August 24

UK Civil Aviation Authority

WEIGHT, BALANCE AND PERFORMANCE

SAFETY SENSE

SS09

YOUR SAFETY SENSE LEAFLET FOR: **WEIGHT, BALANCE AND PERFORMANCE**

Weight, balance and aircraft performance are important factors for safe flying. This leaflet is intended to refresh pilots on the key principles and application.

As pilot in command, you are legally responsible for ensuring your aircraft remains within weight and balance limitations throughout a flight, and that the aircraft can safely take off, climb and land within the applicable runway lengths and operating areas.

There have been many fatal accidents involving general aviation aircraft in which overloading or flying outside the permitted centre of gravity envelope were contributory factors. A common theme is a failure to account for additional payload above the norm or appreciate the impact of environmental conditions such as increased density altitude.

Regulation

Flights involving other-than-complex Part 21 aeroplanes and helicopters must comply with Part-NCO of the UK Air Operations Regulation. NCO.GEN.105 requires that the pilot in command be satisfied that a flight can be safely made, and that the weight[1] and centre of gravity location remains within the prescribed limitations for the aircraft. Article 69 of the Air Navigation Order 2016 applies the same requirement for flights involving non-Part 21 aircraft.

Article 43 of the Air Navigation Order and NCO.POL.105 of the Air Operations Regulation also require that every aircraft has a weight and balance schedule that reflects the actual weight, including any modifications or additional equipment. Note that the operator of the aircraft is obliged to ensure the schedule is accurate and provide this information to the pilot in command.

The CAA has successfully prosecuted pilots and operators who have not complied with the regulations applicable to weight, balance or performance. Failure to comply with regulations may also impact the aircraft's insurance and affect any claims in the event of an accident.

Weight

You should have good knowledge of your aircraft's permitted payload under typical operating conditions. In many GA aircraft it is not possible to fill all the seats, carry full fuel and load the maximum baggage capacity. This is particularly true of popular four seat aircraft, such as most models of the Piper PA28 family. Even many two-seat aircraft cannot legally carry two large adults and full fuel.

Basic empty weight

Be clear on what items are included in the basic empty weight of the aircraft. Basic empty weight normally includes oil, unusable fuel and fitted items for that particular airframe.

Equipment such as fire extinguishers and first aid kits may not be included, depending on whether they were onboard when the aircraft was last weighed.

[1]Part-NCO refers to mass rather than weight. The two terms are considered interchangeable in this context.

WEIGHT

Weighing the load

When planning a flight, if there is any possibility of being over the maximum takeoff weight, you must establish actual weights for passengers and baggage. You should establish a realistic payload and communicate with passengers to ensure they do not bring excess baggage. Ensure you account for miscellaneous items such as lifejackets, handbags and heavy coats.

Many flying clubs will have a set of scales for use by pilots and their passengers. A spring balance is a compact alternative to a platform scale, normally suitable for items up to around 25 kg. Note any individual loading point limits – the baggage compartment will have a weight limit and some aircraft seats have a maximum occupancy weight. Ensure baggage and any other items are properly stowed and secured so that they cannot move or obstruct exits.

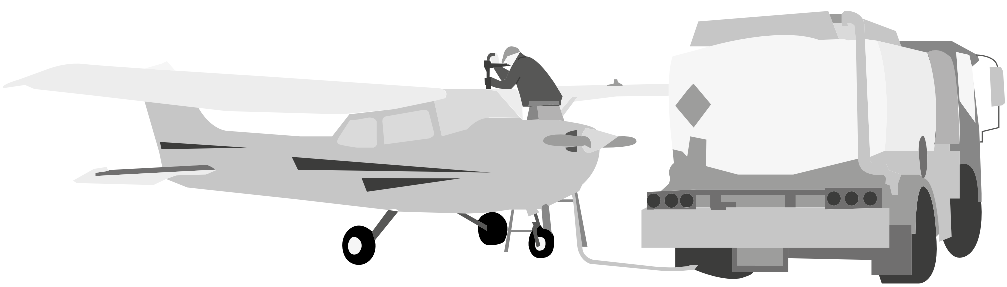
Fuel

Ensure that the fuel tank configuration and quantities placarded on the aircraft match the weight and balance schedule. If extra fuel tanks have been fitted, filling them will add a lot of weight.

If the fuel tanks are partially full, it may be difficult to establish the exact fuel quantity onboard. Fuel gauges are often inaccurate – you should use a fuel dipstick or other suitable means for verifying the fuel quantity onboard. Estimate your fuel load to be on the higher side for weight and balance purposes, but on the lower side for fuel planning.

Use the correct specific gravity figure for converting a fuel volume to a weight:

- AVGAS is around 0.72 kg/litre;
- JET A-1 around 0.8 kg/litre; and
- MOGAS is normally a similar weight to AVGAS, but this may vary – consider weighing a litre from your supply to verify.



