Operations, Performance and Planning), then the alternate leg's planning is done in accordance with the procedures laid out in this chapter.

The alternate leg starts at the destination aerodrome and follows a route of user defined waypoints to the nominated alternate aerodrome. The flight to the alternate will also have a climb, cruise and descent sector and is planned exactly as discussed earlier and the details recorded on separate lines of the flight plan form.

The total fuel to fly from the destination to the alternate is deemed “Alternate Fuel” and is taken into account when the fuel plan is compiled. The alternate leg fuel is added to the fuel already determined for the actual flight's climb, cruise and descent.

9.5 Determining Fuel Requirements for the Flight

Once the time and fuel for each of the phases of flight is known, it can be combined to calculate the total time and fuel for the flight. When the fuel requirements of the climb, cruise, descent and alternate legs are combined the total is referred to as “Flight Fuel”.

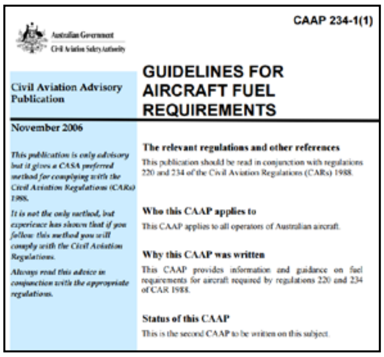
Flight Fuel is defined as the fuel required based on forecast wind and conditions to fly from the departure to destination. It comprises of take-off, climb, cruise and descent fuel, including alternate fuel if required.

On a typical flight, fuel would also be required to start the aircraft and taxi it to the threshold of the active runway. From taking off on the runway, until the final landing, the flight fuel would be consumed. Similarly the aircraft might require fuel at the final point of landing to taxi to the apron and shut down.

If the flight goes exactly as planned and if actual weather conditions match forecast conditions, then the flight fuel should be sufficient to reach the final destination.

However, should there be stronger than anticipated headwinds or a diversion required around a thunderstorm, then the flight fuel will not be sufficient. The aircraft might not be able to land immediately at its destination due to traffic congestion and might require additional fuel to hold before it can land.

It is clear that a certain amount of extra fuel need to be carried for in-flight contingencies to cover these types of events. Fuel that is carried specifically to contend with in-flight contingencies is termed “Reserve Fuel”.



CAAP 234-1(1)

Australian Government
Civil Aviation Safety Authority

Civil Aviation Advisory Publication

GUIDELINES FOR AIRCRAFT FUEL REQUIREMENTS

November 2006

This publication is only advisory but it gives a CASA preferred method for complying with the Civil Aviation Regulations (CARs) 1988.

It is not the only method, but experience has shown that if you follow this method you will comply with the Civil Aviation Regulations.

Always read this advice in conjunction with the appropriate regulations.

The relevant regulations and other references

This publication should be read in conjunction with regulations 220 and 234 of the Civil Aviation Regulations (CARs) 1988.

Who this CAAP applies to

This CAAP applies to all operators of Australian aircraft.

Why this CAAP was written

This CAAP provides information and guidance on fuel requirements for aircraft required by regulations 220 and 234 of CAR 1988.

Status of this CAAP

This is the second CAAP to be written on this subject.

From a planning point of view, reserve fuel must be retained in the aircraft until the final landing and may only be used during the flight should specific contingencies arise. Reserve fuel may not be used to supplement the flight fuel in the case of poor planning.

The recommended amount of reserve fuel and the types of contingencies covered and planned for is detailed in CAAP 234-1(1).

The CAAP details the recommended minimum reserve requirements and operators may increase the amount of reserves to that deemed to be safe for specific operation types.

9.5.1 Minimum Legal Fuel Requirements

The minimum legal amount of fuel in a typical fuel plan, planned at the pre-flight stage will therefore consist of:

- Start/Taxi Fuel.
- Flight Fuel.
- Variable Reserve Fuel.
- Fixed Reserve Fuel.
- Holding Fuel (if required).

FUEL PLAN		
FROM→TO	MINS	L/KG
CLIMB		
CRUISE		
ALTERNATE		
SUBTOTAL		
VARIABLE 15%		
FIXED RESERVE		
HOLDING		
TAXI		
FUEL REQUIRED		
FUEL MARGIN		
ENDURANCE		

9.5.1.1 Start/Taxi Fuel

Start/Taxi Fuel is the fuel required for start, taxi and run-up. This is a fixed amount of fuel, which is detailed in the operations manual and is specific to the aircraft type being flown.

9.5.1.2 Flight Fuel

Flight Fuel is the fuel required, based on forecast wind conditions, and includes the following:

- The take-off of the aircraft from brakes release on the departure runway.
- The climb to cruise altitude.
- The cruise towards the destination.
- The descent to the intended destination.
- The diversion from the intended destination towards an alternate airfield (also covering the alternate leg's climb, cruise and descent fuel).
- The landing up to the point where the aircraft comes to a stop on the applicable runway.

Flight fuel is a variable fuel amount and will be different for each flight. Even if the waypoints are the same the weather would be different, resulting in different groundspeeds and leg times for identical flights on different days.

9.5.1.3 Variable Reserve Fuel

Variable Reserve Fuel is the amount of fuel on board an aircraft that is sufficient to provide for unexpected fuel consumption caused by factors other than loss of pressurisation or an engine failure.

The CAAP 234-1(1) dictates the types of flight which require variable reserve fuel and what the amount should be. It is not legally required for private and aerial work, but can be carried if desired. If the flight is a public transport or charter operation, then a variable reserve of 15% of the flight fuel must be carried for piston engine fixed wing aircraft and helicopters.

The variable reserve will therefore change based on the flight fuel amount, and the requirement thereof, is dictated by the operation type.

For operations at FTA, a variable reserve is required for navigational flight and calculated at 15% of the flight fuel for fixed wing aircraft and 10% of the flight fuel for helicopters.

For the CASA CNAV exam, apply the guidelines from CAAP 234-1(1) regarding Variable Reserves, NOT FTA procedures.

9.5.1.4 Fixed Reserve Fuel

Fixed Reserve Fuel is the amount of fuel, expressed as a period of time, holding at 1,500ft above an aerodrome at standard atmospheric conditions that may be used for unplanned manoeuvring in the vicinity of the aerodrome at which it is proposed to land, and that would normally be retained in the aircraft until the final landing.

Fixed reserve fuel is required for every flight and is a fixed amount of fuel, based on the aircraft category and flight rules under which the flight is operated.

