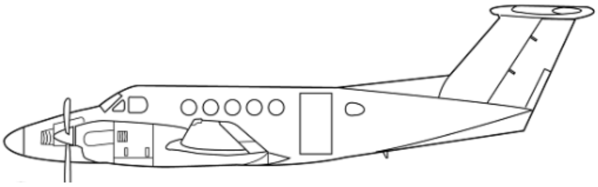
ANNEX B to AC 91-15

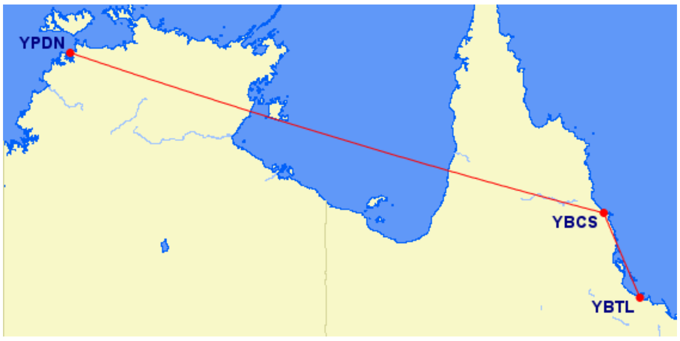
Guidelines for aircraft fuel requirements

Sample fuel calculations - Multi-engine turboprop aeroplane (Beechcraft B200)

Scenario and conditions



Flight Route Scenario is from Darwin to Cairns in a Super King Air (B200). Townsville is the destination alternate aerodrome for the scenario development where a destination alternate aerodrome becomes required.



Route distance:	906 NM
Destination alternate distance:	153 NM
Aircraft take-off weight:	12 500 lbs
Usable fuel capacity:	3 645 lbs
Climb wind and temp:	20 kt headwind, ISA +20 deg
Cruise wind and temp:	40 kt headwind, ISA +20 deg
10 000 ft wind and temp:	20 kt headwind, ISA +20 deg
Descent wind and temp:	10 kt headwind, ISA +20 deg

Note: Wind and temperature for climb is generally taken at 2/3 of the cruise height. For descent, it is generally taken at ½ of the descent height.

Performance data – from POH/AFM

Extracted from Beechcraft Super King Air B200/B200C POH/AFM Section 5. This Annex assumes knowledge of how to extract performance data from an AFM so charts will not be reproduced.

The methods described here follow those explained in the B200/B200C POH/AFM. Pilots are reminded that they must comply with the requirements of their aircraft's AFM.

Units of measurement

As stated in the B200/B200C POH/AFM, he unit of measurement for fuel values will be pounds (lbs). However, in these examples the fuel uplift information has been stated in litres (L). The conversion of Jet A from lbs to L is based on a conversion factor of 1.76.

Note: Where fuel values contain varied units of measurement, care must be taken to ensure that the conversion of those values is based on correct information and accurately performed.

Usable fuel required at the commencement of a flight

Part 91 of CASR prescribes that the following amounts of fuel must be on board at the commencement of a flight:

- taxi fuel
- trip fuel
- destination alternate fuel (if required)
- holding fuel (if required)
- contingency fuel (if applicable)
- final reserve fuel
- additional fuel (if applicable).

Darwin to Cairns – IFR – no destination alternate aerodrome

Taxi fuel

From the B200/B200C POH/AFM, 90 lbs is the engine start, taxi, and take-off allowance and should be taken as the minimum figure. In situations where extended taxi or ground delay after starting can be anticipated, this value should be increased accordingly.

As take-off fuel is a component of trip fuel, a simple proportional estimate can be used to determine the start and taxi (and run-up if required) and the take-off.

- start and taxi: 40 lbs

Note: This is NOT part of trip fuel. While the AFM refers to 'start and taxi', for these calculations that amount of fuel will be referred to only as 'taxi'.

- take-off: 50 lbs

Note: Take-off fuel IS part of trip fuel.

Table 1: Taxi fuel

Item	Fuel amount	Minutes	lbs	Litres
a	Taxi fuel	0	40	23

Trip fuel

Trip fuel is the amount of fuel required to enable an aircraft to fly from any point along a route until landing at a destination aerodrome including (as applicable) the following:

a. fuel for take-off and climb from departure aerodrome elevation to initial cruising level or altitude, taking into account the expected departure routing
b. fuel for cruise from top of climb to top of descent, including any step climb or 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 executing an approach and landing at the planned destination aerodrome.

The B200/B200C POH/AFM recommends calculating fuel for take-off and climb followed by fuel for descent. It then suggests using the results of those calculations to determine fuel for cruise. That process will be used in this AC.

Fuel for take-off and climb

Data for time, fuel and distance to climb are provided in the B200/B200C POH/AFM. Calculations to determine time, fuel and distance to climb are shown in

Table 2.

Table 2: Calculation of time, fuel and distance to climb

Scenario data	Data from POH/AFM (normal climb section)	Wind corrections
Aircraft take-off weight: • 12,500 lbs	Outside air temperature (OAT): • -20 deg	TAS (distance/time): • 61 NM / 0.33 hr = 180 kt
Departure elevation: • sea level	Time to climb: • 20 min (0.33 hr)	Ground speed (GS) (TAS – headwind): • 180 kt – 20 kt = 160 kt
Climb wind and temp: • 20 kt headwind, ISA +20 deg	Fuel to climb: • 242 lbs	Wind-corrected distance to climb, TOPC (GS x time): • 160 kt x 0.33 hr = 53 NM.
Planned cruising level: • 27,000 ft	Distance (nil wind): • 61 NM	

If the departure includes extended departure tracking, allowance should be made to the fuel and time for those anticipated conditions. For a take-off from Runway 11 at Darwin, with a departure runway closely aligned to the departure track, no such adjustment is necessary in the scenario case.

