

# Short-Field Takeoff & Landing

Developing the student's decision-making processes in relation to taking off or landing on runways of minimal length provides a real challenge for the professional flight instructor.

This briefing uses the performance data provided in the Flight Manual to operate the aeroplane at its safe and legal limit.

A short (or minimal) field is one where the runway length is shorter than that normally available for the conditions, but is still sufficient for takeoff and/or landing. It is not one that is too short. Nor is it one where the runway length is unknown.

When a runway group number is not available, or is available but less than the aeroplane's group number, reference must be made to the Flight Manual to ensure there is adequate runway length available under the existing conditions. As a rule,

if doubt exists under any circumstances, refer to the Flight Manual.

Performance ('P') charts, where available, are a valuable source of takeoff performance information. Manufacturer's graphs in Flight Manuals should be used in the absence of P-charts. If using the latter, it is recommended that pilots apply the appropriate surface correction factors from Advisory Circular 91-3 *Aeroplane performance under Part 91*.

An approach to a field where the runway length is unknown, or is known to be too short, may occur during the precautionary landing. This is an emergency procedure, but the approach technique is the same as for a short-field landing.

The *Takeoff and Landing Performance Gap* booklet is a useful reference for this lesson.

## Objectives

To ensure, by calculation, that there is adequate runway length for takeoff and landing in accordance with the aeroplane's performance data.

To apply sound decision making principles before adopting the recommended procedure for takeoff or approach for a runway of minimal length.

To operate the aeroplane in accordance with the manufacturer's recommended short-field techniques in order to obtain the best possible performance.

## Takeoff Considerations

### Temperature

The most important effect of temperature is to change density. An increase in temperature will result in a decrease in density. Since the expected engine performance is based on a standard temperature of 15 degrees Celsius at sea level, a correction will need to be made for the actual or ambient temperature.

If you are in the aeroplane, on the field of takeoff, the aeroplane's outside air temperature (OAT) gauge gives ambient temperature. Otherwise, this information is provided in a METAR if available.

### Density

Density also affects the indicated airspeed (IAS). As density decreases, IAS decreases. Therefore, as the density decreases, the aeroplane's actual speed (TAS) will need to be increased to achieve the same IAS for any given rotate IAS. This will increase the length of the takeoff roll, but the effects of density on engine performance are far more critical.

### Pressure Altitude

The calculation of pressure altitude (PA) is vital for takeoff, as this corrects the airfield elevation under the existing conditions to an elevation within the standard atmosphere, and the standard atmosphere is what the expected engine performance is based on.

If you're on the aerodrome of takeoff and in the aeroplane, you can simply set 1013 hPa on the altimeter sub-scale and read off the pressure altitude. However, if you're not on the aerodrome of takeoff, you need to know the airfield's QNH (from the METAR) and elevation (from the aerodrome chart) in order to calculate pressure altitude.

### Aeroplane Weight

The aeroplane's weight is derived from the weight and balance calculations and will directly affect the takeoff and climb performance.

### Runway Surface

The takeoff roll is reduced on a firm or sealed surface compared to a soft or grass surface, as there is less surface friction. Since the takeoff performance figures provided in the Flight Manual must be calculated using known parameters, a grass surface is defined as short dry grass. Long or wet grass will markedly increase the takeoff distance.

### Slope

An up-slope increases the takeoff distance and a down-slope reduces it. The slope of a runway, as a percentage, is given in the operational data on the aerodrome chart in the AIP Vol 4.

### Headwind Component

When the wind is at an angle to the runway in use, the headwind component will need to be calculated. Use the chart provided in the Flight Manual.

### Wind

If strong or gusty winds are present, there is always the possibility of windshear in the climb-out. If a decrease in wind speed is suddenly encountered during takeoff, additional power will not be available to arrest the sink. Therefore, the

rotate speed ( $V_R$ ) and the takeoff safety speed ( $V_{TOSS}$ ) are increased by an appropriate amount to counter the possible effects of windshear.

For steady wind speeds of 10 knots or less, use the book figures.

For winds above 10 knots, this speed is progressively increased (refer CFI and Flight Manual).

Whenever the rotate, takeoff safety speed or best-angle-of-climb speed needs to be increased because of the conditions, think about whether to continue with the exercise.

### Calculation

The calculation of the required takeoff or landing distance should be a relatively simple process that encourages its regular use and the application of ADM principles.

The use of performance graphs should have been covered in previous lessons.

Collect all the necessary information and consult the Flight Manual to determine the required takeoff distance.