WEIGHT

Effects of overloading

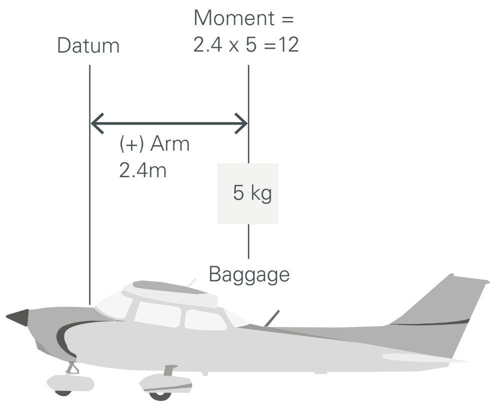
Overloading an aircraft beyond its permitted maximum takeoff weight will cause negative effects, including:

- reduced acceleration and increased take-off speed, requiring a longer take-off run;
- decreased angle of climb, reducing obstacle clearance capability;
- reduced altitude ceiling and rate of climb;
- reduced range;
- impaired controllability;
- increased stall speeds;
- increased landing speeds, requiring a longer runway;
- reduced braking effectiveness; and
- reduced structural strength margins.

The Aircraft Flight Manual (AFM) or Pilot's Operating Handbook (POH) will only provide data for the certified weight and balance envelope – once those limits have been exceeded, there is no way to accurately predict take-off, climb and landing performance.

Balance

Balance refers to the location of the centre of gravity (CG) along the longitudinal axis of the aircraft. The CG is the average location of the weight of an object and from where an aircraft would balance in a level attitude if suspended from that point.



Moment arm

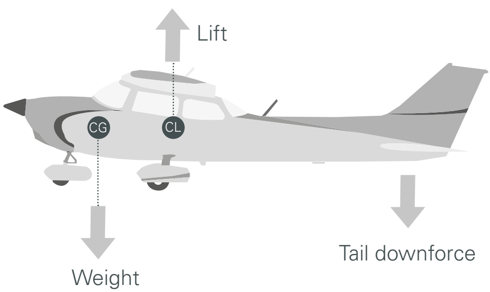
The CG position is measured from a datum reference, which varies by aircraft type – check the AFM or POH. The arm is the horizontal distance defined by the manufacturer from the reference datum to the point at which an item is located.

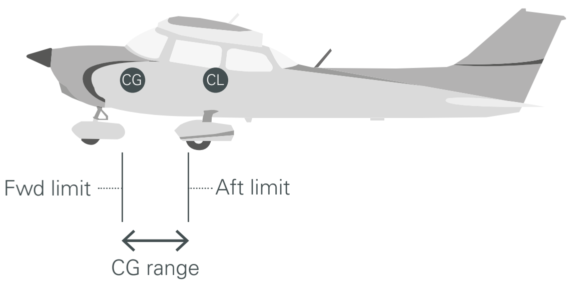
The moment is an item's weight multiplied by the distance arm. The principle of a moment can be thought of in the same way as a seesaw, where the greater the distance a weight is from the pivot point, the more it will tip the balance in that direction.

CG limits

To remain stable in pitch, most aircraft designs place the CG ahead of the centre of lift. The centre of lift is the average location of the lift force acting on the aircraft. In this configuration the pitch down tendency of the aircraft is balanced by the downward force from the horizontal tailplane. With the CG further aft, the aircraft becomes less stable in pitch. With the CG further forward, pitch stability is normally improved, but to maintain level flight a higher angle of attack is required and elevator authority is reduced.

There are forward and aft CG limits established during certification flight testing of the aircraft type – the limits are based on the positions at which the longitudinal stability requirements can be met. Operation outside these limits means you would be flying in an area where the aircraft's handling has not been investigated or has been found to be unsatisfactory. The limits for each aircraft are contained in the AFM or POH for the aircraft.





BALANCE

During the flight

Check that you will remain within limits throughout the flight. It is possible to commence a flight within the CG range but move outside it as fuel is burned. Depending on the location of the fuel tanks, burning fuel will move the CG either forward or aft.

Small but heavy objects can make a big difference to CG, such as a toolbox or spare parts. Be careful where you stow them and make sure they cannot move.

An incident was once reported in which a passenger in the rear seats had moved a toolbox from the footwell to the baggage compartment, without informing the pilot. When attempting to land, he encountered control difficulties in pitch and executed a go around. After realising the toolbox had been moved, he ensured it was returned to its original location and made a normal landing.

The CG will also have a lateral position, although for most light aircraft this does not need to be calculated. However, there may be AFM limits for fuel imbalance between the wing tanks, and when loading passengers and baggage, balance the lateral load as evenly as possible.

Exceeding CG limits

Exceeding the limits of the CG range will create negative effects on aircraft handing and performance:

Exceeding forward limit:

- increased stall speed;
- increased loads on the nose landing gear;
- reduced upward pitch authority and trim, causing difficulties during takeoff and landing; and
- greater induced drag from the extra tail downforce required to keep the aircraft in level flight, decreasing performance and increasing fuel consumption.

Exceeding the aft limit:

- difficulty trimming;
- less stable in pitch, particularly in turbulence;
- tendency to pitch up, particularly at low speed and high power;
- with a tail wheel type, difficulty raising the tail and maintaining directional control on the ground;
- degraded stall qualities; and
- unknown spin behaviour, with delayed or inability to recover.

Note that even within CG limits, the aircraft's handling behaviour may seem different depending on CG position. Pitch stability will reduce with a more aft CG position – be aware of this particularly during take-off, landing and go-arounds.

W & B Calculation

Loading data

The AFM or equivalent document for your aircraft will contain tables and/or graphs for calculating the total weight of the aircraft and the CG position. Ensure you use the schedule applicable to your airframe and not a generic one for the aircraft model. If hiring an aircraft, you must ask for this information so that you can determine the weight and balance will be in limits for the flight.

