Australian Government
Civil Aviation Safety Authority

Civil Aviation Advisory Publication

January 2016

Guidelines for aircraft fuel requirements

This Civil Aviation Advisory Publication (CAAP) provides guidance, interpretation and explanation on complying with the *Civil Aviation Regulations 1988* (CAR) or a Civil Aviation Order (CAO).

This CAAP provides advisory information to the aviation industry in support of a particular CAR or CAO. Ordinarily, the CAAP will provide additional 'how to' information not found in the source CAR, or elsewhere.

A CAAP is not intended to clarify the intent of a CAR, which must be clear from a reading of the regulation itself, nor may the CAAP contain mandatory requirements not contained in legislation.

***Note:** Read this advisory publication in conjunction with the appropriate regulations/orders.*

This CAAP will be of interest to:

- all operators of Australian registered aircraft.

Why this publication was written

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

Status of this CAAP

This is the second revision of this CAAP and supersedes CAAP 234-1(1) published November 2006. The changes in this revision are to:

- more closely align Australian legislation with ICAO Annex 6 Standards and Recommended Practices
- address recommendations from the Australian Transport Safety Bureau (ATSB) investigations into fuel related incidents and accidents
- adopt international standards for in-flight fuel management
- provide detailed guidance on the application of in-flight fuel management techniques.

The major changes included in this revision are:

- clarification of existing definitions and addition of new definitions
- reference to *Civil Aviation (Fuel Requirements) Instrument 2016* for fuel reserve requirements
- inclusion of 'additional fuel'
- expanded description of methods of determining fuel quantity.
- inclusion of a detailed description of in-flight fuel management procedures and practices.

For further information

Telephone the CASA office closest to you on 131 757.

Contents

The relevant regulations and other references

- Regulation 220 of CAR
- Regulation 234 of CAR
- CAO 82.0
- *Civil Aviation (Fuel Requirements) Instrument 2016*
- Annex 6, Operation of Aircraft to the Convention on International Civil Aviation (the Chicago Convention).
- ICAO Document 9976 – Flight Planning and Fuel Management (FPFM) Manual (2015)
- ICAO Doc 4444 PANS-ATM - Air Traffic Management (15th edition 13Nov14)
- CAAP 82-1(1) Extended Diversion Time Operations (EDTO)
- CAAP 215-1(1) Guide to the preparation of Operations Manuals

1. Acronyms and abbreviations

ATC	Air Traffic Control
ATS	Air Traffic Services
CAAP	Civil Aviation Advisory Publication
CAO	Civil Aviation Order
CAR	*Civil Aviation Regulations (1988)*
CASA	Civil Aviation Safety Authority
CASR	*Civil Aviation Safety Regulations (1998)*
CP	Critical Point
EDTO	Extended Diversion Time Operations
ETP	Equal Time Point

ISA	International Standard Atmosphere
MEL	Minimum equipment list
MMEL	Master minimum equipment list
OEM	Original Equipment Manufacturer
PNR	Point of No Return

2. Definitions

ADDITIONAL FUEL – the supplementary amount of fuel required if the minimum fuel calculated in accordance with paragraphs 5.2.1 and 5.3.1 is not sufficient to allow the aircraft to descend as necessary and proceed to an alternate aerodrome (or, for a helicopter, a suitable helicopter landing site) in the event of engine failure or loss of pressurisation—whichever requires the greater amount of fuel based on the assumption that such a failure occurs at the most critical point along the route—then fly for 15 minutes at holding speed at 1,500ft above aerodrome elevation in international standard atmosphere (ISA) conditions; and make an approach and landing. See Appendix B for further information.

> ***Note:*** *Fuel planning for a failure that occurs at the most critical point along a route may place the aeroplane in a fuel emergency situation.*

ALTERNATE AERODROME – an aerodrome to which an aircraft may proceed when it becomes either impossible or inadvisable to proceed to or to land at the destination aerodrome where the necessary services and facilities are available, where aircraft performance requirements can be met and which is operational at the expected time of use.

ALTERNATE FUEL – the amount of fuel required to enable the aircraft to perform a missed approach at the destination aerodrome, climb to the expected cruising altitude, fly the expected routing, descend to the point where the expected approach is initiated; and conduct the approach and landing at the destination alternate aerodrome.

BALLAST FUEL – fuel that may be required to be carried to maintain the aircraft centre of gravity within limits. In certain aeroplanes, a zero fuel weight above a defined threshold requires that a minimum amount of fuel be carried in the wing fuel tanks through all phases of flight to prevent excessive wing bending. In both cases, this fuel is considered ballast and is not considered part of the usable fuel load for the flight. This fuel shall not be consumed except in emergency circumstances.

CRITICAL POINT (CP) – is the point along a route that is most critical from a fuel requirement point of view. It is the point from which an aeroplane can proceed towards the destination aerodrome or initiate a diversion to an alternate aerodrome. The CP is usually, but not always, the last equal-time point (ETP; see below) along the planned route.

DESTINATION AERODROME – the aerodrome to which a flight is planned.

DESTINATION ALTERNATE – an alternate aerodrome at which an aircraft would be able to land should it become either impossible or inadvisable to land at the destination aerodrome.