The CAAP 234-1(1) dictates the amount of fixed reserve that must be carried for fixed wing aircraft and helicopters. For VFR operations in fixed wing aircraft this is 45 minutes at the holding rate as specified above and for VFR helicopter operations it is 20 minutes at the holding rate.

For operations at FTA the same values of time is used, the fuel amount is a fixed amount specified in the operations manual, unique to each aircraft and operation type.

For the CASA CNAV exam, apply the guidelines from CAAP 234-1(1) regarding Fixed Reserves, NOT FTA procedures.

9.5.1.5 Holding Fuel

Holding Fuel is the amount of fuel that will allow an aircraft to fly for a specified period of time, being an amount that is calculated at the holding rate established for the aircraft, at a level not greater than FL200 and at a temperature not less than forecast.

Holding fuel is only carried when required and depends on the weather, traffic congestion or work in progress on the ground at an airfield.

The NOTAMS specify the holding period required in the case of traffic congestion or work in progress at an airfield, causing delays to the arrival of an aircraft.

Refer to the weather forecast to determine if weather holding would be required and how much holding fuel needs to be carried:

- INTER = 30 minutes holding fuel required.
- TEMPO = 60 minutes holding fuel required.

For operations at FTA the holding rate for each aircraft shall be at a specific fuel consumption documented in the appropriate section of the operations manual.

9.5.1.6 Margin Fuel

When a flight is planned and the sum of Start/Taxi fuel, Flight Fuel, Variable Reserve, Fixed Reserve and Holding Fuel for a particular flight is calculated, this value equates to the minimum legal amount of fuel required for the flight

Additional fuel may be added as a safety margin. This surplus fuel is called "Margin Fuel".

Margin fuel is not part of flight fuel or reserves and is available for use at any stage during the flight and is planned to be consumed at the cruise rate in the fuel plan.

9.5.2 Total Endurance

Total endurance is the total time the aircraft can remain airborne, using all available fuel on board. It is the duration for which the aircraft can fly until only the unusable fuel remains in the tanks. Total endurance will include all the fuel except the start/taxi fuel in the calculation. Total endurance may be calculated using the following formula:

$$\text{Endurance (mins)} = \frac{\text{Total Fuel - Start/Taxi Fuel}}{\text{Cruise Fuel Flow}} \times 60$$

In practice this does not take into account the variable fuel consumption during different flight phases and it is better to complete the Fuel Plan explained below to obtain a more accurate endurance value. The above formula is useful to calculate total endurance.

9.5.3 Safe Endurance

Safe endurance is the total time the aircraft can remain airborne, using all available fuel on board, excluding reserves. It is how long the aircraft can fly, without using any of the reserve fuel quantities.

Safe endurance will therefore be based on flight fuel and margin fuel only and can be calculated with the following formula:

$$\text{Safe Endurance (mins)} = \frac{\text{Flight Fuel} + \text{Margin Fuel}}{\text{Cruise Fuel Flow}} \times 60$$

9.5.4 Completing the Fuel Plan

After the navigation plan has been completed, the fuel plan can be calculated. The fuel plan determines not only the minimum legal amount of fuel required for the flight, but also the margin fuel and total endurance.

Example: Complete a fuel plan for a flight by referring to the details below:

Start/taxi fuel:	5 litres
Cruise sector length:	96mins
Cruise fuel flow:	40 litres per hour
Climb adjustments:	4mins and 4 litres
Variable reserves:	15% of flight fuel
Fixed reserves:	45mins and 40 litres
Holding requirements:	15mins due to traffic
Holding fuel flow:	32 litres per hour

FUEL PLAN		
FROM→TO	MINS	L/KG
CLIMB		
CRUISE		
ALTERNATE		
SUBTOTAL		
VARIABLE 15%		
FIXED RESERVE		
HOLDING		
TAXI		
FUEL REQUIRED		
FUEL MARGIN		
ENDURANCE		

Some of the particulars in the example above would normally come from the navigation plan and the aircraft performance data can be retrieved from the operations manual.

FUEL PLAN		
FROM→TO	MINS	L/KG
CLIMB	4	4
CRUISE	96	64
ALTERNATE		
SUBTOTAL	**100**	**68**

- Insert the climb fuel adjustments to time and fuel in the appropriate blocks.
- Insert the total cruise leg time and fuel in the appropriate blocks. Calculate the total cruise leg fuel from the cruise fuel flow and cruise leg time converted to hours. 40 litres per hour × 96mins ÷ 60 = **64 litres**.
- There is no alternate for this flight, draw a diagonal line through these blocks.
- Calculate the subtotal (Flight Fuel) by adding the climb and cruise fuel and time. 96mins cruise + 4mins climb adjustment = **100mins total** and 64 litres cruise fuel + 4 litres climb fuel = **68 litres total**.
- Calculate the 15% variable reserve amount. The flight fuel was calculated to be 68 litres and 15% of 68 equals 10.2 litres. The fuel plan is completed in whole units of fuel. **Any reserve fuel quantity must always be rounded up** to the nearest whole unit; 10.2 ≈ **11 litres**. By always rounding up the variable reserve will never be less than 15% due to rounding.

FUEL PLAN		
FROM→TO	MINS	L/KG
CLIMB	4	4
CRUISE	96	64
ALTERNATE		
SUBTOTAL	**100**	**68**
VARIABLE 15%	16	11
FIXED RESERVE	45	40
HOLDING	15	8
TAXI		5
FUEL REQUIRED		
FUEL MARGIN		
ENDURANCE		

- Calculate the time (in minutes) the aircraft can fly on the variable reserve amount by using the cruise consumption rate and insert this amount in the time column of the variable reserve. 11 litres ÷ 40 litres per hour × 60 = 16.5mins. The fuel plan is completed in whole units of time. If mathematical rounding is applied, there will be time added that the aircraft does not have the fuel for and hence the **time is always rounded down** to plan conservatively; 16.5mins **≈ 16mins** for the fuel plan form.
- The fixed reserve time and fuel is a given, insert the values in the correct blocks.
- Calculate the holding fuel requirements from the total required holding time in hours and holding fuel flow. 32 litres per hour × 15mins ÷ 60 = **8 litres**. Insert the total holding time and fuel in the blocks provided.
- Insert the fuel required for taxi.
- Calculate the fuel value for the total fuel required block by adding the fuel values of the flight fuel (subtotal) and all the reserves, together with the taxi fuel. Total fuel required = 68 litres + 11 litres + 40 litres + 8 litres + 5 litres = **132 litres total**.
- Calculate the time value for the total fuel required block by adding the time values for the flight fuel (subtotal) and all the reserve fuel times. Total time for required fuel = 100mins + 16mins + 45mins + 15mins = **176mins total**.
- The fuel required value (litres) is the minimum legal amount of fuel the aircraft is allowed to be fuelled with for this flight and it would be perfectly safe to do the flight with only 132 litres on-board. Additional fuel can be added for a safety buffer.
- The actual total in the tanks (before start) is written in the litres/kg column in the row for endurance. Assume the aircraft is fuelled with **200 litres** for the flight and insert the value in the block provided.