There are various types of tables or graphs, but they all use the concept of loading positions, such as 'front seats', 'rear seats' or 'baggage compartment'. A calculation table example is illustrated below:

Item	Weight (kg)	Arm (metres aft of datum)	Moment (Kg-m)
Empty aircraft	700	2.22	1,554
Front seats	160	2.05	328
Rear seats	70	2.98	208.6
Baggage compartment	15	3.63	54.45
Fuel	100*	2.41	241
Totals	**1045**		**2386.05**

*Remember to convert fuel volume to weight by using the specific gravity figure. AVGAS normally weighs around 0.72 kg/litre. Ensure you use the correct volume and mass units when converting.

The loading positions and arm distances should be prepopulated in the table. To complete the calculation:

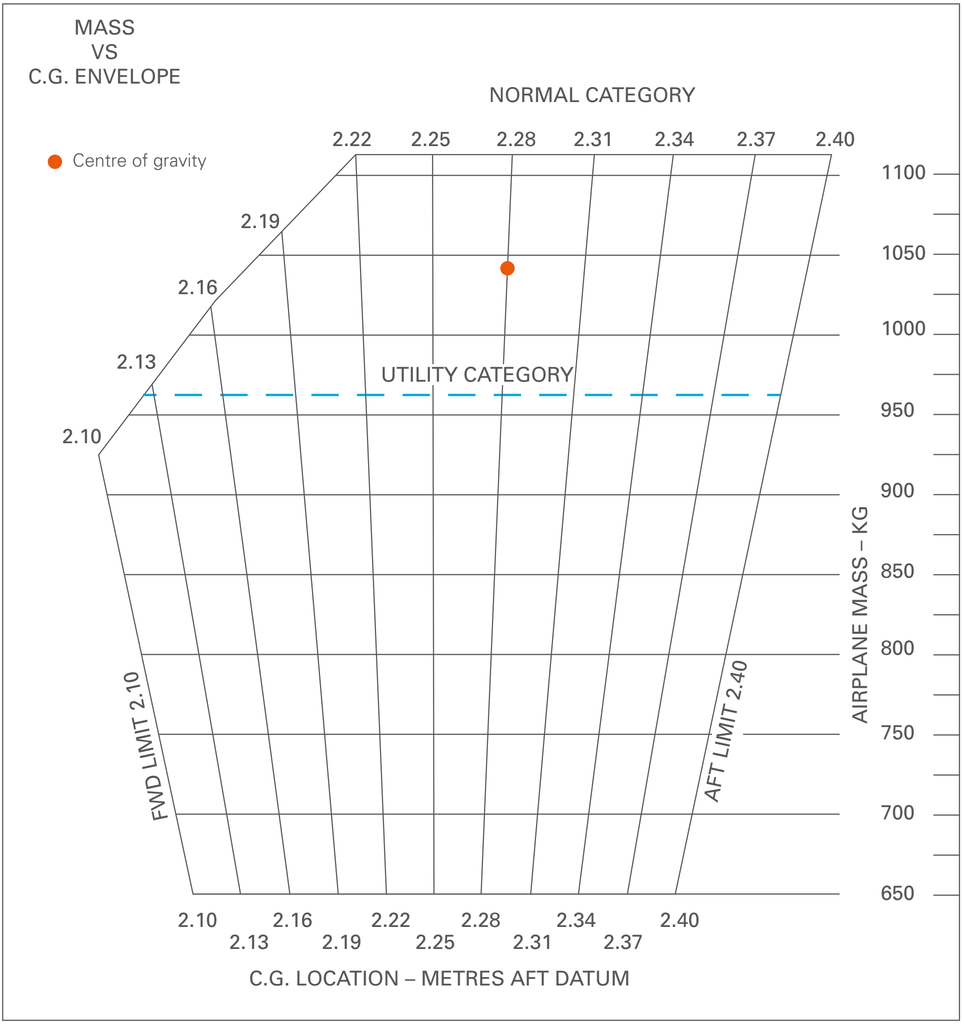
- Multiply the weight of each loading point (including the empty weight) in the 'Weight' column by its distance from the datum in the 'Arm' column. Place the result in the applicable 'Moment' column;
- Add together all the weights and add together all the moments; and
- Divide the total moments by the total weight – this generates the CG position.

$$\frac{\text{Moment (2386.05)}}{\text{Weight (1045)}} = \textbf{C of G (2.28)}$$

Remember to calculate CG position for both takeoff and landing.
Use the estimated fuel burn as required.

W & B CALCULATION

Using the weight and CG envelope from the AFM or POH, determine whether the result **(2.28)** falls within limits:



Many light aircraft will have manoeuvre or g-loading restrictions defined by weight and balance. For example, types approved for intentional spinning or aerobatics may have a reduced weight and CG range for these purposes, compared to normal flight.

Always refer to the AFM or POH for details of any restrictions. In the example above, the weight of the aircraft is such that it cannot operate in the 'utility category', which may mean certain manoeuvres are prohibited.

W & B CALCULATION

Guidance

With light loads and under benign performance conditions, it is acceptable to operate based on a good working knowledge of the aircraft's weight and balance, provided you have verified at some point that a representative load falls well within the applicable limits.