Fuel for descent

To calculate the length of the cruise portion of the flight, the distance for descent is required. Data for time, fuel and distance to descend are provided in B200/B200C POH/AFM. Relevant data is shown in Table 3.

Table 3: Calculation of fuel for descent

Scenario data	Data from POH/AFM (descent data)	Wind corrections
Planned cruising level: • 12,500 lbs	Time: • -18 min (0.3 hr)	TAS (distance/time): • 86 NM / 0.3 hr = 286 kt
Destination elevation: • sea level	Fuel: • 170 lbs	Ground speed (GS) (TAS – headwind): • 286 kt – 10 kt = 276 kt
Descent wind/temp: • 10 kt headwind, ISA +20 deg	Distance (nil wind): • 86 NM	Wind-corrected distance to descend, TOPD (GS x time): • 276 kt x 0.3 hrs = 83 NM

Fuel for cruise

Cruise data is provided in the B200/B200C POH/AFM. Five sets of data are provided: normal cruise power (1 700 rpm), maximum cruise power (1 700 rpm), normal cruise power (1 800 rpm), maximum cruise power (1 800 rpm), and maximum range power. For this exercise, data will be taken from the normal cruise power (1700 rpm) tables.

For a short sector it may be valid to use the actual departure weight value (12 000 lbs is the heaviest provided in the B200/B200C POH/AFM) as the aircraft weight at 27 000 ft, although using this value on longer sectors may result in overly conservative cruise fuel burn values.

The B200/B200C POH/AFM requires the estimation of an average cruise weight (sometimes known as a 'mid-sector' weight).

In this scenario relevant data is shown in Table 4.

Table 4: Calculation of fuel for cruise

Scenario data	Data from AFM (interpolated)	Calculations
Cruise wind and temp: • 40 kt headwind, ISA +20 deg	TAS: • -274 kt	Cruise distance (route distance – TOPC – TOPD): • 906 NM – 53 NM – 83 NM = 770 NM
Cruise level: • 27 000 ft	Fuel flow: • 520 lbs/hr	Ground speed (GS) (TAS - headwind): • 274 kt – 40 kt = 234 kt
Mid-sector weight: • 11 000 lbs		Cruise time (cruise distance / GS): • 770 NM / 234 kt = 3.3 hr (197 min)
		Fuel for cruise (cruise time x fuel flow): • 3.3 hr x 520 lbs/hr = 1 711 lbs

Fuel for approach and landing

If an approach to the destination aerodrome is anticipated to consume more fuel than would be used during descent, it would be well-advised to include an approach allowance in addition to descent fuel. This may be calculated at an intermediate level and at an appropriate power setting for the anticipated circumstances. If holding is anticipated, the holding fuel consumption rate can also be used.

In this case, an intermediate level-off and manoeuvring segment is anticipated in the arrival to Cairns, with an anticipated duration not exceeding five minutes, with a conservative value of 50 lbs based on a 'holding fuel' rate of 600 lbs/hr.

- approach fuel allowance: 50 lbs
- approach time allowance: 5 min.

Total trip fuel

Having calculated the climb, cruise, descent and approach fuel, the elements of Trip Fuel are known and can be summed. In the scenario presented, the trip fuel would calculated as shown in Table 5.

Table 5: Calculation of total trip fuel

Trip scenario	Calculations	Total
Fuel amount	Take-off (50 lbs) + climb (242 lbs) + cruise (1 711 lbs) + descent (170 lbs) + approach (50 lbs)	= 2 223 lbs
Time	Climb (20 mins) + cruise (197 mins) + descent (18 mins) + approach (5 mins)	= 240 mins

Table 6: Total trip fuel

Item	Fuel amount	Minutes	lbs	Litres
b	Trip fuel	240	2,223	1,263

Destination alternate fuel

Not required for this part of the scenario.

Holding fuel

Not required for this part of the scenario.

Contingency fuel

Because the maximum take-off weight of the B200 is less than 5 700 kg, contingency fuel is not required.

Note: The maximum take-off weight of the B200 is 12,500 lbs (5,670 kg).

Final reserve fuel

The final reserve fuel for this operation is fuel to fly for 30 mins (0.5 hr), calculated at the anticipated weight at holding speed 1 500 ft above the planned destination aerodrome in ISA conditions.

From the AFM:

- fuel required: 450 lbs

Table 7: Final reserve fuel

Item	Fuel amount	Minutes	lbs	Litres
e	Final reserve fuel	45	450	256

Additional fuel

An illustrative example to assist in understanding the additional fuel calculation is as follows. The case for the Darwin to Cairns flight has two available aerodromes (an en route alternate is not available). The critical point is the wind-adjusted point between the two aerodromes where the flight must have sufficient fuel to fly depressurised on, or back, and conduct an approach and landing with 15 mins fuel reserve remaining If the planned fuel at that point is less than the critical fuel, an amount of additional fuel must be uplifted.

Note: the one engine inoperative or OEI case is not the most critical fuel case for this aircraft type.

To determine the amount of additional fuel that must be carried, up to three calculations will be required:

- basic fuel planning (assuming all operations normal)
- fuel to address critical fuel scenario assuming engine failure at the most critical point
- fuel to address critical fuel scenario assuming depressurisation at the most critical point.

Basic fuel planning

Basic fuel planning is the planning required to address the following fuel amounts:

- taxi fuel
- trip fuel
- destination alternate fuel (if required)
- holding fuel (if required)
- contingency fuel (if applicable)
- final reserve fuel.