FUEL PLAN		
FROM→TO		
	MINS	L/KG
CLIMB	4	4
CRUISE	96	64
ALTERNATE		
SUBTOTAL	100	68
VARIABLE 15%	16	11
FIXED RESERVE	45	40
HOLDING	15	8
TAXI		5
FUEL REQUIRED	176	132
FUEL MARGIN	102	68
ENDURANCE	278	200

- Calculate the fuel margin (litres) by comparing the total amount of litres required against the total amount of fuel in the aircraft. 200 litres in the tanks – 132 litres required = **68 litres margin fuel**. Insert the amount in the litres/kg column in the fuel margin row.
- Calculate the fuel margin time (in minutes) by applying the cruise fuel flow to the fuel margin quantity. 68 litres ÷ 40 litres per hour × 60 = **102mins fuel margin time**.

- Calculate the total endurance time (in minutes) by adding the fuel margin time to the time value of the total fuel required. 176mins + 102mins = **278mins total endurance**.

9.6 Map Preparation

The flight plan form contains the navigational and fuel plan details for the flight and must be carried in the aircraft for reference during the flight, in addition to a suitable topographical map of the area of operations.

To simplify the task of reading the map in the air and to limit the amount of forms and publications a pilot needs to refer to during the flight, most of the pertinent navigational and fuel plan data is copied to the map so that the map can act as the primary reference document during the flight.

During the navigational flying training phase of the course, the flying instructor will brief you on exactly how the map needs to be prepared for a navigational flight, in support of the data contained in the navigational and fuel plans.

The discussion is limited to the following:

- Highlighting waypoints.
- Drawing the flight plan track.
- Indicating leg distances.

9.6.1 Highlighting Waypoints

Waypoints are highlighted on the map by drawing a circle around each waypoint. The circle is drawn in black ink and centred on the specific spot on the map the pilot intends to fly over during the flight.

On the VTC map the size of this waypoint circle is recommended to be the same size as a 20c coin and on the VNC the circle should be the size of a 10c coin.

The purpose of waypoint circles is two-fold. Firstly, it highlights each waypoint by making it stand out and secondly, no other information or lines are written or drawn inside each waypoint circle.

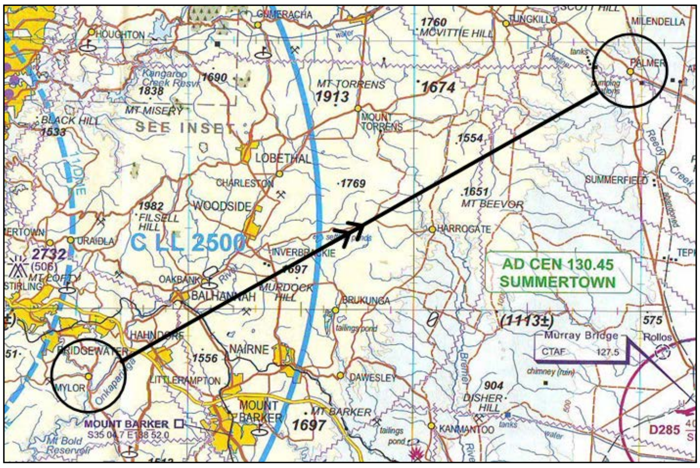
By keeping the inside of each waypoint circle clear of clutter, the navigational features defining each waypoint can be clearly observed.

9.6.2 Drawing the Flight Plan Track

The flight plan track is drawn in black ink as a straight line between each waypoint. The track direction is indicated by a double set of arrows located midway along the track.

Take care not to draw the track inside each of the waypoint circles and to align it with the features at the centre of each circle.

On all Australian topographical maps a straight line on the map can be assumed to be a great circle.



The flight plan track does not always have to be straight. It is possible to have a curved track between waypoints, e.g. when following a line feature like a river through a valley, a road, or a coastline.

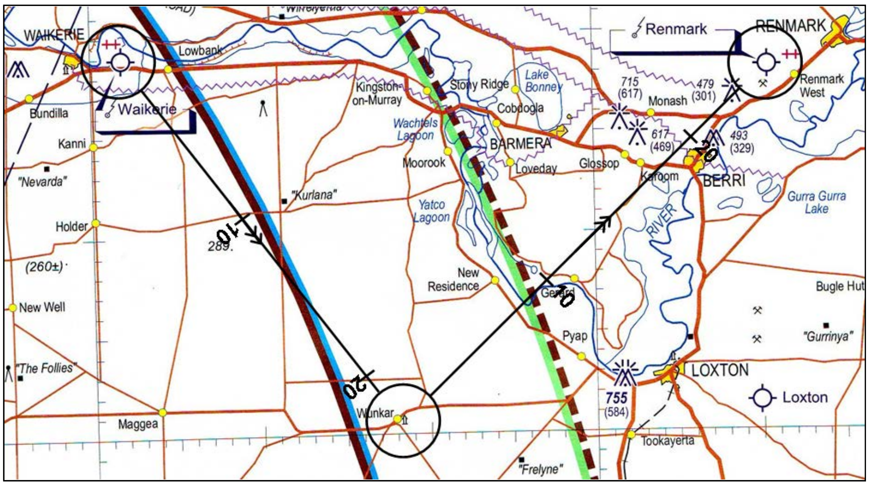
Whether straight or curved, the flight plan track is the path over the earth's surface the pilot intends to follow during the flight. During the flight corrections will have to be made to the heading to keep the aircraft on the flight plan track.

9.6.3 Indicating Leg Distances

The role of leg distance markers is to assist with judging distance during the flight and applied in two ways; as either distance to go or distance gone markings.

Distance markers can also be drawn for each leg, resetting to zero distance after each waypoint or it can reflect the total distance travelled from the departure airfield or total distance to go towards the destination.