Circumstances when you should conduct a calculation:

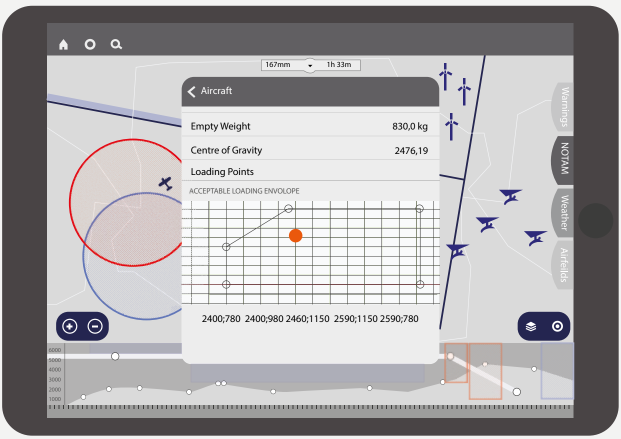
- Flying an aircraft for the first time, to gain familiarity with the W&B characteristics;
- Carrying passengers, baggage or more fuel than normal;
- If you need to confirm aircraft performance.

If operating from a shorter runway than normal or during periods of hotter weather, you should conduct a performance calculation, for which an accurate W&B calculation is a prerequisite.

Software

Flight planning software often includes the facility for weight and balance calculation, which may be quicker than using a traditional schedule or loading graph. However, you must ensure the software contains the exact empty weight and CG position data for your airframe, and that you enter all applicable loading weights correctly.

Before using software as the primary means of doing your weight and balance, you should run several parallel calculations against the aircraft's weight and balance schedule in the AFM and ensure you derive the same answer.



Takeoff and landing performance

Aircraft data

The AFM or POH should be consulted for takeoff and landing performance data. Note that for typical GA aircraft, the data is 'unfactored' and is based on what has been achieved in flight testing with a new aircraft, proficient pilot and no operational factors that may reduce performance.

In practice, engines may not produce their rated power, and pilot technique may not be optimal. Dirt or minor damage on the airframe will increase drag, and runway surface conditions may reduce acceleration or braking performance.

Note that older or uncertified aircraft may not have complete or reliable data. If there is any doubt regarding data accuracy, conduct some real-world performance checks using a reasonably long runway, before using one that is potentially marginal.

For landing performance, the aircraft must cross the threshold at the correct approach speed and the assumed height specified in the AFM or POH – an excess of either will substantially increase the landing distance required.

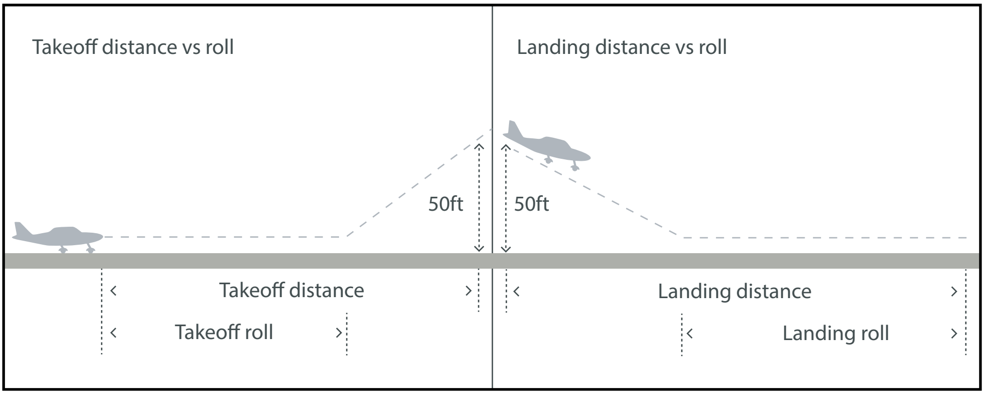
Commercial operators are required by regulation to add safety factors to takeoff and landing performance data. GA pilots are strongly encouraged to do the same – see p.15 for recommended figures to apply.

Distance vs roll

It is important to understand the difference between 'distance' and 'roll' figures:

- **Takeoff distance required** includes a climb to a specified height above the runway.
- **Landing distance required** assumes the aircraft crosses the threshold at a specified height.

The specified height is normally 50 ft but may vary depending on the aircraft – check your POH or AFM. The 'roll' (sometimes referred to as 'run') refers to the length during which the aircraft's wheels are in contact with the ground.