> ***Note:*** *The aerodrome from which a flight departs may also be an en-route alternate or destination alternate aerodrome for that flight.*

EMERGENCY FUEL – is a situation of fuel emergency when the calculated usable fuel predicted to be available upon landing at the nearest aerodrome where a safe landing can be made is less than the fixed fuel reserve and as a result of this predicted fuel state, the aircraft requires immediate assistance.

> ***Note:*** *MAYDAY FUEL DECLARATION is a distress message indicating the pilot-in-command has assessed that the aircraft is threatened with grave and imminent danger and requires immediate assistance.*

EN-ROUTE ALTERNATE (ERA) – an alternate aerodrome at which an aircraft would be able to land in the event that a diversion becomes necessary while en-route.

EQUAL TIME POINT (ETP; also referred to as the 'equi-time point') – is a point along the planned route that is located at the same flight time from any two aerodromes.

EXTRA FUEL – is the supplementary amount of fuel carried at the discretion of the pilot-in-command.

FIXED FUEL RESERVE – the amount of fuel, expressed as a period of time, required to fly at holding speed at 1,500 feet above aerodrome elevation at ISA conditions, calculated with the estimated weight on arrival at the destination alternate aerodrome, or the destination aerodrome when no destination alternate aerodrome is required, that would be useable fuel remaining in the fuel tanks until completion of the final landing.

> ***Note:*** *The values of fixed fuel reserve to be applied by type and category of operation are contained in Table 1.*

HOLDING FUEL – the quantity of fuel that will allow an aircraft to fly for a specified period of time calculated at the holding fuel consumption rate established for the aircraft for the anticipated operational conditions, environmental conditions or ISA as applicable.

MASTER MINIMUM EQUIPMENT LIST (MMEL) – A list established for a particular aircraft type by the original equipment manufacturer (OEM) responsible for the type design, with the approval by CASA containing items that are permitted to be unserviceable at the commencement of a flight. The MMEL may be associated with special operating conditions, limitations or procedures.

MINIMUM FUEL – occurs when, having committed to land at a specific aerodrome, the pilot calculates that any change to the existing clearance to that aerodrome may result in landing with less than fixed fuel reserve.

> ***Note:*** *The declaration of MINIMUM FUEL informs air traffic control (ATC) that all planned aerodrome options have been reduced to a specific aerodrome of intended landing and any change to the existing clearance may result in landing with less than fixed fuel reserve. This is not an emergency situation but an indication that an emergency situation is possible should any additional delay occur. Pilots should not expect any form of priority handling as a result of a MINIMUM FUEL declaration. ATC will, however, advise the flight crew of any additional expected delays as well as coordinate when transferring control of the aircraft to ensure other ATC units are aware of the aircraft's fuel state.*

POINT OF NO RETURN (PNR) – the last possible geographic point at which an aircraft can proceed to the destination aerodrome as well as to an available en-route alternate aerodrome for a given flight. It is the point beyond which diversion to the en-route alternate aerodrome is no longer possible and the pilot is committed to proceeding to the destination aerodrome.

REMOTE ISLAND - Christmas Island, the Cocos (Keeling) Islands, Lord Howe Island or Norfolk Island.

TAKE-OFF ALTERNATE – an alternate aerodrome at which an aircraft would be able to land should this become necessary shortly after take-off and it is not possible to use the aerodrome of departure.

TAXI FUEL – the amount of fuel expected to be used prior to take-off. Local conditions at the departure aerodrome and auxiliary power unit consumption (if applicable) shall be taken into account.

> ***Note:*** *For helicopter operations requiring a take-off prior to taxi, such as hover taxi from a confined helipad, taxi fuel would be the fuel expected to the consumed prior to the commencement of the departure.*

TRIP FUEL – the amount of fuel required to enable the aircraft to fly from take-off, or the point of in-flight re-planning, until landing at the destination aerodrome, taking into account the operating conditions in paragraph 4.3. This includes (as applicable):

a. fuel for take-off and climb from departure aerodrome elevation to initial cruising level/altitude, taking into account the expected departure routing
b. fuel for cruise from top of climb to top of descent, including any step climb/descent
c. fuel from top of descent to the point where the approach is initiated, taking into account the expected arrival procedure
d. fuel for conducting an approach and landing at the destination aerodrome.

UNFORESEEN FACTORS – factors that could have an effect on fuel consumption to the destination aerodrome, such as deviations of an individual aeroplane from the expected fuel consumption data, deviations from forecast meteorological conditions, extended delays and deviations from planned routings and/or cruising levels.

VARIABLE FUEL RESERVE – the amount of fuel required to compensate for unforeseen factors. It shall be the highest of the percentage of the planned trip fuel specified in Table 1 for the applicable category and class of aircraft or, in the event of in-flight re-planning, the percentage specified in Table 1 for the remainder of the flight, or the fuel required to fly for 5 minutes at holding speed at 1,500 ft above the destination aerodrome elevation in ISA conditions.

3. Introduction

3.1 Aircraft fuel management

3.1.1 The total quantity of usable fuel required to be carried on board an aircraft must be sufficient for the planned flight and must include a safe margin for deviations from the planned operation.

3.1.2 The primary goal of effective fuel management is to ensure protection of fuel reserves to allow safe completion of flight, with a secondary goal of improving operational efficiency by reducing unnecessary fuel uplift.