Note that basic fuel planning is the calculations done so far in this scenario. The totals required by basic fuel planning are shown in Table 8.

Table 8: Additional fuel - basic fuel planning

Item	Fuel amount	Minutes	lbs	Litres
a	Taxi fuel	0	40	23
b	Trip fuel	240	2 223	1 263
c	Contingency fuel	0	0	0
d	Destination alternate fuel	0	0	0
e	Final reserve fuel	45	450	256

Item	Fuel amount	Minutes	lbs	Litres
f	Additional fuel	0	0	0
g	Holding fuel	0	0	0
h	Fuel required (a+b+c+d+e+f+g)	285	2 713	1 541

Fuel to address critical fuel scenario assuming depressurisation at the most critical point (CP)

In this scenario, the following data is used:

- aircraft take-off weight: 12 500 lbs
- departure elevation: sea level
- climb wind and temp: 20 kt headwind, ISA +20 deg
- planned cruising level to CP: 27 000 ft
- cruise wind and temp: 40 kt headwind, ISA +20 deg
- planned cruising level from CP: 10 000 ft (as required by AFM)
- cruise wind and temp: 20 kt, ISA +20 deg

The location of the CP is calculated using the following formula:

$$\text{Distance from departure aerodrome} = \frac{\text{Total Distance} \times \text{Ground Speed Back}}{\text{Ground Speed Back} + \text{Ground Speed Forward}}$$

Figure 1: Critical point depressurised (CPD) Darwin to Cairns without en route alternate

For this scenario, the CP calculation is presented in Table 9 and the result (i.e. the CP) is shown in Figure 1.

Table 9: Calculation of critical point

Calculation of Critical Point	*Parameters*			
	altitude	10,000	ft	
	From the AFM:			
	TAS	270	kt	
	Calculations	on to Cairns	back to Darwin	
	wind	-20	20	kts
	GS	250	290	kts

Critical Point	487	NM from Darwin
	419	NM from Cairns

Having determined the location of the CP, the amount of fuel required to travel to that point can be calculated by the same methods used earlier in this document, as shown in Table 10.

Table 10: Calculation of fuel to reach CP

Calculation of fuel required to reach CP (assuming operations normal)				
From the AFM:				
Start and taxi	40	lbs		
Take-off	50	lbs		
Climb				
From earlier calculations				
time	20	min		
fuel required	242	lbs		
dist (wind adjusted)	53	NM		
Cruise				
From the AFM:				
TAS	274	kt		
fuel flow	520	lbs/hr		
Calculations				
dist (dist to CP - dist to climb)	443	NM		
wind	-40	kt		
GS	234	kt		
time	1.9	hrs	114	min
fuel	985	lbs		
Total fuel required to reach Critical Point	1,317	lbs	134	mins

Having determined both the location of the CP and the amount of fuel required to reach that point, the amount of fuel to travel to an aerodrome depressurised can be calculated as shown in Table 11. Because the CP is an equi-time point, travelling forward to Cairns or back to Darwin results in the same figure.

Table 11: Calculation of fuel required to reach Darwin (depressurised)

Calculation of fuel required to reach Darwin		
Cruise		
From the AFM:		
TAS	270	kts
total fuel flow	830	lbs/hr
Calculations		
dist	487	NM
wind	+20	kt
GS	290	kt

time	1.68	hr	101	min
total fuel	1,394	lbs		
Holding at 1,500 ft AGL				
From the AFM:				
hold @1,500 ft	150	lbs	15	min
approach and landing	50	lbs	5	min
Total fuel required to return to Darwin unpressurised				
cruise	1,394	lbs	101	min
hold @1,500 ft	150	lbs	15	min
approach and landing	50	lbs	5	min
total	1,594	lbs	121	min

Having completed those calculations, the total amount of fuel required to address the critical fuel scenario can be determined:

Total fuel required to address critical fuel scenario (depressurised):

- fuel required to reach Critical Point 1 317 lbs
- fuel required to return to Darwin unpressurised 1 594 lbs
- total 2 911 lbs

As the amount of fuel required to address the critical fuel scenario (depressurised) is greater than the amount of fuel required by basic fuel planning, additional fuel must be carried.

Total additional fuel required:

- fuel required to address critical fuel scenario 2 911 lbs
- fuel required by basic fuel planning 2 713 lbs
- total (difference) 198 lbs

Fuel to address critical fuel scenario assuming engine failure at the most critical point (CP)

Although the one engine inoperative (OEI) case is not the most critical fuel case for this aircraft type, the details are included to demonstrate the result.

Calculations are the same as for the depressurised case. The detail of the calculations will not be included here. The results of the calculations are shown below:

Total fuel required to address critical fuel scenario (one engine inoperative):

- fuel required to reach Critical Point 1 276 lbs
- fuel required to return to Darwin (OEI) 914 lbs
- total 2 190 lbs

As the amount of fuel required to address the critical fuel scenario (OEI) is less than the amount of fuel required by basic fuel planning, additional fuel is not required in this case.

Total additional fuel

The amount of additional fuel is the higher of that required by the two critical fuel scenarios. Therefore, additional fuel is 175 lbs.