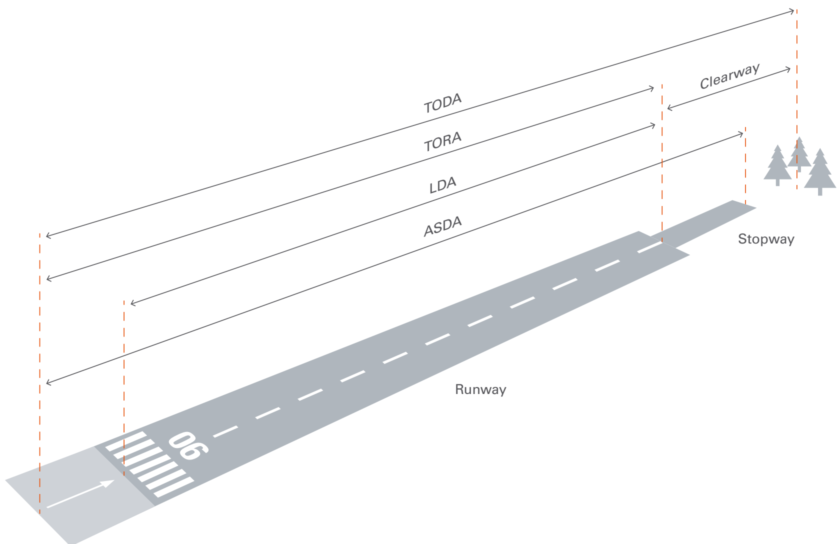
Aerodrome data

It is essential that you know the correct runway distances available for takeoff and landing. For licensed and certificated aerodromes, these can be found in the UK AIP. Unlicensed aerodromes normally publish a total length for the takeoff and landing area. However, portions of this length may not be usable due to surrounding obstacles or surface conditions. The accuracy of the measurements may also vary. You will need to make a judgement based on local assessment as to what distances are available.

Establishing operating lengths and surface conditions is especially important when flying from airstrips, which are often little more than fields sometimes used by aircraft. For more information on strip flying, see SSL 12.

The following definitions apply for takeoff and landing calculations:

- **Take-off run available (TORA)** is the length of the runway surface that the aircraft can use during the ground run (roll) of the take-off.
- **Take-off distance available (TODA)** includes the TORA plus any 'clearway' distance inside the aerodrome boundary within which the aircraft may safely climb.
- **Landing distance available (LDA)** is the runway length available for landing.
- **Accelerate stop distance available (ASDA)** is the length of the runway surface available for the take-off run, plus any 'stopway' the runway may have. The stopway is not normally intended to support the regular movement of aircraft, however it may be used to bring the aircraft to a stop in the event of an aborted take-off.



TAKEOFF AND LANDING PERFORMANCE

Guidance

With light loads and under benign conditions, it is acceptable to operate based on a good working knowledge of the aircraft's performance capabilities, provided you have verified at some point that a representative load falls well within the applicable limits.

Aircraft performance figures are normally quoted with reference to the International Standard Atmosphere (ISA) mean sea level pressure of 1013 hPa and outside air temperature of 15° C. Increased temperatures or lower pressures from standard will reduce performance.

Conditions can be subjective, and it is important to appreciate when they are less forgiving. UK pilots are often unfamiliar with the effect of higher air temperatures and operating altitudes.

At maximum takeoff weight on a hot summer's day, factored takeoff distances for some light aircraft may be more than 800 m – very different from operating during the winter with light loads.

Two definitions are important to understand:

- **Pressure altitude** refers to the altitude displayed when 1013 hPa is set on the altimeter; and
- **Density altitude** is pressure altitude corrected for temperature, effectively the altitude the aircraft experiences for performance purposes.

Calculations

The relevant environmental conditions must be applied when using the aircraft's AFM or POH calculation graphs. The table below gives an indication of the changes to performance you should expect for different variables. These figures could also be used if minimal performance data is available for the aircraft:

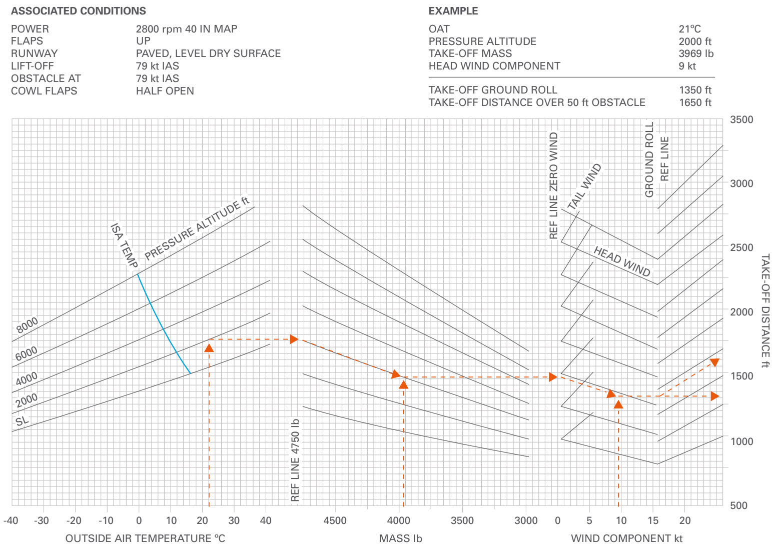
Performance changes		
For every	**Take-off distances**	**Landing distances**
10% increase in weight	x1.2	x1.1
1,000 ft increase in elevation	x1.1	x1.05
10°C increase in temperature	x1.1	x1.05
Tailwind component 10% of lift-off speed	x1.2	x1.2
2% Slope (uphill)	x1.1	-
2% Slope (downhill)	-	x1.1
Note: If calculating multiple factors, they should be multiplied together, for example 1.2 x 1.1.		

TAKEOFF AND LANDING PERFORMANCE

Most take-off, climb and landing graphs use a ‘reference line’ system to reach a performance figure for the given conditions. You must be familiar with the graphs applicable to your aircraft, and observe any conditions stated such as power or flap settings.

The graphs normally work left to right and commence with a vertical line that starts at the outside air temperature for the day in question:

Take-Off – Normal Procedure



In this example the following steps are shown:

1. Draw the line up from the temperature until it meets the reference line for the pressure altitude. Interpolate as necessary between the lines.