3.2 Basic principles

3.2.1 The basic principles of aircraft fuel management are divided into four broad topics that address fuel-related considerations and procedures:

- the matters to be considered in determining sufficient fuel quantity for flight (section 4)
- determining the quantity of fuel that must be carried for a flight (section 5)
- determining and monitoring fuel quantity (section 6)
- procedures to be followed in the event of fuel quantity below specified levels (section 7).

4. Matters to be considered in determining sufficient fuel quantity for a flight

4.1 General

4.1.1 In order to mitigate some of the risks posed by the variability of the aviation environment, a range of fuel-related matters must be considered[1] to ensure that a fuel quantity sufficient to ensure the safe completion of flight is determined before the flight is commenced and thereafter continued.

4.2 Aircraft-specific fuel consumption data

4.2.1 Effective fuel planning and fuel management rely on the accuracy of the predicted fuel consumption rate. The accuracy of the fuel consumption data used for planning and decision making depends on the source of that data.

4.2.2 Where available, current aircraft-specific fuel consumption data derived from a fuel consumption monitoring system must be used[2]. In the absence of such data, the original equipment manufacturer's (OEM) fuel consumption data must be used2. Where the OEM aircraft flight manual or pilot's operating handbook does not contain such data, the engine manufacturer's fuel consumption data should be used.

Note: This may be the case for certain reciprocating engine helicopters (e.g. Enstrom).

4.2.3 Where no specific fuel consumption data exists for the precise conditions of the flight, the aircraft may be operated in accordance with estimated fuel consumption data.

4.3 Operating conditions for the planned flight

4.3.1 The following operating conditions potentially affect the predicted fuel consumption for a planned flight:

- anticipated weight of the aircraft
- Notices to Airmen
- meteorological reports and forecasts (i.e. temperature, wind, turbulence, icing, smoke)
- ATS procedures, restrictions and anticipated delays
- effects of deferred maintenance items and/or configuration deviations e.g. configuration deviation list or supplementary type certificate.

[1] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 3
[2] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 3

4.4 Potential deviations from planned flight path

4.4.1 The pre-flight planning stage should produce an efficient flight plan that provides minimum sector time (and associated minimum fuel consumption) on the best possible route that avoids adverse weather conditions and follows all air traffic management requirements.

4.4.2 Pilots and operators must2 consider the adverse effects on fuel consumption of potential or likely deviations from the optimum planned path or flight conditions. To this end, flight planning must be based on realistic assumptions and assessments. When potential or likely deviations from planned fuel consumption are not well considered, there is an increased likelihood that the actual fuel consumption may exceed planned consumption, with possible erosion of safety margins.

> ***Note:*** *Area work flights such as scenic, surveillance or survey operations may not seek to minimise sector time. Those types of flights should; however, consider the optimum flight path for the final route segment when returning to land and the potential for deviations from that routing.*

4.4.3 The carriage of variable fuel reserve will, to some degree, mitigate the risk of unforeseen factors.

5. Quantity of fuel that must be carried for a flight

5.1 Fuel reserves

5.1.1 The quantities of fixed fuel reserves and variable fuel reserves required for a flight are prescribed in *Civil Aviation (Fuel Requirements) Instrument 2016* and reproduced in Table 1.

	Aeroplanes & Airships							
	Private & Aerial work				RPT & Charter			
	Piston		Turbine or Jet		Piston		Turbine or Jet	
	VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR
Fixed fuel reserve	45 mins	45 mins	30 mins	30 mins	45 mins	45 mins	30 mins	30 mins
Variable fuel reserve	Not Applicable	Not Applicable	Not Applicable	Not Applicable	15% (not less than 5 mins)	15% (not less than 5 mins)	10% (not less than 5 mins)	10% (not less than 5 mins)

	Helicopters			
	Private & Aerial work		RPT & Charter	
	VFR	IFR	VFR	IFR
Fixed fuel reserve	20 mins	30 mins	20 mins	30 mins
Variable fuel reserve	Not Applicable	Not Applicable	15% (not less than 5 mins)	15% (not less than 5 mins)

Table 1: Fixed fuel reserve and variable fuel reserve requirements

Note: *Variable reserve for RPT and charter operations is the higher of either:*

a) the specified percentage (%) of trip fuel (as time)

b) an amount of fuel to fly for 5 minutes at holding speed at 1,500 ft above the destination aerodrome elevation in ISA conditions.

5.1.2 When variable fuel reserve is required, the minimum value of 5 minutes is intended to mitigate the risk of unforeseen factors that are not proportional to the length of flight, but to a per-sector occurrence, such as unexpected holding, delays or additional tracking within the arrival terminal area.

5.2 Usable fuel quantity required at the commencement of a flight

5.2.1 The pre-flight planning process must[3] include a calculation of the quantity of usable fuel an aircraft must carry before the flight commences. The quantity of usable fuel required to be on board at the commencement of a flight must3 include:

- taxi fuel
- trip fuel
- variable fuel reserve (if applicable)
- alternate fuel (if applicable)
- fixed fuel reserve
- holding fuel (if applicable)
- additional fuel (if applicable).