Draw the leg distance markers as distance gone since the last waypoint. This method is used to assist with in-flight navigation by means of the 1-in-60 rule.



The distance markers are drawn as short black lines, 90° across the flight plan track at 10nm intervals, starting from the first waypoint of each leg and resetting back to zero at the next waypoint.

Distance markers are not to be placed inside waypoint circles and the distance value every 10 nm is written “track up” next to each distance marker to the right of track.

9.7 Self Briefing and Map Study

Once the navigation plan has been completed the route is studied by following the flight plan track and forming a mental picture using the symbols on the map representing the various terrain and cultural features that will be encountered during the flight.

As the features along the track are examined, the map is turned and the track is pointed in the direction of flight and the orientation of features will be presented as encountered during flight.

Is not necessary to memorise all features along the flight plan track, only key features that will be used to fix the aircraft’s position or navigate whilst flying should be studied. The general idea with map study is to study the route so that it feels like you’ve been there before when the route is flown.

At the very least the features that will be used to identify the various waypoints need to be identified and memorised. Using features of vertical development unique to the area, will aid in early identification of waypoints and reduce the navigation workload in the flight.

Do not neglect map study. By visualising the flight during map study, the professional pilot can foresee any problems that might be encountered during the flight and find effective solutions to those problems in the planning room instead of in the air when under pressure.

9.8 Weather Briefing

The weather forecast must be consulted not only to extract the wind information to complete the planning, but also to assess if it is safe to conduct a flight. The weather conditions should be evaluated for suitability and safety at:

- departure aerodrome,
- destination aerodrome,
- alternate aerodrome, and
- along the route.

The interpretation and understanding of weather forecasts is dealt with in the subject Meteorology.

Weather conditions at the airfield can be obtained from operations and for other aerodromes in Australia, accessed via the internet using the NAIPS system or directly through the Bureau of Meteorology website.

9.9 Submission of the Flight Notification

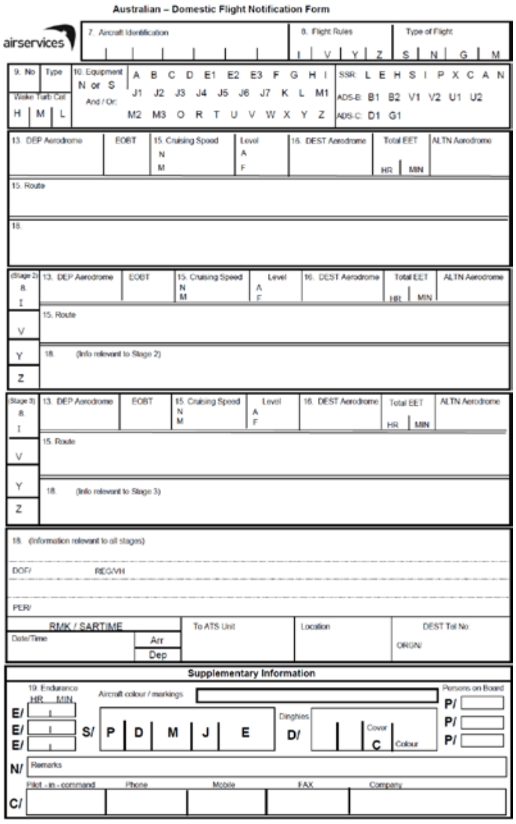
After the flight plan form has been completed with navigation and fuel planning data, it is necessary to inform Air Traffic Control (ATC) and other pilots of our intention to fly by means of a flight notification.

The flight notification form contains the relevant route details, flight times and aircraft particulars necessary to allow ATC to provide the pilot with an air traffic service (ATS) and search and rescue (S&R) function, if required.

A flight notification is required, for instance, when we want ATC to provide us with search and rescue action or when we are planning to enter controlled airspace during the flight.

Exact details of when to submit a flight notification can be found in the Jeppesen Air Traffic Control section (page AU606).

The form is completed by the pilot and normally submitted to the Air Traffic Services (ATS) authority at the departure aerodrome, who then distributes it. The information is distributed to the relevant aerodromes the aircraft is operating between as well as the controlling authority responsible for the flight information region the aircraft is operating in, i.e. Melbourne or Brisbane Centre.



This informs the destination aerodrome when to expect arriving aircraft in order to provide traffic information and sequencing.

Details to complete the flight notification form can be found in the Jeppesen ATC section (page AU613).

In Australia, the NAIPS Internet Service is one of the most convenient portals through which pilots can complete and submit flight notifications online. Other services available through NAIPS include obtaining area weather forecasts and NOTAMS for the areas of operation.

Not all flights require a flight notification and during the flying phase the flying instructor will brief the student on how and when a flight notification is submitted.

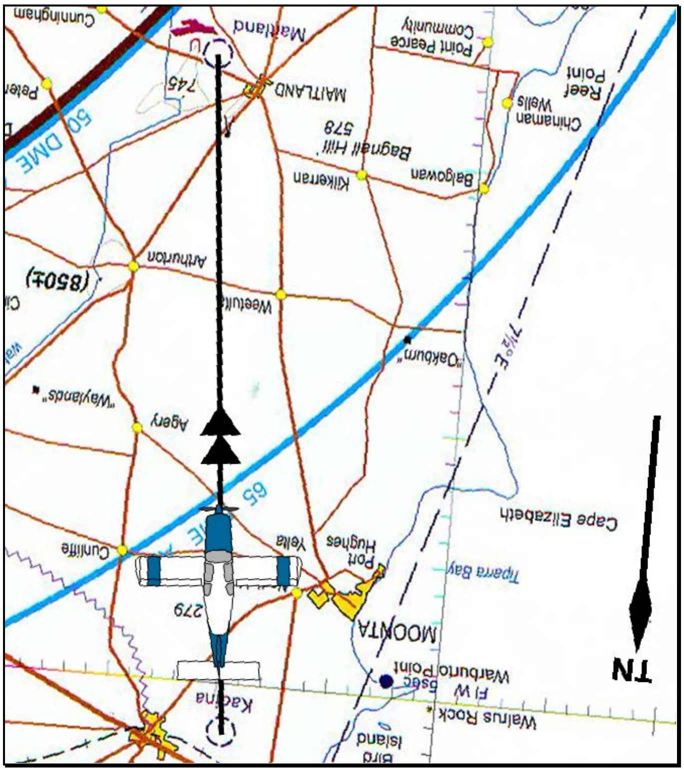
9.10 In-Flight Procedures

This next section will discuss elements of how the planning is put into action during the flight and will focus on the following:

- Chart orientation and map reading.
- Use of features when map reading.
- Establishment of a dead reckoning position.
- Actions when unsure of position.
- In-flight fuel management.
- Climb and descent calculations.