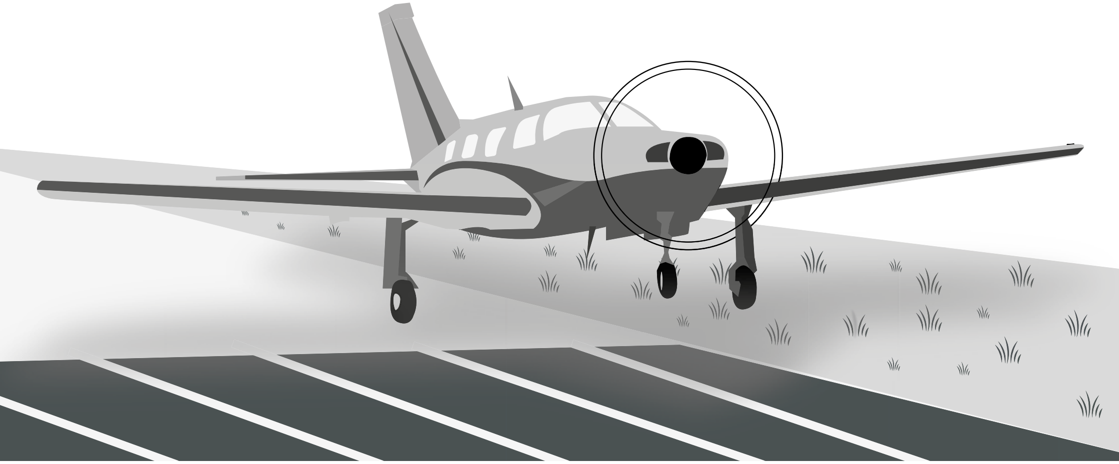
2. Translate the aerodrome elevation into a pressure altitude, by calculating the altimeter reading with 1013 hPA set. For example, if the elevation is 500 ft and the QNH is 1000 hPa, it would display 851 ft with 1013 hPa set – assuming 27 ft per hPa.

3. Once at the correct pressure altitude, draw a line horizontally from that point, across to the next section of the graph (usually mass). Draw another vertical line originating from the applicable take-off mass.

4. Follow the reference line (interpolate between the lines as necessary) until it intersects with the vertical line originating from the take-off mass. This sets the point from which to draw the next horizontal line towards the last section of the graph, usually the wind component.

5. Using the same method as before, follow the reference lines to the applicable wind component.

6. On the example graph, both takeoff ground roll and distance are indicated. Some AFMs separate the take-off run and distance into different graphs.



Safety factors

You must take account of different surface conditions. Some factors (for example grass) may be stated in the aircraft's AFM or POH, otherwise apply as per the table below. When using AFM figures, ensure you understand any conditions such as the maximum grass length or snow depth.

The general safety factors are similar to those required in commercial air transport operations and cover any degraded performance or variations in pilot technique. It is not recommended to operate if the factored distances required exceed those available.

Safety factors		
Condition	**Take-off**	**Landing**
Dry grass (up to 20cm)	x1.2	x1.15
Wet grass (up to 20cm)	x1.3	x1.35
Wet paved surface	-	x1.15
Soft ground or snow	x1.25	x1.25
General safety factors	x1.33	1.43
Note: You should apply this after the application of the other factors.		

Rejected takeoffs

Consider actions in the event of a problem during the takeoff roll or failure to achieve adequate acceleration. It is safer to make an early decision to reject the takeoff, but this requires structured thinking and self-briefing beforehand.

Stopping distance

It is recommended that there should be enough runway length available to stop the aircraft during the roll, at least up until the point of rotation. Ideally the accelerate-stop distance required should not exceed the accelerate-stop distance available (ASDA) for the runway.

Single engine piston aircraft will not normally have published figures for an accelerate-stop distance – this can be approximated by adding together the takeoff and landing roll figures, plus a margin for reaction time. A three second reaction time equates to around 100 m at typical light aircraft takeoff speeds.

On shorter runways the full ASDA may not be available, even if you are within the takeoff distance required. Consider the environment beyond the end of the runway – an area of hard surface or a flat field may cause only minor damage to the aircraft, but a line of trees will be less forgiving.

Decision points

You should identify a decision point along the runway at which you will abort if acceleration is not sufficient, or if there is any other problem that might threaten the safety of the takeoff.

Use a visual reference point along the runway, such as a holding point, windsock or abeam a building. If operating regularly from a strip, consider positioning frangible marker boards to act as reference points. If the full ASDA is not available, your decision point should be adjusted to allow enough distance to stop on the runway.

A decision point that allows sufficient space to stop is particularly important when operating from unforgiving surfaces, such as wet or muddy grass, where the rolling resistance may be unpredictable.

Avoid putting yourself in a pressured situation – for example landing at a muddy strip and then finding that the aircraft sinks into the surface and struggles to accelerate on takeoff.

If necessary, adjust the decision point and acceleration criteria in accordance with your performance calculations – if heavy or operating with increased density altitudes, the aircraft will take longer to stop in the event of a rejected takeoff. Acceleration may also not feel normal, but you should anticipate where on the runway you expect the aircraft to achieve rotation speed and adjust your expectations for acceleration accordingly.

REJECTED TAKEOFFS

Rejection criteria

At the start of the roll, verify engine parameters are correct and that the airspeed indicator (ASI) rises.