5.2.2 The commencement of a flight is when the aircraft first moves under its own power for the purpose of take-off. There may, however, be helicopter operations that, for the purposes of departing the aerodrome, require an airborne segment of the taxi before take-off.

5.3 Usable fuel quantity required to continue a flight

5.3.1 The quantity of usable fuel required to be on board from the point of in-flight re-planning must[4] include:

- trip fuel
- variable fuel reserve (if applicable)
- alternate fuel (if applicable)
- fixed fuel reserve
- holding fuel (if applicable)
- additional fuel (if applicable).

5.3.2 The quantity of usable fuel required to be on board to continue a flight must[5] include:

- trip fuel
- alternate fuel (if applicable)
- fixed fuel reserve
- holding fuel (if applicable)
- additional fuel (if applicable).

5.3.3 If, during a flight, the pilot decides to use fuel for a purpose other than was intended during pre-flight planning, they must[6] conduct a re-analysis and, if applicable, adjust the planned flight to ensure continued compliance with the minimum usable fuel requirements. This will ensure that fuel

[3] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 4.2
[4] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 4.2
[5] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 4.4
[6] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 4.3

that was intended or required for the continuation of the flight is not consumed during a prior flight phase without the pilot giving consideration to the consequences.

5.3.4 It follows that consumption of taxi fuel in excess of that planned may reduce the quantity of remaining available fuel to less than the amount required to safely conduct the flight. In such a case, the flight may not proceed without re-planning. Similarly, the use of trip fuel in excess of that planned may reduce the quantity of available alternate fuel to less than the required amount, thus necessitating re-planning or diversion.

5.3.5 When planned fuel is not consumed in a prior phase, the surplus fuel may be used in a subsequent phase. For example, if a flight is planned with the requirement for a destination alternate and during the course of the flight that operational requirement is removed; the planned alternate fuel may be used for other purposes. However, the fixed fuel reserve must be preserved in all cases.

5.4 Usable fuel quantity required for flights to remote islands

5.4.1 Passenger-carrying aeroplane operations to remote islands—undertaken as RPT, charter or aerial work operations for ambulance functions (i.e. medical transport operations including positioning legs)—have additional specific conditions and requirements as detailed in CAO 82.0.

5.4.2 The ***minimum safe fuel*** for a passenger-carrying flight to a remote island is the greater of:

- the amount of fuel sufficient to enable the aeroplane to fly, with all its engines operating, to the remote island and then from the remote island to an alternate aerodrome that is not on a remote island, together with any required fuel reserves

  or
- the amount of fuel that would, if the failure of an engine or loss of pressurisation were to occur, enable the aeroplane to:
  - fly to the planned destination aerodrome or to the planned alternate aerodrome
  - fly for 15 minutes at holding speed at 1,500 ft above that aerodrome under ISA conditions
  - make an approach and land at that aerodrome.

5.4.3 CASA recommends that private flights to remote islands carry fuel quantities as described in paragraph 5.4.2, where possible.

5.5 Fuel quantity required for EDTO

5.5.1 Fuel quantity requirements, approvals and considerations for EDTO, as applicable to holders of an Air Operator’s Certificate, are contained in CAO 82.0 and detailed in CAAP 82-1(1).

6. Determining and monitoring fuel quantity

6.1 General

6.1.1 Knowing how much fuel is on-board during the flight is essential to safety. The process of determining and monitoring fuel quantity—to ensure fuel reserves are protected—is divided into three task phases in order to differentiate the priorities and consequential elements required as a flight commences and then continues:

- pre-flight fuel quantity checks (section 6.2)
- in-flight fuel quantity checks (section 6.3)
- in-flight fuel management (section 6.4).

6.2 Pre-flight fuel quantity checks

6.2.1 Before commencing a flight, the pilot-in-command must[7] ensure that a pre-flight determination of fuel quantity is conducted and that the quantity of usable fuel on board is recorded. It is critical that the actual usable fuel quantity on-board an aircraft at the commencement of, and during a flight, is known with certainty. The actual fuel quantity contained in the tanks at the commencement of the flight is the datum upon which fuel calculations and subsequent fuel-related decisions are based.

6.2.2 Unless assured and verified by the pilot-in-command that the aircraft fuel tanks are completely full, or a totally reliable and accurately graduated dipstick, sight gauge, drip gauge or tank tab reading can be made, the pilot-in-command should endeavour to use the best available fuel quantity crosscheck process before engine start. The crosscheck should use at least two different verification methods to determine the quantity of fuel on board. The following are examples of recommended verification combinations:

- check of visual readings (e.g. tank tab, dipstick, drip gauge, sight gauges) against fuel consumed indicator readings
- having regard to previous readings, a check of cockpit fuel quantity indications or visual readings against fuel consumed indicator readings
- after refuelling and having regard to previous readings, a check of cockpit fuel quantity indications or visual readings against the refuelling uplift readings
- when a series of flights is undertaken by the same pilot and refuelling is not carried out at intermediate stops, checking of the cockpit fuel quantity indications against computed fuel on board and/or fuel consumed indicator readings, provided the particular system is known to be reliable.