9.10.1 Chart Orientation and Map Reading

During the flight the chart is orientated with the track pointing away from the pilot towards the front of the aircraft. This ensures that the symbols on the map that indicate the different terrain features are orientated in the same manner as the features encountered along the flight, aiding the process of map reading.



Map reading is the process of interpreting the symbols on the chart and forming a mental picture of the terrain and features depicted by these symbols, in order to match this mental picture to the area the aircraft operates in.

Map reading allows the pilot to accurately fix the aircraft's position on the map and determine if the flight is going according to plan.

When relatively certain of position, the normal process of map reading is to read from the map to the ground; that is using the symbols on the map to create a mental image and then locating those specific features outside the aircraft, confirming the aircraft is located where the pilot thinks it is.

When less certain of position, the reverse is carried out. Map reading is done from ground to map. First locate large features towards the horizon and then identify them on the map. Progressively locate smaller, closer features outside the aircraft, and then identify them on the map, until the features located directly below, or close to the aircraft are identified and thereby the aircraft's position is established.

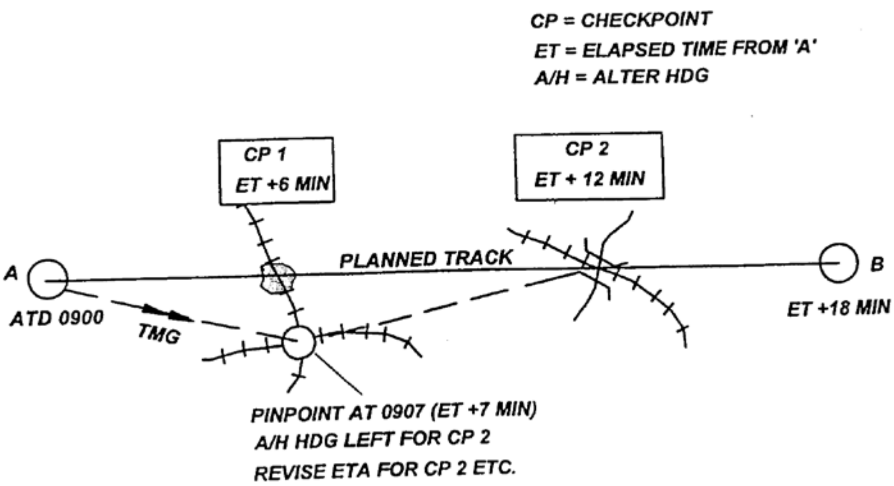
9.10.2 Use of Features When Map Reading

Map reading is a specific skill, requiring practice and experience to develop. Through proper flight planning and pre-flight route study, the professional pilot can make the task easier in flight.

In flight ensure the track is maintained or regained as soon as possible. Keep a good lookout for other traffic, weather or terrain to ensure safety.

When flying a route, whether using visual (map reading) or electronic methods of navigation, the pilot will be comparing:

- **Actual position with flight planned position** so that heading corrections can be made to regain planned track or to reach the end-of-leg Turning Point (TP). This allows mental assessment of the actual W/V affecting the aircraft and permits revision of future headings to make good the planned track(s).
- **Actual Time of Arrival (ATA) with flight plan Estimated Time of Arrival (ETA)** at checkpoints for updating of the ETA at future navigation checkpoints.



The success of map-reading techniques is determined by thorough pre-flight preparation. Study the route and select the best ground features to use for position and timing checkpoints. Produce an accurate flight plan of the route so that calculation of accurate timing for checkpoints can be made.

Two types of line features will be encountered during map reading:

- Line features running along the flight plan track.
- Line features located 90° across the flight plan track.

Line features located close to the flight plan track, orientated in the same direction as the flight plan track, can be used for track keeping purposes as an easy way to confirm the aircraft is on track or moving in the correct general direction. The closer the line feature follows the flight plan track the better use the feature will provide in the air. These features assist in determining the track made good.

Two line features that are perpendicular to the flight plan track can be used for groundspeed calculations. The time difference and distance between two features is used to calculate groundspeed. The closer the features are to an angle of 90° to track, the greater the accuracy of the groundspeed calculated.

An accurate track made good and groundspeed allows for an accurate prediction of where the aircraft will be at a future time. Updated groundspeed also allows the recalculation of leg times and updating of estimated time of arrival (ETA) at upcoming waypoints.

9.10.3 Establishment of a Dead Reckoning Position

The process of calculating the future position of the aircraft, based on a known track and groundspeed, is known as establishing a dead reckoning (DR) position.

To establish a DR position the pilot requires:

- Ground position (fix).
- Time at the fix.
- Current track.
- Groundspeed.