Table 12: Total additional fuel

Item	Fuel amount	Minutes	lbs	Litres
f	Additional fuel	14	198	113

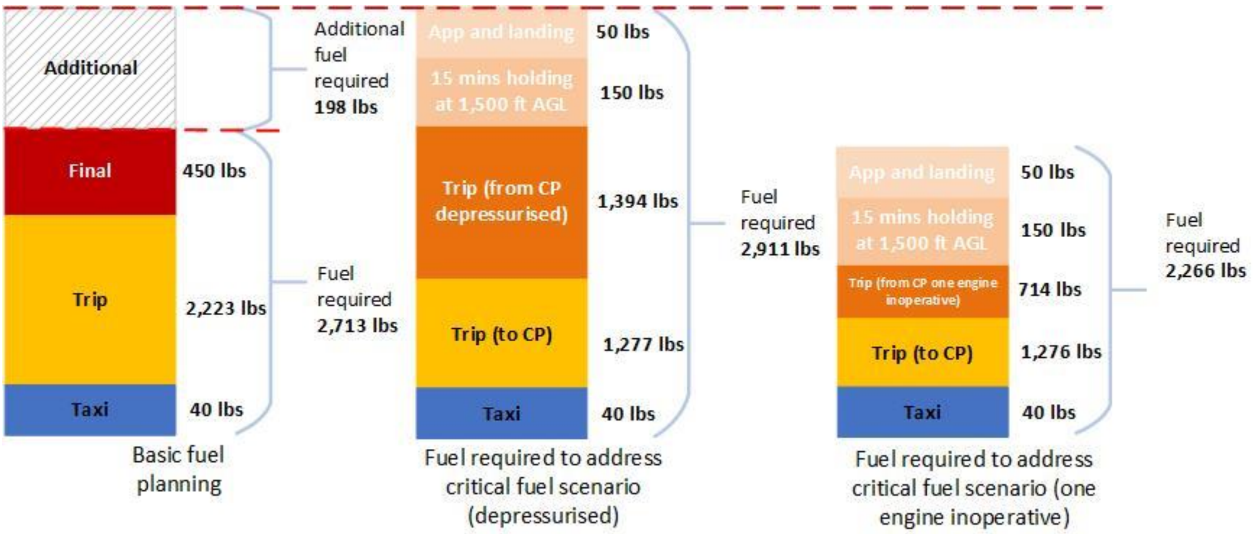


Figure 2: Additional fuel required

Usable fuel required at the commencement of a flight

Having calculated the fuel elements in the previous sections, the usable fuel required to conduct the flight, in this instance, is shown in Table 13.

Table 13: Usable fuel required at the commencement of the IFR flight

Item	Fuel amount	Minutes	lbs	Litres
a	Taxi fuel	0	40	23
b	Trip fuel	240	2,223	1,263
c	Contingency fuel	0	0	0
d	Destination alternate fuel	0	0	0
e	Final reserve fuel	45	450	256
f	Additional fuel	14	198	113
g	Holding fuel	0	0	0

Item	Fuel amount	Minutes	lbs	Litres
h	Fuel required (a+b+c+d+e+f+g)	299	2,911	1,654

Margin fuel and endurance

Having determined the fuel and time for the planned flight, a calculation of the fuel in excess of requirements allows endurance to be calculated. The starting point for this calculation is the known or planned start state of aircraft fuel, up to full capacity. In this example, we will use full tanks for the scenario B200, that is, 3 645 lbs of usable fuel.

Table 14: Calculation of margin fuel and endurance

From the AFM and Table 13	Calculations
total usable fuel: • 3 645 lbs	margin fuel (total useable – useable required): • 3 645 lbs – 2 911 lbs = 734 lbs
useable fuel required: • 2 911 lbs	margin time (margin fuel / fuel flow): • 734 lbs/600 lbs/hr = 1.22 hr (73 min)
fuel consumption rate (holding rate): • 600 lbs/hr	endurance (total useable fuel / fuel flow): • 3 645 lbs/600 lbs/hr = 6.08 hr (365 min)

Table 15: Margin and endurance

Item	Fuel amount	Minutes	lbs	Litres
h	Fuel required	299	2,911	1,654
i	Discretionary fuel	0	0	0
j	Margin fuel	66	734	417
k	Endurance	365	3,645	2,071

Overall fuel analysis

The overall fuel analysis for this journey is shown in Table 16 and Figure 3.

Table 16: Fuel analysis — IFR (no destination alternate aerodrome)

Item	Fuel amount	Minutes	lbs	Litres
a	Taxi fuel	0	40	23
b	Trip fuel	240	2 223	1 263
c	Contingency fuel	0	0	0
d	Destination alternate fuel	0	0	0
e	Final reserve fuel	45	450	256
f	Additional fuel	14	198	113
g	Holding fuel	0	0	0
h	Fuel required (a+b+c+d+e+f+g)	299	2 911	1 654
i	Discretionary fuel	0	0	0
j	Margin fuel	73	734	417
k	Endurance	365	3 645	2 071