6.2.3 Fuel gauges, particularly on smaller aircraft, may be unreliable. Except when the fuel tank is full, it is difficult to accurately establish the quantity of fuel in a tank unless the aircraft is in the attitude recommended by the manufacturer and the manufacturer has provided an accurately graduated dipstick, sight gauge, drip gauge or fuel tank tab. Unless the aircraft is in the attitude recommended by the manufacturer, any direct reading of a partially filled tank should be discounted or rounded down to a figure consistent with the next lower tab or marking.

6.2.4 Placing sole reliance on a fuel quantity gauge to assess fuel quantity (i.e. not cross-checking fuel quantity information from a second source), exposes the pilot-in-command to the risk

[7] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 5.1

of being unable to determine actual fuel remaining should the fuel quantity gauge indication become faulty.

6.2.5 Given the designs and location of helicopter fuel tank installations, it is often difficult to obtain a direct reading of fuel tank quantity at a level other than full. In order to ensure an accurate fuel quantity, it is imperative that flight times and fuel uplifts are recorded and routinely reconciled as part of the fuel quantity cross-checks. The accurate recording of flight times and respective fuel uplifts presents an additional means of tracking actual fuel consumption for subsequent flight planning and in-flight fuel management decision-making.

6.2.6 Modern certified fuel quantity indication systems can integrate fuel tank probe volume readings and fuel density measurements, combined with full authority digital engine control engine fuel consumption information, to present the flight crew with the weight of the fuel remaining in the fuel tanks. These systems may also contain independent fuel tank low fuel level warning sensors. Even so, the manufacturers of these systems still recommend that the flight crew conduct regular in-flight checks to confirm anticipations and detect any discrepancies.

6.3 In-flight fuel quantity checks

6.3.1 The pilot-in-command must[8] ensure that fuel quantity checks are carried out in-flight at regular intervals. The established quantity of usable fuel remaining is evaluated to:

- compare actual fuel consumption with planned fuel consumption
- determine that the usable fuel remaining is sufficient to complete the planned flight (see paragraph 5.3.2)
- determine the expected usable fuel remaining on landing at the destination aerodrome.

6.3.2 The interval between in-flight fuel quantity checks should be sufficient to allow the pilot-in-command to remain aware of the aircraft fuel state. In addition to periodic fuel quantity checks, there are specific instances where an additional fuel check is needed to ensure that in-flight decisions are supported by accurate fuel state awareness. For example, specific checks are needed before passing a critical point (i.e. ETP/PNR/CP).

6.3.3 Whenever possible, the in-flight fuel quantity checks should include a reconciliation of the fuel remaining indicated from the available aircraft fuel quantity indication systems, such as debit-meters. Raw data information, such as fuel quantity gauges, should also be checked to confirm fuel balance and fuel tank quantity against known fuel usage so as to minimise the possibility of an undetected fuel leak. The maximum efficiency for fuel quantity checks is achieved when conducted at regular intervals and follow a consistently applied methodology.

6.3.4 The relevant fuel quantity data must[9] be recorded after the specific in-flight fuel quantity checks are completed.

6.4 In-flight fuel management

6.4.1 After a flight has commenced, in-flight fuel management is the practical means by which the pilot-in-command ensures that fuel is used in the manner intended during pre-flight planning, or in-flight re-planning.

6.4.2 In-fight fuel management does not replace pre-flight planning or in-flight re-planning activities, rather it acts to ensure continual validation of planning assumptions that influence fuel

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[8] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 5.2
[9] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 5.3

usage and required fuel reserves. Such validation serves as a trigger for re-analysis and adjustment activities that ultimately ensure that each flight is safely completed with the planned fixed fuel reserve on board at an aerodrome where a safe landing can be made.

6.4.3 The pilot-in-command should ensure that a critical point of last diversion to the final en-route alternate is identified during the pre-flight planning stage. This is particularly important when operating to a remote island. During the course of the flight, the critical point should be assessed and, if necessary, revised based upon actual fuel consumption and in-flight conditions.

6.4.4 The revised critical point then becomes the last point by which the pilot-in-command should obtain and assess updated destination information (i.e. meteorological conditions, traffic and other operational conditions at the destination aerodrome) in order to validate the destination planning assumptions and allow timely diversion to occur if necessary (i.e. the revised critical point is the final opportunity to assess options for preserving the required fuel reserves should the destination aerodrome no longer be available).

6.4.5 An example methodology for in-flight fuel management includes the four process steps: monitor, analyse, formulate and modify (Figure 1). Refer to Appendix A for a detailed description of these process steps, including the iterations between steps.