The takeoff performance graphs in most light aircraft Flight Manuals provide only one weight, All Up Weight (AUW). This is because the range of weights for takeoff or landing is insignificant and, since AUW cannot be exceeded, provides a safety margin at lower weights. Larger aircraft Flight Manuals provide two or more weights. Where only an AUW is given, lesser weights cannot be extrapolated. AUW must be used regardless of the aeroplane's actual weight.

Using either P-charts where available, or the Flight Manual performance data, plus AC91-3 surface correction factors, calculate the distance for takeoff under the existing conditions. Compare this with the distance available, as given in the aerodrome chart's operational data, or as determined by other means.

If the takeoff distance available is less than the takeoff distance required – walk away!

If the takeoff distance available is equal to or slightly more than the takeoff distance required – think carefully!

Double-check your calculations. Have all factors been properly taken into account?

Remember that an accurately performed short-field takeoff will be required in order to ensure that the performance data contained in the Flight Manual is met.

Takeoff performance figures are based on shiny new engines and propellers – how does this aeroplane compare? Is the surface short dry grass or a bit long? How important is it that a takeoff be conducted now – under these conditions – and how will the conditions be affected by a delay?

The calculated takeoff distance to a height of 50 feet assumes full power is applied before brake release and that the stated flap setting is used. The distance required for takeoff includes the ground roll and the distance travelled over the ground to reach a height of 50 feet at the takeoff safety speed ( $V_{\text{Toss}}$ ) which is based on the aeroplane's stall speed and therefore varies with the weight.

The takeoff safety speed ( $V_{\text{Toss}}$ ) is the speed to be achieved after liftoff and before a climb above 50 feet. Although, for most light training aeroplanes, it is commonly the same speed as the best angle of climb speed ( $V_x$ ), however, this speed does not usually include the use of flap (refer to Flight Manual for manufacturer's recommended procedures and/or CFI).

Some Flight Manuals have two takeoff charts, one without flap and another with flap. The use of flap is often recommended for takeoff from a soft field or where obstacles are present in the climb-out path (refer Flight Manual). This is because the increase in lift provided by flap allows the aeroplane to lift off sooner at a lower airspeed, thereby minimising the ground roll and surface friction.

Commonly, a lower takeoff safety speed ( $V_{\text{Toss}}$ ) is nominated when flap is used. This is because flap lowers the stalling speed, making a lower takeoff speed possible. In addition, the decreased groundspeed resulting from the lower climb airspeed allows a similar angle to the best-angle, to be achieved.

Takeoff distance calculations should be based on the appropriate performance figures, depending on whether flap is recommended for takeoff or not.

Unless all of these are applied with, calculation of the required takeoff distance is negated.

As this exercise is not generally carried out from minimal length fields, remember to advise students that such conditions are being simulated.

Do not allow the student to round off the rotate or takeoff safety speed to the nearest mark on the airspeed indicator, for example, takeoff safety speed 54 knots, which is "near enough to 55 knots". This exercise requires accurate flying skills, and these only come from practise. Although one knot may make no appreciable difference to the aeroplane's performance, this practise will ultimately make a considerable difference to the student's attitude towards performance.

## Landing Considerations

### Aerodrome Elevation or Pressure Altitude

Because of the low power setting used on the approach, aerodrome elevation is used when calculating landing distance and the effects of pressure altitude ignored. However, an increase in altitude will result in a decrease in the air density. As density decreases, IAS decreases and the aeroplane's actual speed (TAS) will be increased for any given indicated threshold crossing speed. Therefore, the aerodrome height above sea level will affect the length of the landing roll, and pressure altitude may be used for more accurate calculations (refer Flight Manual and CFI).

### Weight

The aeroplane's weight affects inertia and therefore the stopping distance.

### Runway Surface

The landing roll is reduced on a firm dry surface compared with a grass or wet surface because of the improved braking action. Remember that grass is defined as short dry grass.

### Slope

An up-slope decreases the landing distance, and a down-slope increases it. Slope is given in the aerodrome operational data.

### Headwind Component

When the wind is at an angle to the runway in use, the headwind component will need to be calculated. Use the chart provided in the Flight Manual.

### Wind

If strong or gusty winds are present, there is always the possibility of windshear on the approach. The approach and target threshold speeds ( $V_{TT}$ ) are increased by an appropriate amount to counter the possible effects of windshear.

For steady wind speeds of 10 knots or less, use the book figures.

For winds above 10 knots, this speed is progressively increased (refer CFI and Flight Manual).