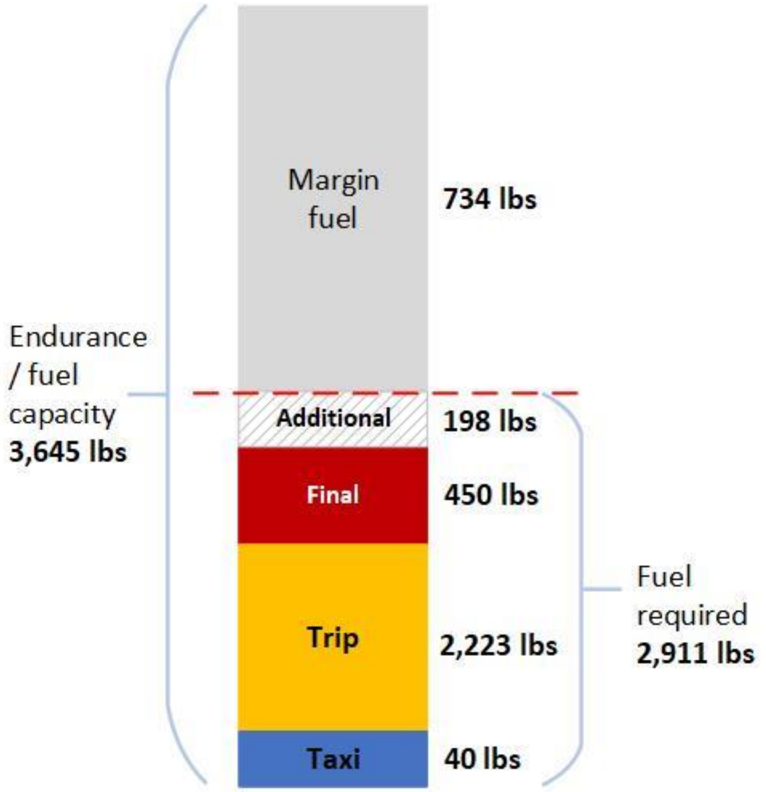


Figure 3: Fuel analysis — IFR (no destination alternate aerodrome)

Darwin to Cairns – IFR – with destination alternate aerodrome

The only difference between this part of the scenario and the previous scenario is the requirement for destination alternate fuel. Other than that fuel amount, fuel amounts remain the same. Additional fuel requirements will vary as discussed later.

Destination alternate fuel - Townsville

If the flight were conducted under conditions such that a destination alternate was required, the alternate fuel would need to be calculated. This is done in a manner similar to the calculation of trip fuel (without the take-off element).

For the scenario, the destination alternate aerodrome is 153 NM from the planned destination aerodrome.

Fuel for missed approach and climb

The calculation for determining the fuel required for missed approach and climb are shown in Table 17.

Table 17: Calculation of fuel for missed approach and climb

Scenario data	Data from AFM	Wind correction
Climb wind and temp: • 10 kt headwind, ISA +20 deg	Time: • 9 mins (0.15 hr)	TAS (distance/time): • 27 NM/0.15 hr = 180 kt
Cruise level: • 21 000 ft	Fuel: • 130 lbs	GS (TAS – headwind): • 180 kt – 10 kt = 170 kt
	Distance (nil wind): • 27 NM	Wind-corrected distance to climb, TOPC (GS x time): • 170 kt x 0.15 hr = 26 NM.

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Fuel for descent

To calculate the length of the cruise portion of the flight, the distance for descent is required. Data for time, fuel and distance to descend are provided in the B200/B200C POH/AFM.

Table 18: Calculation of fuel for descent

Data from POH/AFM (descent data)	Wind corrections
Time: • -18 min (0.3 hr)	TAS (distance/time): • 86 NM / 0.3 hr = 286 kt
Time:	TAS (distance/time):

Data from POH/AFM (descent data)	Wind corrections
• 14 min (0.23 hr)	• 66 NM/0.23 hr = 283 kt
Fuel: • 142 lbs	ground speed (GS) (TAS – headwind): • 283 kt – 10 kt = 273 kt
Distance (nil wind): • 66 NM	wind-corrected distance to desc, TOPD (GS x time): • 273 kt x 0.23 hr = 64 NM

Fuel for cruise

For this exercise, data will be taken from the maximum range power (1 700 rpm) tables. A mid-sector weight is not necessary as the aircraft weight will be below the weight data provided by the AFM.

In this scenario, the relevant data is shown in Table 19.

Table 19: Calculation of fuel for cruise

Scenario data	Data from AFM	Calculations
cruise wind and temp: • 10 kt headwind, ISA +20 deg	TAS: • -221 kt	cruise distance (route distance – TOPC – TOPD): • 153 NM – 25 NM – 64 NM = 64 NM
cruise level: • 21 000 ft	Fuel flow: • 409 lbs/hr	GS (TAS - headwind): • 221 kt – 10 kt = 211 kt
		cruise time (cruise distance / GS): • 64 NM/211 kt = 0.30 hr (18 min)
		fuel for cruise (cruise time x fuel flow): • 0.30 hr x 409 lbs/hr = 123 lbs

Fuel for approach and landing

In this scenario, the authorised weather forecast for the destination alternate aerodrome suggests that a visual approach can be conducted. NOTAMs and the AIP do not state that unusual tracking requirements are in force. Therefore, no extra descent or approach fuel is required.

Total destination alternate fuel

Having calculated the fuel for missed approach and climb, cruise, and descent the elements of destination alternate fuel are known and can be summed. In the scenario presented, the destination alternate fuel would now be:

- fuel amount: missed app and climb (130 lbs) + cruise (123 lbs) + desc (142 lbs) = 395 lbs

- time: missed app and climb (9 min) + cruise (18 min) + desc (17 min) = 54 min.

Table 20: Total destination alternate fuel

Scenario	Total
Fuel amount: • missed app and climb (130 lbs) + cruise (123 lbs) + desc (142 lbs)	= 395 lbs
Time: • missed app and climb (9 mins) + cruise (18 mins) + desc (17 mins)	= 54 mins

Table 21: Destination alternate fuel

Item	Fuel amount	Minutes	lbs	Litres
d	Destination alternate fuel	54	395	224

Additional fuel

The concept and process are the same as the situation in which an ERA is not available and destination alternate fuel is not required (as shown earlier in this Annex in the section 'Darwin to Cairns – IFR – no destination alternate aerodrome). The detail of the calculations will not be included here. The results of the calculations are shown below.

Basic fuel planning

Basic fuel planning is the calculations done so far in this scenario, including that for destination alternate fuel. The totals required by basic fuel planning are shown in Table 22.