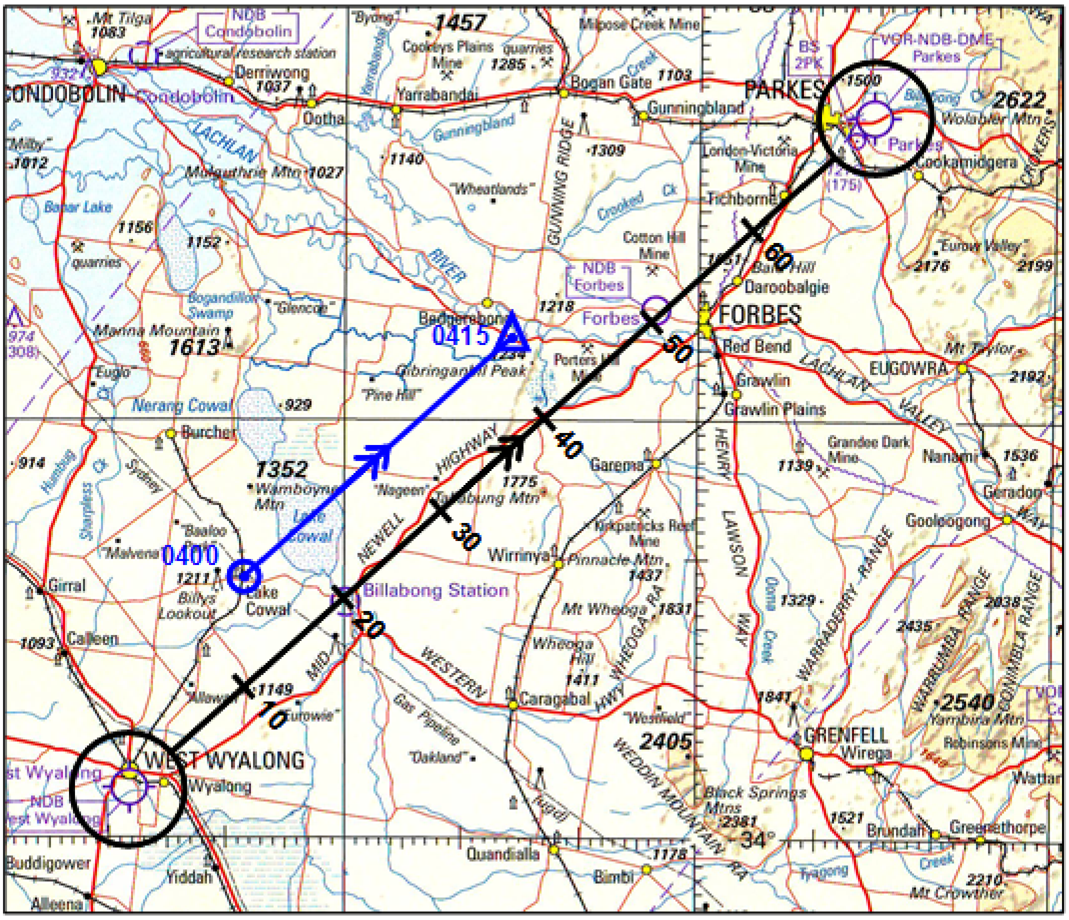
The track determines the direction of the vector to draw and the groundspeed for a chosen time determines the magnitude.

In the example below a flight plan track between West Wyalong and Parkes has been drawn and labelled with distance markers every 10nm. The aircraft departed West Wyalong and is overhead a station at 0400 UTC where a pipeline is crossing a railway line in an east-west direction.

The groundspeed is calculated to be 104kts and the aircraft has altered heading to parallel track. The pilot intends to use the Newell highway as a line feature to track parallel to the flight plan track towards Parkes, but wishes to alter heading for Parkes once the heading correction has been determined.

To allow the pilot time to calculate the required heading change whilst the aircraft is tracking parallel to track, the decision is made to calculate the aircraft's dead reckoning position for 0415 UTC. The pilot calculates that 104kts GS for 15mins is a distance of 26nm and draws a line parallel to track, 26nm in length to determine where the aircraft will be. The DR position will allow the pilot to know when and where the heading change for Parkes should be made.

From the location of the DR position, the pilot can identify the ground features that will assist to identify when the heading change should be made. This will simplify the navigation tasks and the pilot is now free to perform other tasks in the cockpit until these ground features are spotted and it is time to turn towards Parkes.



9.10.4 Actions When Unsure of Position

On becoming aware of position uncertainty immediate action should be taken to resolve the problem. A common mistake in such a situation is to concentrate too much on sorting out the position uncertainty. The pilot may then mismanage the fuel or fail to carry out other critical safety checks. Getting lost will probably not in itself cause an aircraft accident. Running out of fuel or running into a hill/mountain will.

- Check compass and ASI to ensure the correct heading and speed have been flown.
- Check that fuel is sufficient and the aircraft is not flying into a hazardous situation, e.g. poor weather, hilly or mountainous terrain, controlled airspace or prohibited/restricted/danger (PRD) areas.
- If possible (check weather and ATC restrictions), climb to increase visual horizon and radio range and fix the aircraft's position using all possible means (both radio navigation and visually).
- If unable to obtain a position fix, construct a Dead Reckoning (DR) position. This will be the best estimation of the aircraft's position computed from a last

known position, and subsequent track and distance over the ground since that position.

- Construct (mentally or by drawing) a circle (known as the circle of uncertainty) around this DR position with a radius of 10% of the distance flown since the last known position. Attempt to identify a ground feature within this circle (by map reading ground to map i.e. find a feature on the ground and try to relate it to a feature on the map).
- If still unable to establish position, turn the aircraft towards a good visual line feature outside the circle of uncertainty (e.g. coastline, motorway, major railway) and follow the line feature until a definite visual fix is obtained from which normal navigation can be resumed. Ensure a line feature is utilised that points in the same general direction as the intended direction of travel.
- If still uncertain of position or no suitable line (or other) ground feature exists, declare an emergency and/or land the aircraft at the nearest suitable airfield. Great care must be taken with fuel and terrain clearance monitoring and an excellent look out should be maintained, particularly if having to land at a major or busy airfield (e.g. due to fuel shortage).
- Make good use of the aircraft radio (which at this stage will probably be on an emergency frequency, and should be monitored by all ATC and other aircraft). An early call to ATC may prevent a minor uncertainty of position becoming a potential catastrophe.

9.10.5 In-Flight Fuel Management

During the flying phase the flying instructor will teach the student procedures that will assist them in managing the workload in the cockpit for tasks other than just navigation.

These procedures are a series of actions that occur before, overhead and just after passing over a turning point, to help organise the tasks of fuel management, engine management, radio work, lookout and navigation. For the moment only fuel management is discussed.

9.10.5.1 Fuel management

The fuel plan made before the flight serves as the baseline reference during the flight and great care is taken that the fuel consumption occurs as planned or in a more efficient manner in the air.

Periodically fuel checks will be done to compare the planned quantity of remaining fuel with actual amounts and calculate actual fuel flows and forecast new values for remaining fuel at upcoming waypoints.

If the actual fuel remaining is less than planned, immediate action should be taken to investigate and find a solution.

Should it be discovered at any stage that the actual fuel remaining is less than planned, then immediate action should be taken to investigate and find solutions to any problems that are found.

When reassessing the fuel plan in flight, the following fuel quantities need to be taken into consideration:

- Flight Fuel from present position to the destination (including to the alternate, if required).
- Variable reserve fuel (if required, based on 15% of the re-calculated flight fuel amount).
- Fixed reserve fuel (same as the pre-flight planning amount).
- Holding fuel (if required).

Fuel management in-flight is normally done at a position fix. At the fix the total fuel remaining is read from the fuel gauges and the pilot needs to know how much of the remaining fuel is flight fuel (i.e. available to be used) and what amount needs to be set aside as reserves.

It is also necessary to know if there is any margin fuel and if the aircraft will still be able to continue along the planned route to the destination. Often the latest safe endurance is also required to update the Point of No Return (PNR) for the flight.