Whenever the approach or threshold speed needs to be modified, consider whether to continue with the exercise. The answer may be affected by the excess runway available over that required.

### Calculating the Landing Distance

With the necessary information collected, the Flight Manual is consulted in order to determine the landing distance required.

The calculated distance for landing under the existing conditions, is compared to that available, which is given in the aerodrome chart's operational data.

If the landing distance available is less than the landing distance required – walk or fly away!

If the landing distance available is equal to or slightly more than the landing distance required – think carefully!

Double-check your calculations. Have all factors been properly taken into account?

Remember that an accurately performed short-field landing will be required in order to ensure that the performance data contained in the Flight Manual is met.

The Flight Manual for each aeroplane type states the maximum speed for crossing the threshold, and the flap setting to be used.

The required landing distance in the Flight Manual is calculated from a height of 50 feet above the threshold in the stated configuration. That is, the distance required for landing includes the distance to touch down from 50 feet over the threshold and the ground roll to a full stop.

Crossing the threshold higher than 50 feet, using less than full flap, or crossing the threshold at a higher airspeed, will increase the landing distance.

## Airmanship

Pilots should consider their own ability before attempting a takeoff from or landing onto a runway of minimum length.

The decision-making considerations of a normal takeoff apply; but additional decision making is required in relation to a strong or gusty wind and EFATO.

The possibility of EFATO during a short-field takeoff requires an amendment to the takeoff safety brief. Rather than simply lower the nose, as a result of the very high nose attitude and the low airspeed during the initial climb out, the brief is modified to emphasise immediately and positively lowering the nose.

Discuss the decision making required when deciding to go or to abort the takeoff or landing.

## Aeroplane Management

Full power before brake release is confirmed by checking that the required static rpm is being achieved. This figure (often stated as a range, eg, 2280 to 2380 rpm) is in the Flight Manual.

If static rpm is not achieved, simple ADM should result in a logical sequence of: full power is not achieved therefore, maximum performance cannot be achieved, and therefore, the takeoff must not be attempted.

Have an aircraft engineer check out and clear the problem before further flight.

There are a few reasons why static rpm may not be achieved, and consideration of these requires the application of a higher level of ADM.

### **Iceing**

Check for carburettor ice and that the carburettor heat control is set to COLD. If this cures the problem, continue with the takeoff.

### **Instrument error**

Is this rpm normal for this aeroplane? Has this rpm reading been confirmed by the engineers as indicative of full power in this aeroplane? (If so, why is this state of affairs acceptable? Refer CFI).

### **Propeller**

Is the propeller in good condition, and is it the same propeller installed by the manufacturer, on which the static rpm is based. Or has it been replaced with a propeller of coarser pitch?

These last two possibilities cannot be confirmed while sitting at the holding point; taxi back to the start-up area and consult an aircraft engineer.

## **Human Factors**

Vision may be affected by the high nose attitude on takeoff and terrain ahead may produce a false horizon. Therefore, regular cross-reference to instruments is emphasised.

During an approach to land, perception may be influenced by the visual cues of surrounding terrain, a false horizon or runway length and width. Therefore, regular cross-reference to instruments is emphasised.

## **Air Exercise**

### **Takeoff**

While holding the aeroplane on the brakes (nosewheel straight) with elevator neutral, full power is applied. Static rpm and temperatures and pressures are checked for normal indications.

Good aviation practice dictates that all takeoffs must be made using full runway length.

Ensure a clean brake release, and as soon as the aeroplane starts to move, take the weight off the nosewheel with elevator, to reduce surface friction, and check for normal acceleration.

The nosewheel should be held on the ground until the rotate speed ( $V_R$ ) is achieved. This will require an adjustment to backpressure as the airspeed increases and the elevator becomes more effective. Rotating early only increases the aerodynamic drag and prolongs the takeoff roll.

As  $V_R$  is reached, smoothly rotate the aeroplane and lift off (do not 'haul' into the air). Lower the nose and allow the aeroplane to accelerate to the takeoff safety speed ( $V_{TOS}$ ). This generally requires only a small decrease in backpressure rather than a noticeable check forward.

On reaching  $V_{TOS}$  the attitude is adjusted and held. As a result of the high power setting and low airspeed, more rudder than normal will be required to keep straight on the reference point.

At a safe height (assuming that any obstacles have been cleared), accelerate to best rate of climb ( $V_Y$ ) or the normal recommended climb speed (refer CFI). Check the aeroplane is in balance.