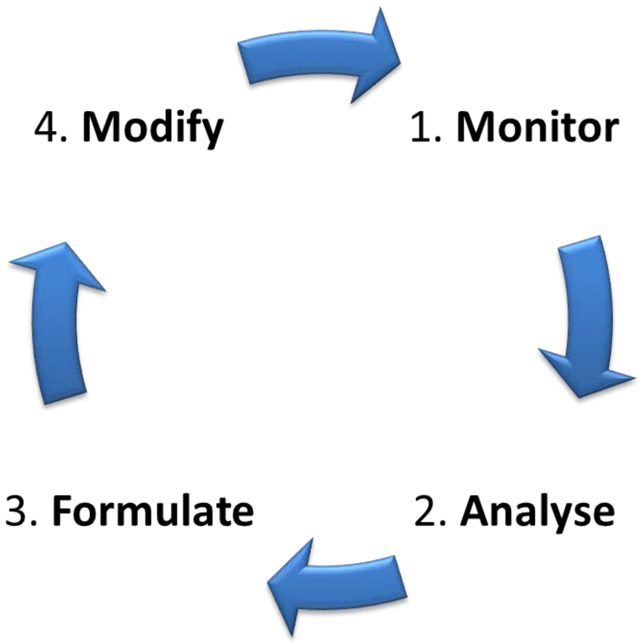

Figure 1: Process steps for in-flight fuel management

7. Procedures in the event of fuel quantity below specified levels

7.1 Identification and communication of fuel states

7.1.1 Four procedural steps can be used to identify and communicate situations in which the fuel quantity falls below the threshold level for that step (2). A detailed description of each step follows in sub-sections 7.2 to 7.5.

Steps to identify and communicate fuel states	
Step 1	The pilot-in-command is to continually ensure that the amount of usable fuel remaining on board is not less than the fuel required to proceed to an aerodrome where a safe landing can be made, with the planned fixed fuel reserve remaining upon landing.
Step 2	Request delay information when unexpected circumstances may result in landing at the destination aerodrome with less than the fixed fuel reserve.
Step 3	Declare “MINUMUM FUEL” when committed to land at a specific aerodrome and any change in the existing clearance may result in a landing with less than planned fixed fuel reserve.
Step 4	Declare a fuel emergency when the calculated fuel on landing at the nearest suitable aerodrome (i.e. where a safe landing can be made) will be less than the planned fixed fuel reserve.

Table 2: Steps to protect fuel reserves

7.2 Step 1: In-flight fuel check value less than planned value (not less than required)

7.2.1 If, as a result of an in-flight fuel quantity check, the actual fuel remaining is less than the planned fuel remaining and is close to the minimum amount specified—but not projected to be less than the required fixed fuel reserve for the planned flight—the pilot-in-command should endeavour to restore fuel safety margins provided by the variable fuel reserve (as applicable) by:

- flying at a more economical speed than planned
- seeking a more economical cruise level
- seeking more efficient routing from ATC
- re-routing to reduce the length of the critical diversion
- selecting a different (closer) destination alternate if feasible.

7.3 Step 2: Expected fuel remaining is approaching minimum values

7.3.1 When the pilot-in-command recognises that unexpected circumstances may result in the aircraft landing at the destination aerodrome with less than the fuel required to proceed to an alternate aerodrome (if applicable) plus fixed fuel reserve, they should request delay information from ATC.

7.3.2 The request for delay information is not a request for assistance or an indication of urgency. It is simply a procedural means for the pilot-in-command to determine an appropriate course of action when confronted with unexpected delays.

7.3.3 There is no specific phraseology recommended for use with ATC in this case as each situation may be different. The pilot-in-command would use the information obtained from ATC to determine the best course of action, up to and including a determination of when it would be necessary to divert to an alternate aerodrome and/or make additional declarations related to the fuel state of the flight.

7.4 Step 3: 'Minimum fuel' state

7.4.1 After a request for delay information, the minimum fuel declaration represents the third step taken by the pilot-in-command to ensure remaining fuel on board is used as planned and the fixed fuel reserve is protected. The pilot-in-command must[10] declare "MINIMUM FUEL" when, based on the current ATC clearance at the aerodrome to which the aeroplane is committed, the amount of fuel predicted to be remaining upon landing will approach the planned fixed fuel reserve quantity.

7.4.2 The minimum fuel declaration is intended to convey that, provided the current clearance is not adversely modified, the flight should be able to proceed as cleared without compromising the pilot-in-command's responsibility to protect the fixed fuel reserve.

7.5 Step 4: 'Emergency fuel' situation

7.5.1 The last line of defence to ensure the safe completion of a flight is the declaration of an emergency. The pilot-in-command must[11] determine that the aircraft is in an emergency fuel situation when the usable fuel predicted to be remaining upon landing at the nearest suitable aerodrome (i.e. where a safe landing can be made) will be less than the required fixed fuel reserve. The "MAYDAY FUEL" declaration is used when all opportunities to protect the required fixed fuel reserve have been exhausted and, in the judgment of the pilot-in-command, the flight will land with less than fixed fuel reserve remaining in the tanks.

7.5.2 The pilot-in-command must declare11 an emergency fuel situation by broadcasting "MAYDAY MAYDAY MAYDAY FUEL". This declaration provides the clearest and most urgent expression of an emergency situation brought about by an insufficient quantity of usable fuel remaining to protect the fixed fuel reserve. It communicates that immediate action must be taken by both the pilot-in-command and the ATC authority to ensure that the aircraft can land as soon as possible.

7.5.3 The "MAYDAY FUEL" declaration is used when all opportunities to protect the required fixed fuel reserve have been exhausted and in the judgment of the pilot-in-command, the flight will now land with less than fixed fuel reserve remaining in the tanks. The word "FUEL" is used as part of the emergency declaration simply to convey the nature of the emergency to ATC. It is also important to note that an emergency declaration not only opens all options for pilots (e.g. available closed runways, military fields, etc.) but it also allows ATC to apply extra flexibility in handling the aircraft.