You should think of eventualities that might trigger a rejection at or prior to your decision point, for example:

- abnormal engine indications
- inadequate acceleration
- failure to maintain runway centerline
- bird strike
- open door
- loss of ASI

Once you have passed your decision point, you should only reject the takeoff if you believe that the aircraft is incapable of safely climbing away, and that potentially overrunning the end of the runway would be preferable to taking the problem into the air. For example, beyond the decision point, issues such as a door coming open should be taken into the air, however a significant loss of engine power may force you to accept an overrun.

Liftoff speed

Historic accidents show that as a reaction to an imminent runway excursion, pilots sometimes try to force the aircraft into the air, prior to achieving a safe liftoff speed. This often results in the aircraft becoming airborne, only to subsequently stall and result in a worse outcome than had the pilot closed the throttle and applied maximum braking.

A runway excursion is less likely to be fatal than a low-level stall, so do not try to lift off prior to a safe rotation speed. Sticking to your takeoff decision point and rejection criteria will reduce the risk of a potential runway excursion occurring in the first place.

Multiengine aircraft

Multiengine piston (MEP) aircraft cannot normally continue a takeoff in the event of an engine failure. It is recommended to operate with the full accelerate-stop distance available – if it is not, you may have to accept an overrun in the event of an engine failure during the takeoff roll.

Most MEPs will only climb on one engine once the landing gear has been retracted and 'blue line' speed achieved. In the event of an engine failure at or immediately after liftoff, in most MEPs it is recommended to close both throttles and land ahead. There are too many variables in type performance and aerodrome characteristics to provide rules for every situation – refer to the AFM or POH, and establish the criteria for continuing into the air versus landing ahead.

REJECTED TAKEOFFS

Case study: runway excursion

A flight in a piston engine Piper PA46 aircraft was planned to a destination approximately 100 NM away, for the purpose of demonstrating the aircraft to some potential buyers. The commander was joined by five passengers, one of whom was a qualified pilot and occupied the right-hand seat in the cockpit.

The right-hand seat occupant was given control for the takeoff, and initially exceeded the maximum permitted manifold pressure (MAP) for the engine. In response, the commander reduced the MAP to slightly below that normally set for takeoff.

During the takeoff roll, the commander sensed that the aircraft was not accelerating normally. As the aircraft rotated, the stall warner sounded. The commander judged the aircraft was not going to become airborne safely, so took over the controls and rejected the takeoff. The aircraft overran the end of the runway and the landing gear collapsed. There were no injuries, but the aircraft was substantially damaged.

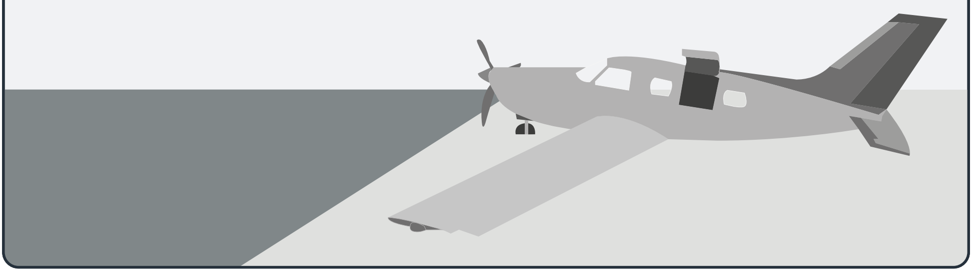
Subsequent calculations concluded that the aircraft was 170 kg overweight – the fuel onboard was 22 US gallons more than the commander believed, and the actual weight of the passengers was more than estimated.

With the actual takeoff weight and recommended safety factors applied, the takeoff run required was 61 m more than that available. The takeoff distance required was also found to be more than the distance between the start of the runway and trees at the airfield boundary.

Situational pressure may have contributed to an overly optimistic interpretation of the aircraft's load and performance status. The commander felt under time pressure due to the passengers having other commitments later in the day. This may have caused him to misinterpret the fuel information on the aircraft's electronic flight display and underestimate passenger weights.

The negative consequences of cancelling the flight or offloading passengers may also have discouraged the commander from making a more conservative assessment of performance, for example by applying recommended safety factors.

When faced with poor acceleration and approaching the end of the runway, the decision to reject may have avoided a low-level stall or collision with trees at the airfield boundary. However, identification of a takeoff decision point would have acted as a final safety barrier and may have avoided a runway excursion.



Climb performance

Climb performance is important to consider, particularly if there are obstacles or high terrain in the vicinity of your departure aerodrome. Calculate your climb performance from the AFM or POH, using the aircraft's weight and applicable operating conditions.

Knowing the anticipated climb performance will allow you to determine if the aircraft is still performing in accordance with the AFM. A significant loss of climb performance is often an indication that the engine is no longer achieving its rated power and may need mechanical attention.

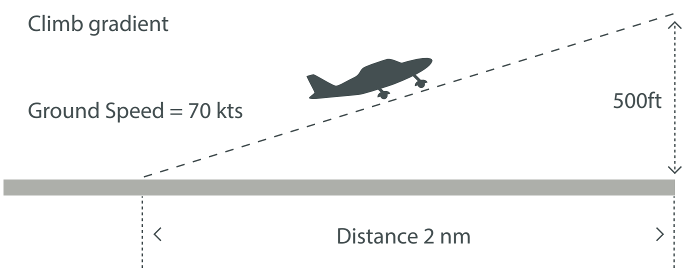
For climbs of more than several thousand feet, you should include the increased fuel consumption in your fuel calculations. Some AFMs will include a graph that calculates fuel, time and distance figures for the climb.