Example: A pilot of a VFR charter flight obtains a fix en-route and performs a fuel check. Using the details below, calculate the updated safe endurance for the flight.

Fuel remaining:	135 litres
Start/taxi fuel:	5 litres
Cruise fuel flow:	40 litres per hour
Variable reserves:	As required
Fixed reserves:	As required for a fixed wing aircraft (piston engine)
Holding requirements:	15 mins at the cruise rate, due to traffic congestion.

If the flight fuel amount was known, or could be calculated, then the same method could be followed as when planning fuel requirements before flight. In this case the flight fuel is not known and a different approach is taken:

- Since the fuel check is done at a fix during the flight, the start/taxi fuel requirement does not need to be considered in the calculation.
- Determine which reserve fuel types are required for the operation by referring to the CAAP 234-1(1). This VFR charter flight, in a fixed wing (piston engine) aircraft, will require 15% variable reserves, 45 mins fixed reserves and holding fuel as indicated for traffic congestion.

- Calculate the amount of fixed reserves required. 45 mins × 40 litres per hour = 30 litres.
- Calculate the amount of holding fuel required. 15 mins × 40 litres per hour = 10 litres.
- The variable reserves can't be calculated yet, as it is based on a percentage value of the flight fuel, which is also not yet known.
- Subtract from the total fuel remaining the known values for fixed reserves and holding fuel. 135 litres total remaining – 30 litres fixed reserves – 10 litres holding = 95 litres.
- This amount is known as the 115% flight fuel, since it contains 100% of the flight fuel and the 15% variable reserve.
- Extract the 15% variable reserve from the 115% flight fuel amount. 95 litres ÷ 1.15 = 82.609 litres. Round this amount down to the nearest litre, ≈ 82 litres.
- The difference between this amount and the 115% flight fuel is the variable reserves. Variable reserves = 95 litres – 82 litres = 13 litres.
- Calculate the safe endurance (in minutes) using the flight fuel amount. 82 litres ÷ 40 litres per hour × 60 = 123 mins.

When using this method there will not be a separate margin fuel amount as the flight fuel so calculated would include any margin fuel that was in the aircraft before start.

Think of this flight fuel amount as being the total amount of fuel available for use during the flight that excludes the minimum legal amount of reserve fuel.

In an actual flight, the pilot can (by means of planned data), remaining distances measured on the chart, latest groundspeed, leg times and fuel flow values determine the actual amount of flight fuel that would be required. This value can be used to check if there is any margin fuel.

9.10.6 Climb and Descent Calculations

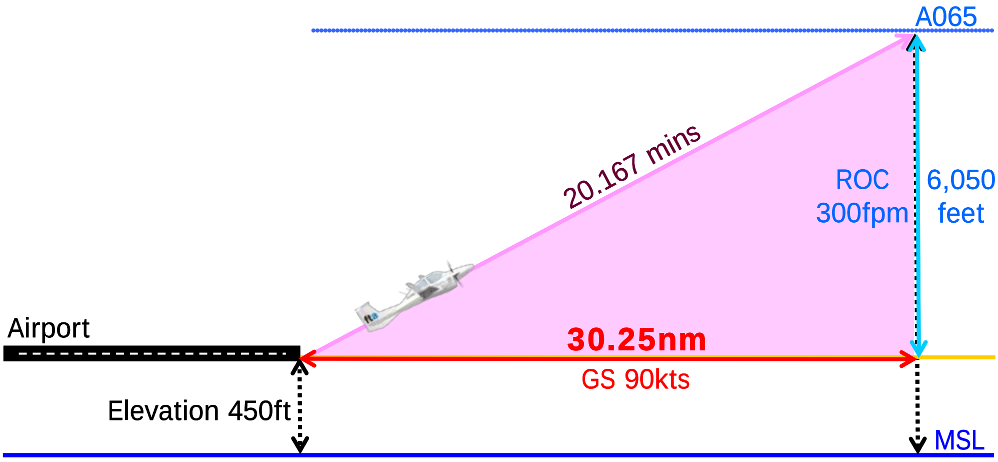
During the flight it is necessary to reassess the aircraft's climb or descent distance and rate of climb/descent as part of dealing with the changes to planning that occur during flying activities.

This could be to verify planned values or to cope with a new requirement due to changing circumstances or to comply with an instruction from air traffic control.

9.10.6.1 Calculating Climb Distance

To calculate the distance to climb to a target altitude, the climb groundspeed and rate of climb are required.

Example: An aircraft has departed a runway with elevation 450ft AMSL and is climbing to 6,500ft at 300 feet per minute. Determine the distance the climb would take, if it is maintaining a groundspeed of 90kts during the climb.



- Determine the altitude to gain.
  6,500ft – 450ft = 6,050ft.
- Determine the time to climb.
  6,050ft ÷ 300ft/min = 20.167mins.
- Determine the climb distance using the time (in hours) and the groundspeed.
  20.167mins ÷ 60 × 90kts = **30.25nm**.

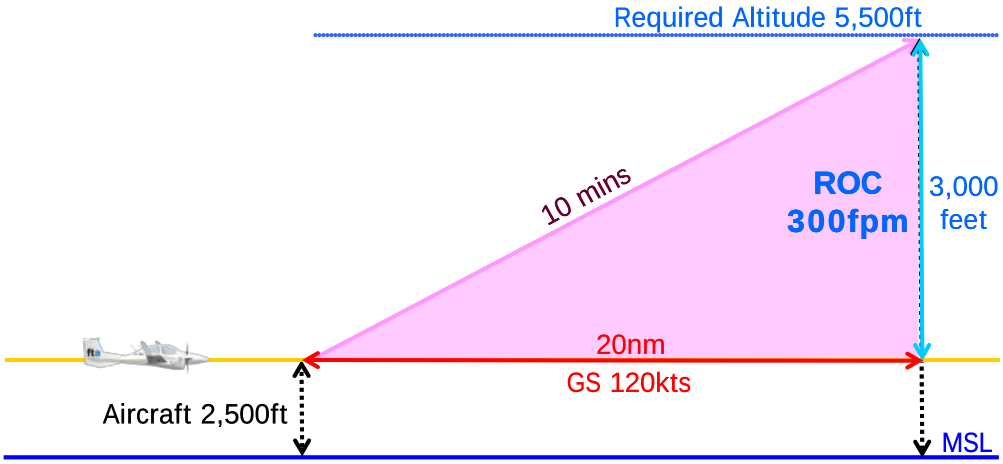
$$\text{Time (mins)} = \frac{\text{Altitude to climb (ft)}}{\text{ROC (ft/min)}}$$

$$\text{Dist (nm)} = \text{GS(kts)} \times \text{Time(hrs)}$$

9.10.6.2 Calculating Required Rate of Climb

Calculating the required rate of climb to attain a target altitude in a known distance, the groundspeed at which the climb is to take place needs also to be known. In general, the faster the groundspeed, the higher the rate of climb required in a set distance.