Table 22: Additional fuel - basic fuel planning

Item	Fuel amount	Minutes	lbs	Litres
a	Taxi fuel	0	40	23
b	Trip fuel	240	2 223	1 263
c	Contingency fuel	0	0	0
d	Destination alternate fuel	54	395	224
e	Final reserve fuel	45	450	256
f	Additional fuel	0	0	0
g	Holding fuel	0	0	0
h	Fuel required	339	3 108	1 766

Item	Fuel amount	Minutes	lbs	Litres
	(a+b+c+d+e+f+g)			

Fuel to address critical fuel scenario assuming depressurisation at the most critical point (CP)

In this scenario, Townsville was not used in the calculation of the critical point. Therefore, fuel planning is the same as earlier in exercise.

Total fuel required to address the critical fuel scenario (depressurised):

- total= 2 911 lbs

Additional fuel is not required in this case as the amount of fuel required to address the critical fuel scenario (depressurised) is less than the amount of fuel required by basic fuel planning.

Fuel to address critical fuel scenario assuming engine failure at the most critical point (CP)

The same fuel calculations should be conducted to determine whether additional fuel is required to address the critical fuel scenario (one engine inoperative).

Total fuel required to address critical fuel scenario (one engine inoperative):

- total= 2 190 lbs

Because the amount of fuel required to address the critical fuel scenario (one engine inoperative) is less than the amount of fuel required by basic fuel planning, additional fuel is not required in this case.

Total additional fuel

Additional fuel is not required in this case. Because destination alternate fuel is now required, the amount of fuel required by basic flight planning is greater than the amount required to address either of the critical fuel scenarios.

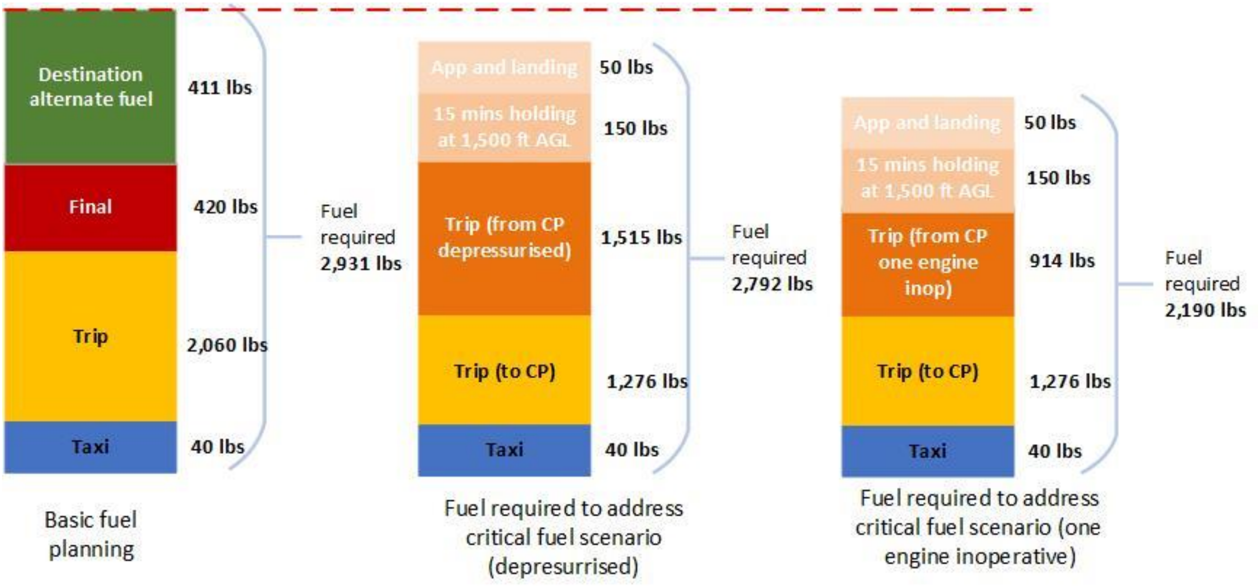

Figure 4: Additional fuel not required

Usable fuel required at the commencement of a flight

Having calculated the fuel elements in the previous sections, the minimum fuel to conduct the flight, in this instance, is shown in Table 23.

Table 23: Usable fuel required at the commencement of the IFR flight

Item	Fuel amount	Minutes	lbs	Litres
a	Taxi fuel	0	40	23
b	Trip fuel	240	2 223	1 263
c	Contingency fuel	0	0	0
d	Destination alternate fuel	54	395	224
e	Final reserve fuel	45	450	256
f	Additional fuel	0	0	0
g	Holding fuel	0	0	0
h	Fuel required (a+b+c+d+e+f+g)	339	3 108	1 766

Margin fuel and endurance

Having determined the fuel and time for the planned flight, a calculation of the fuel in excess of requirements allows endurance to be calculated. Using the same data as in earlier examples:

Table 24: Calculation of margin fuel and endurance

From the AFM and Table 23	Calculations
total usable fuel: • 3 645 lbs	margin fuel (total useable – useable required): • 3 645 lbs – 3 108 lbs = 537 lbs
useable fuel required: • 3 108 lbs	margin time (margin fuel / fuel flow): • 537 lbs/600 lbs/hr = 0.90 hr (54 min)
fuel consumption rate (holding rate): • 600 lbs/hr	endurance (total useable fuel / fuel flow): • 3 645 lbs/600 lbs/hr = 6.08 hr (365 min)

Table 25: Margin and endurance

Item	Fuel amount	Minutes	lbs	Litres
h	Fuel required	339	3 108	1 766
i	Discretionary fuel	0	0	0

Item	Fuel amount	Minutes	lbs	Litres
j	Margin fuel	54	537	305
k	Endurance	365	3 645	2 071

Overall fuel analysis

The overall fuel analysis for this journey is shown in Table 26 and Figure 5.