[10] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 6.3
[11] *Civil Aviation (Fuel Requirements) Instrument 2016*, paragraph 6.4

8. Helicopter fuel differences

8.1 General

8.1.1 Whilst the requirements for helicopters generally follow the same rules as for aeroplanes, the ability of the helicopter to land safely away from aerodromes influences the required fuel reserve quantities.

8.1.2 Flights over hostile terrain or populated areas (i.e. where precautionary landings are not possible or that present a consequential survival problem) may prompt the carriage of increased fuel reserves in order to mitigate the risks posed by the limited options for a safe precautionary landing.

Appendix A Appendix A – In-flight fuel management

The four step process for in-flight fuel management (sub-section 6.4) is described below. It includes a brief overview of information elements integral to the in-flight fuel management decision-making process.

Monitor

Monitoring involves the collection of information in order to determine the adequacy of the current flight plan in ensuring preservation of the required fuel reserves. This step involves gathering relevant information from a diverse range of sources, including cockpit instruments, other pilot reports, ATC and personal observations.

Analyse

Analysis involves the integration of information gathered during the monitoring process to determine whether the current fuel plan is adequate. Monitoring is generally a prioritised data collection task, whilst analysis is a higher level process requiring judgement.

The decision as to whether a fuel plan is adequate can be modelled as a comparison against some form of threshold of acceptability. This threshold may include factors such as regulatory requirements, safety, efficiency, aircraft performance constraints and subjective preferences. In practice, due to the large number of variables involved, it is difficult to determine an explicit description of the analysis.

If analysis of the situation reveals that the current flight plan is adequate, then the monitoring and analysis cycle is continued. If, however, analysis indicates that the plan is inadequate e.g. due to severe weather along the route of flight, the pilot should begin to formulate alternative plans.

Formulate

Formulation is similar to monitoring in that it commences with the collection of information. However, it differs from monitoring in that formulation gathers specific information in order to generate and evaluate options to deviate from the current plan and to devise a new plan.

Once formulated, the alternative plan is subjected to decision-making; this may result in the alternative plan being rejected, in which case additional cycles of formulation and analysis will be required.

Alternative plan formulation is not necessarily initiated by the recognition of a deficiency in the current plan. Pilots generally formulate and analyse alternative plans as a matter of course during a flight, both to determine whether a more preferable course of action is possible and also to 'stay ahead of the aircraft' should re-planning become a necessity at a later time.

The monitoring, analysis, and formulation process depends on a number of information elements upon which decisions are based. These information elements can be grouped into four categories: hazards, efficiency, comfort, and constraints. Hazard information includes external factors that may pose a threat to safety, including terrain, traffic, severe weather, icing, or windshear. Efficiency considerations include winds, fuel usage, and flight time. Comfort considerations include ride quality, turbulence, and workload in developing, implementing, and monitoring the flight plan. Finally, constraints include aircraft performance, airspace restrictions, information accuracy, and system failures or degraded system operations.

Any decision to modify the flight-path requires that the pilot find a suitable balance between the potential impacts of the four information categories. For example, maintaining a large margin around weather improves safety and ride quality, but negatively impacts fuel usage and time.

Achieving a balance requires some degree of knowledge of the relative importance of each element. The conditions most likely to be initiators of the re-planning process are weather, fuel, traffic delay at destination and en-route wind conditions. The pilot-in-command should ensure that the balance of considerations does not result in a flight continuing to an aerodrome where the required fuel reserves are not assured. *That is, safety considerations must be prioritised at all times.*

Modify

Modification involves the physical implementation of the new plan.

Following modification, the in-flight fuel management process begins again as the newly implemented plan becomes the basis for further monitoring, analysis formulation.

Appendix B Appendix B - Additional fuel calculation

Scenario 1 – Additional fuel not required

Figure 2 illustrates a scenario where the uplift of additional fuel is not required. The 'basic fuel' calculation for the flight results in a greater quantity of fuel than the 'additional fuel' calculation.

While variable fuel can be used on the ground, this would not be the case if all or some of the variable fuel is used in the equation to determine the required additional fuel. As such, if part or all of the variable fuel is part of the equation to determine the amount of additional fuel, it may not be used on the ground and must be available at the commencement of take-off or the point of in-flight re-planning.