Before raising flap (if used), there are three criteria that must always be met: safe height, safe airspeed, and a positive rate of climb. When these conditions have been met, raise flap and counter the pitch change. Allow acceleration to continue, and upon reaching the climb speed required (best rate or normal), trim to maintain the appropriate attitude.

### **Landing**

During the downwind leg the conditions used for the approach and threshold speeds are confirmed and an aim point chosen. The aim point should be as close to the threshold as is safe (consider obstacles on approach). If the exercise is being flown onto a marked runway, a point just short of the numbers painted on the surface is a good choice as an aim point.

The selection of this aiming point should not be confused with the club competition of spot landings, where the objective is to land on a spot, usually well into the runway. Although the same approach technique is employed, nominating an aiming point well into a field of minimal length would negate the landing distance calculations.

The procedure to achieve the optimum aeroplane performance for landing as stated in the Flight Manual is used. The stated performance figures are based on the aeroplane being operated at its optimum.

The turn onto base is carried out in the normal manner but delayed slightly by extending the downwind leg to ensure some power must be used throughout the entire approach.

Because this type of approach employs a low threshold speed, a heavy aeroplane with considerable inertia may not have sufficient elevator effectiveness to initiate the flare even though full elevator deflection may be used. Using power throughout the approach gives total control over the rate of descent and additional elevator effectiveness during the flare.

The approach path is monitored by reference to the aiming point and the power adjusted as required to maintain a steady rate of descent to touch down – power controls the rate of descent. If the aeroplane is correctly trimmed the power adjustments will be very small.

Once established on final, full flap is selected and the airspeed progressively decreased, by adjusting the attitude, to achieve the nominated target threshold speed ( $V_{\text{TH}}$ ) by about 200 feet agl. Power will generally need to be adjusted as speed is decreased.

It is important to carry some power into the flare.

If the aeroplane is not properly configured by 200 feet agl on final approach – that is, on centreline, on correct glideslope, aim point identified, and airspeed correct – go around!

The landing is carried out in one phase. The round-out and the hold-off are combined into the flare (a reduction in rate of descent to zero). The aim is to reduce the rate of sink to zero at the same time as the main wheels touch the ground and the throttle is closed.

The nosewheel is lowered, then brakes immediately applied as required; elevator backpressure is used to keep the weight off the nosewheel. Do not use excessive braking.

Flap is raised on completion of the landing roll.

## Airborne Sequence

### On the Ground

The distance required for takeoff has been determined as adequate, and flap has been selected in accordance with the Flight Manual.

### The Exercise

#### *Before Line-Up*

The conditions are assessed and compared with the conditions that were used in calculating the required takeoff distance.

A decision is made on the rotate and takeoff safety speed for the existing conditions.

A safe height, at which to accelerate to best rate or the normal climb speed, is nominated dependent on the height of obstacles in the climb-out path. An obstacle clearance altitude (OCA) is stated, rather than a height above ground, as an altitude is what the student will see on the altimeter.

The OCA should be varied during subsequent exercises to simulate clearing various obstacles in the climb-out path.

The pre-takeoff safety brief is completed, with emphasis on a positive check forward, in the event of an EFATO.

### **On Line-Up**

Full runway length is used, and the high reference point is chosen.

If propeller damage is a possibility because of a loose surface, the aeroplane is not held on the brakes. The minimum static rpm is confirmed as soon as full power is applied. At the point of brakes release, always check that the student drops their heels to the floor.

### **Landing**

Except for extending downwind a little to ensure power is used throughout the entire approach, the turn onto base, base leg and the turn onto final are all normal.

On final (it may look like the profile is too low, due to the downwind extension) full flap is selected.

The airspeed is progressively reduced to the nominated target threshold speed by 200 feet agl.

To reduce the airspeed, the nose attitude will need to be raised, and this usually results in the student assessing the approach as high, with a consequent immediate reduction in power.

During a normal approach the aeroplane is flown down the approach path at 70 knots, whereas during this exercise the aeroplane sinks down the same or steeper approach path at progressively decreasing speeds, only the attitude and airspeed are different. The approach profile should never be flat and low.

The importance of selecting an attitude for the required speed, particularly the  $V_{TT}$ , and trimming the aeroplane to maintain that attitude, cannot be over emphasised.

If the aeroplane is not properly configured by 200 feet agl, or the landing is not assured for any reason – the student should be taught to go around.

Do not allow the student to round off the approach or target threshold speeds to the nearest mark on the airspeed indicator.

### **After Flight**

The student will have plenty of time to practise these takeoffs and landings in their circuit flights.

A full-stop landing should always be made when flying this exercise.