Table 26: Usable fuel required at the commencement of the IFR flight

Item	Fuel amount	Minutes	lbs	Litres
a	Taxi fuel	0	40	23
b	Trip fuel	240	2 223	1 263
c	Contingency fuel	0	0	0
d	Destination alternate fuel	54	395	224
e	Final reserve fuel	45	450	256
f	Additional fuel	0	0	0
g	Holding fuel	0	0	0
h	Fuel required (a+b+c+d+e+f+g)	339	3 108	1 766
i	Discretionary fuel	0	0	0
j	Margin fuel	54	537	305
k	Endurance	365	3 645	2 071

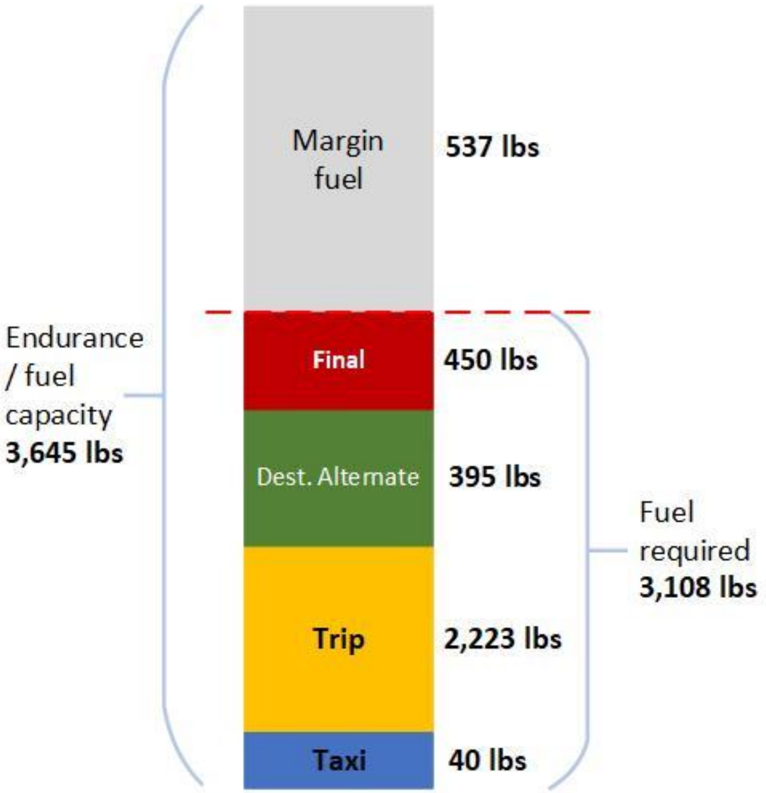

Figure 5: Fuel analysis — IFR (with destination alternate aerodrome)

Additional fuel – En route alternate available

The following section describes the additional fuel calculation for flights with an en route alternate (ERA) available.

Darwin to Cairns (ERA Mt Isa) – no destination alternate

To illustrate a scenario variation and calculation we will consider Darwin, an en route alternate of Mt Isa and the destination aerodrome (i.e. Cairns) as the available aerodromes. To simplify the illustration, destination alternate fuel is not required.. The concept and process are the same as the situation in which an ERA is not available and destination alternate fuel is not required (as shown earlier in this Annex in the section 'Darwin to Cairns – IFR – no destination alternate aerodrome'). The existence of an ERA only changes the figures used in the calculations.

Basic fuel planning

This example does not require destination alternate fuel so the basic fuel planning is the same as that for the section 'Darwin to Cairns – IFR – no destination alternate aerodrome' (see **Error! Reference source not found.**). The total fuel required is shown in Table 27.

Table 27: Additional fuel - basic fuel planning

Item	Fuel amount	Minutes	lbs	Litres
h	Fuel required (a+b+c+d+e+f+g)	285	2,713	1,541

Fuel to address critical fuel scenario assuming depressurisation at the most critical point (CP)

The starting point for the calculation of the critical point is a point on the planned route that is equidistant (nil-wind) from Cairns and Mt Isa. There are several methods available to calculate position and relative distance of the point; they are however, outside the scope of this document.

The point en route at a distance of 312 NM from Cairns is also 312 NM from Mt. Isa. Therefore, the following applies:

- Route distance: 906 NM
- CP: 312 NM from Cairns
  - o 594 NM from Darwin (906 – 312).

The effect of wind displaces the equidistant point and transforms it into an equi-time point (ETP). For the scenario, a nominal headwind in the cruise is applied; assuming that the same headwind component (20 kt) applies to the ETP-to-Cairns as it does to the ETP-to-Mt Isa, we have relatively simple fuel calculations.

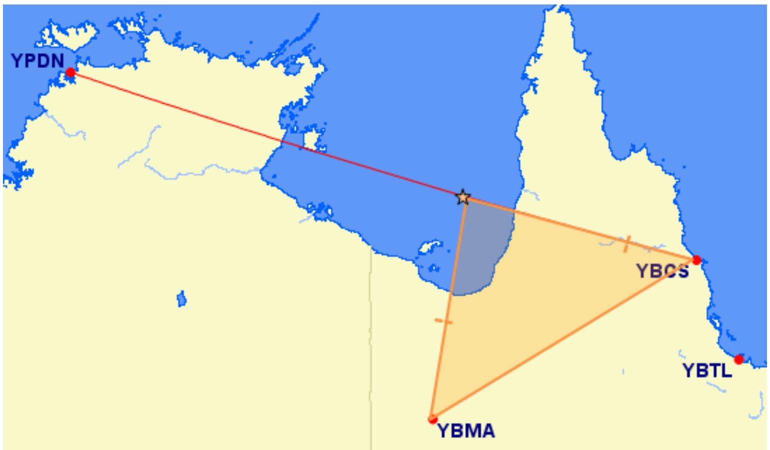

Figure 6: Critical point YPDN to YBCS with YBMA as the ERA

The fuel required from the CP to either Cairns or Mount Isa is now calculated for the required critical fuel scenarios:

In this scenario, the following data is used:

- aircraft take-off weight: 12 500 lbs
- departure elevation: sea level
- climb wind and temp: 20 kt headwind, ISA +20 deg
- planned cruising level to CP: 27 000 ft
- cruise wind and temp: 40 kt headwind, ISA +20 deg
- planned level from CP: 10 000 ft (as required by AFM)
- cruise wind and temp: 20 kt headwind, ISA +20 deg
- AFM data: Normal Cruise Power / 1 700 rpm/ISA +20 deg / 11 000 lbs

Table 28: Fuel required to reach CP

Calculation of fuel required to reach CP (assuming operations normal)	*From the AFM:*		
	Start and taxi	40	lbs
	Take-off	50	lbs
	Climb		
	From earlier calculations		
	time	20	min
	fuel required	242	Lbs
	dist (wind adjusted)	53	NM
	Cruise		
	From the AFM:		
	TAS	274	Kt
	fuel flow	520	lbs/hr
	Calculations		
	dist (dist to CP - dist to climb)	541	NM

	wind	-40	kt		
	GS	234	kt		
	time	2.3	hr	139	min
	fuel	1,202	lbs		
	Total fuel required to reach Critical Point	1,535	lbs	159	min

Table 29: Fuel required to reach en route alternate

Calculation of fuel required to reach Ciarns (assuming depressurised operation)	**Cruise**				
	From the AFM:				
	TAS	270	kts		
	total fuel flow	830	lbs/hr		
	Calculations				
	dist	312	NM		
	wind	-20	kt		
	GS	250	kt		
	time	1.25	hr	75	min
	total fuel	1,036	lbs		
	Holding at 1,500 ft AGL				
	From the AFM:				
	hold @1,500 ft	150	lbs	15	min
	approach and landing	50	lbs	5	min
	Total fuel required to reach Cairns				
	cruise	1,035	lbs	75	min
	hold @1,500 ft	150	lbs	15	min
	approach and landing	50	lbs	5	min
	total	1,235	lbs	95	min

Having completed those calculations, the total amount of fuel required to address the critical fuel scenario can be determined:

Total fuel required to address critical fuel scenario (depressurised)

- fuel required to reach Critical Point 1 535 lbs
- fuel required to reach Cairns 1 235 lbs
- total 2 770 lbs

Because the amount of fuel required to address the critical fuel scenario (depressurised) is greater than the amount of fuel required by basic fuel planning, additional fuel must be carried.

Total additional fuel required:

- fuel required to address critical fuel scenario 2 770 lbs
- fuel required by basic fuel planning 2 713 lbs

– total (difference) 57 lbs

Fuel to address critical fuel scenario assuming engine failure at the most critical point (CP)

Experience has shown that the one engine inoperative or OEI case is not the most critical fuel case for this aircraft, so calculations are not included here.

Total additional fuel

The amount of additional fuel is the higher of that required by the two critical fuel scenarios. Therefore, additional fuel is 57 lbs.

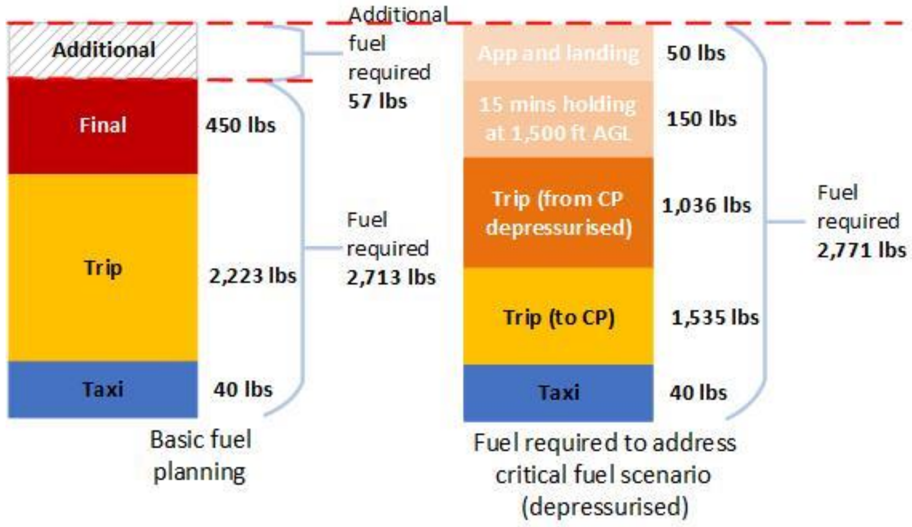

Figure 7: Fuel required considering critical fuel scenario from YPDN to YBCS with YBMA as ERA

Darwin to Cairns (ERA Mt ISA) – with destination alternate

To illustrate a final scenario variation, we again consider an en route alternate Mt Isa. However, in this case, the destination Cairns requires a destination alternate, with Townsville being selected.

The concept and process are the same as the situation in which an ERA is not available and destination alternate fuel is required (as shown earlier in this Annex in the section 'Darwin to Cairns – IFR – with destination alternate aerodrome'). The existence of an ERA only changes the figures used in the calculations. Because the concepts have already been covered by this Annex, it will not be discussed further here.