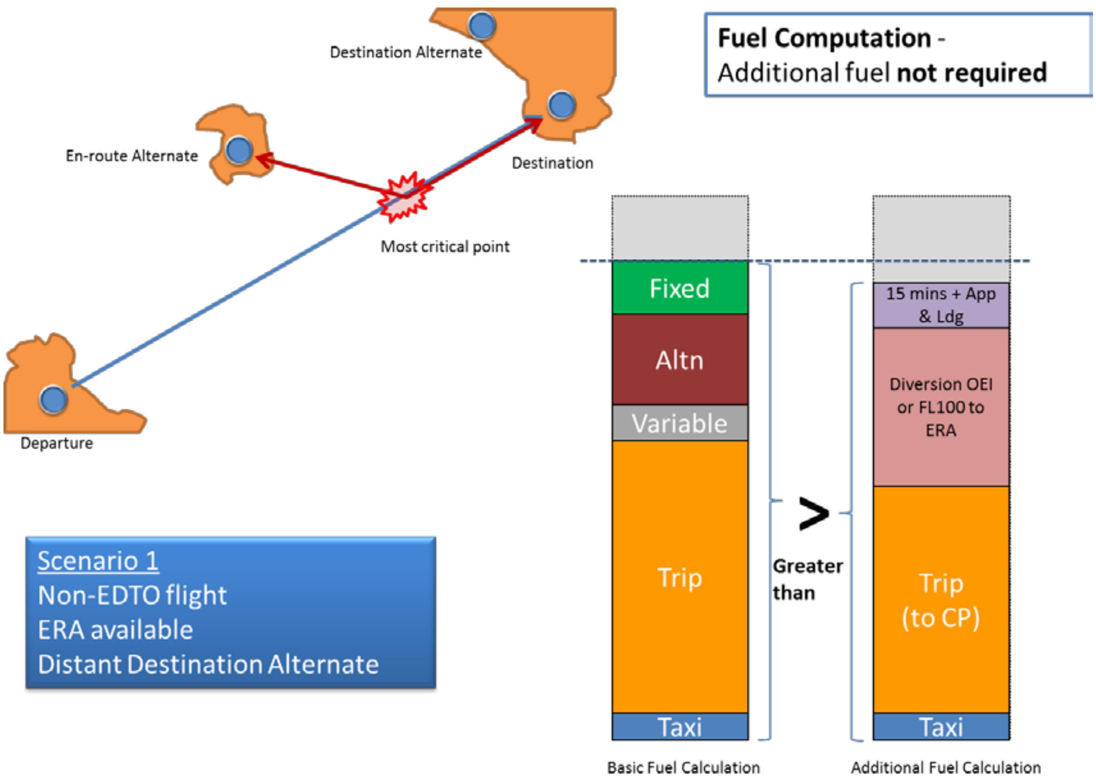

Figure 2: Fuel calculation scenario – additional fuel not required

Scenario 2 – Additional fuel required

The scenario illustrated in Figure 3 varies from Figure 2 in that the en-route alternate (ERA) is more distant from the CP and the destination alternate is closer to the destination. This scenario now results in a 'basic fuel' calculation being less than the fuel required meeting the 'additional fuel' calculation, and therefore the flight is required to uplift additional fuel.

In this case it should be noted that all of the variable fuel is considered in the equation of additional fuel equation and, as such, the variable fuel cannot be used on the ground or before reaching the point of in-flight re-planning.

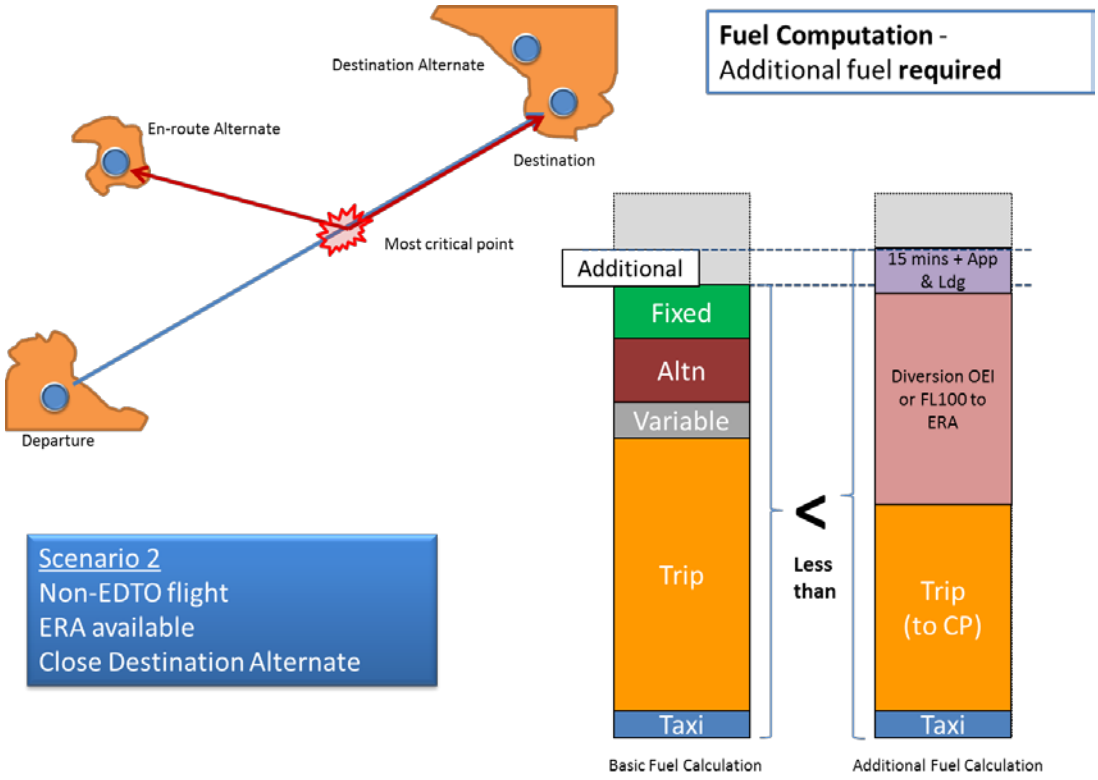

Figure 3: Fuel calculation scenario –additional fuel required