Example: The aircraft is currently 20nm from a mountain with elevation 4,700ft. Calculate the required rate of climb from the current position at 2,500ft to clear the mountain by 800ft, if the groundspeed is 120kts.



- Calculate the time to climb in minutes.
  20nm ÷ 120kts = 0.167hrs × 60 = 10mins.
- Determine the cruise altitude required.
  Mountain elevation is 4,700ft + 800ft clearance = 5,500ft required.
- Determine the altitude to climb.
  5,500ft – 2,500ft = 3,000ft to climb.
- Determine the rate of climb required.
  3,000ft ÷ 10mins = **300ft/min**.

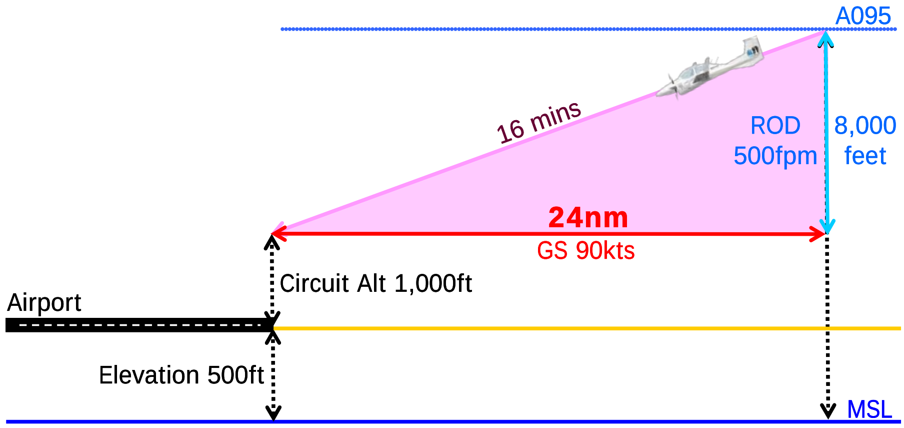
$$\text{ROC (ft/min)} = \frac{\text{Altitude to climb (ft)}}{\text{Time (mins)}}$$

$$\text{Time (hrs)} = \frac{\text{Dist (nm)}}{\text{GS (kts)}}$$

9.10.6.3 Calculating Descent Distance

Calculating how many miles it will take the aircraft to descend from a known altitude towards a desired altitude requires the descent groundspeed and rate of descent to be known.

Example: An aircraft is flying at A095 and wishes to descend to a circuit altitude of 1,000ft above an airport with elevation 500ft. The groundspeed during the descent will be 90kts and the rate of descent 500 feet per minute. Calculate how far from the airport the aircraft must start the descent.



- Determine the altitude to descend.
  9,500ft – 1,000ft – 500ft = 8,000ft.
- Determine the time to descend.
  8,000ft ÷ 500ft/min = 16mins.
- Determine the descent distance using the time (in hours) and the groundspeed.
  16mins ÷ 60 × 90kts = **24nm**.

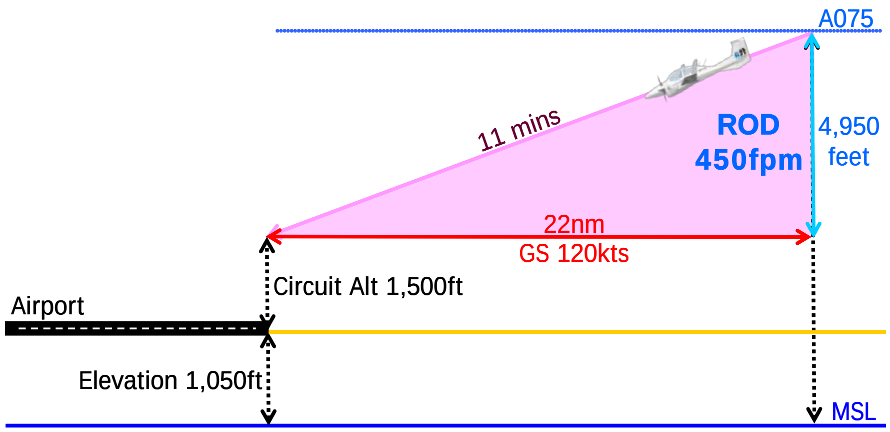
$$\text{Time (mins)} = \frac{\text{Altitude to descend (ft)}}{\text{ROD (ft/min)}}$$

$$\text{Dist (nm)} = \text{GS(kts)} \times \text{Time(hrs)}$$

9.10.6.4 Calculating Required Rate of Descent

Calculating the required rate of descent to lose a certain amount of altitude in a known distance requires the descent groundspeed to be known. In general, the faster the groundspeed, the higher the required rate of descent for a given distance.

Example: An aircraft cruising at A075 is required to descend to a circuit height of 1,500ft over the airport with elevation 1,050ft. The GS will be 120kts during the descent. If the descent must be started 22nm from the airport, what rate of descent is required?



- Calculate the time to descend in minutes.
  22nm ÷ 120kts = 0.183hrs × 60 = 11mins.
- Determine the altitude that the descent will end.
  Elevation 1,050ft + 1,500ft circuit altitude = 2,550ft.
- Determine the altitude to lose during the descent.
  7,500ft – 2,550ft = 4,950ft to lose.
- Determine the rate of descent required.
  4,950ft ÷ 11mins = **450ft/min**.

$$\text{ROD (ft/min)} = \frac{\text{Altitude to descend (ft)}}{\text{Time (mins)}}$$

$$\text{Time (hrs)} = \frac{\text{Dist (nm)}}{\text{GS (kts)}}$$

9.10.7 Summary

Important factors in achieving efficient pilot navigation are:

- Careful, complete and flight planning.
- Sensible use of mental DR procedures.
- Accuracy in flying.

Thorough flight planning is essential to the success of any flight. A definite sequence of planning should be followed to ensure that all necessary factors are covered, to the required depth. The importance of accuracy in all aspects of flight planning cannot be over emphasised.