It is not recommended to operate if under the applicable conditions and operating weight, the aircraft will climb at less than:

- 500 ft/m for a single engine aircraft; or
- 150 ft/m in the event of engine failure on a multi-engine aircraft.

Climb gradient

It may be useful to know the required gradient and rate of climb to reach a height by a certain point. To calculate the required rate of climb (in ft/minute) to achieve a known gradient, divide the aircraft's ground speed by 60 and then multiply the result by the required gradient in ft/NM.



Example:

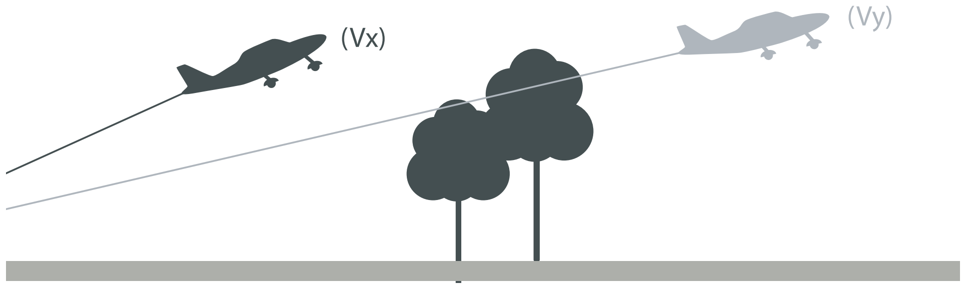
$$\frac{500\text{ ft}}{2\text{ nm}} = 250\text{ ft/nm}$$

$$\frac{70\text{ kts}}{60} = 1.17$$

1.17 x 250 ft/nm = 291 ft/m required rate of climb

CLIMB PERFORMANCE

Know your maximum angle of climb (Vx) and rate of climb speeds (Vy). For obstacle clearance you may need to fly for maximum angle rather than maximum rate, which means climbing in a shorter horizontal distance, even if it takes more time to gain the same height. The AFM may not quote a rate of climb figure for flight at Vx, so you may need to establish this from practical experience.

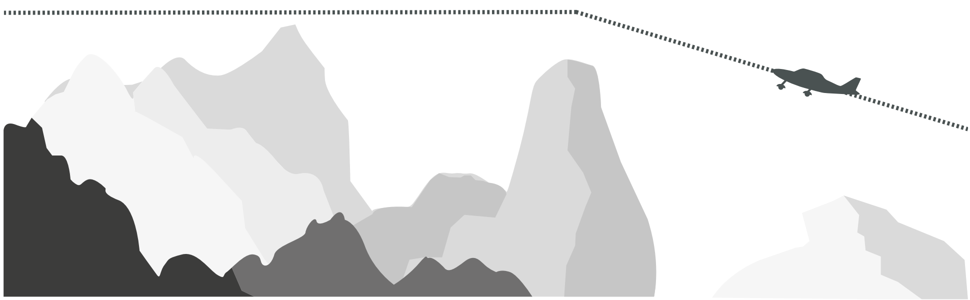


High terrain

In the lowland areas of the UK, terrain related performance considerations are rarely a significant factor. However, if flying in Scotland or mainland Europe, you may encounter high terrain that requires consideration of climb and cruise performance. Establish the applicable operating conditions, which during the summer will involve density altitudes considerably higher than you may have previously experienced.

Most non-turbocharged piston aircraft experience a significant reduction in climb performance in density altitudes above 5,000 ft. Ensure you know your rate of climb and associated climb gradient to ensure terrain and obstacle clearance.

Follow any applicable guidance in the AFM or POH – for example regarding leaning the fuel/air mixture control to ensure optimum power. If conditions dictate, leaning is often permitted at any altitude and may be required during the climb – leaning is not something only reserved for high altitude cruise.



Enroute

Consider the engine power settings for the cruise. Your pilot's log (PLOG) should reflect the speeds and flight times applicable to the intended power settings and environmental conditions. Use the correct fuel/air leaning technique for the desired power output.

You should also have calculated your:

- Range;
- Fuel endurance; and
- Glide range and best glide speed for the operating weight.

Unit conversions

The mixed use of metric and other units for weight, balance and performance purposes has the potential to cause gross errors – this has caused accidents in commercial air transport.

Documentation for North American and older British aircraft will tend to use pounds (lb), gallons and feet (ft) as units of measure, whereas European aircraft will normally use kilograms (kg), litres, and metres (m) for horizontal distances.

Fuel in the UK and Europe is sold in litres – if your aircraft fuel gauges are calibrated in gallons, ensure you know whether they are US or Imperial. When using a specific gravity figure to convert a fuel volume to weight, ensure the volume and weight units match that of the conversion factor.

Common conversion figures			
1 kg	2.205 lb	**1 lb**	0.454 kg
1 inch	2.54 cm	**1 cm**	0.394 inches
1 ft	0.305 metre	**1 metre**	3.28 ft
1 Imp gal	4.546 litres	**1 litre**	0.22 Imp gal
1 US gal	3.785 litres	**1 litre**	0.264 US gal
1 Imp gal	1.205 US gal	**1 US gal**	0.83 Imp gal