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TAKE-OFF, CLIMB AND LANDING PERFORMANCE OF LIGHT AEROPLANES

1 Introduction

1.1 Accidents, such as failure to get airborne in the distance available, collision with obstacles owing to inadequate climb and over-run on landing, continue to occur fairly frequently to light aeroplanes (ie those below 5700 kg maximum weight). Many such accidents have occurred when operating from short strips, often taking-off or landing out of wind, or with sloping ground. Poor surfaces such as wet grass or ice were also frequent contributory factors. What is not generally realised by many pilots is that these are PERFORMANCE accidents and many, if not all, of these accidents could have been avoided if the pilots had been fully aware of the PERFORMANCE LIMITATIONS of their aeroplanes.

1.2 The pilot-in-command of ANY UK REGISTERED aeroplane has a legal obligation placed on him by Article 52 of the Air Navigation Order 2005 which requires him to check that the aeroplane will have adequate performance for the proposed flight. The purpose of this Circular is to remind pilots of private flights of the actions needed to ensure that the take-off, climb and landing performance will be adequate.

1.3 Aeroplane Performance is subject to many variables including:

Aeroplane weight;
Aerodrome altitude;
Temperature;
Wind;
Runway length;
Slope;
Surface;
Flap setting;
Humidity.

1.3.1 The performance data will usually allow adjustment to be made for these variables. On certification, allowances are made to cater for slight variations in individual pilots' handling of a specific technique.

2 Where to Find the Information

2.1 Performance figures may be given in a variety of publications and it is important for pilots to know where to find the data needed to predict the performance in the expected flight conditions. The appropriate document is specified in the Certificate of Airworthiness and may be any one of the following:

(a) The UK Flight Manual;

(b) the Owner's Manual or Pilot's Operating Handbook. These documents, which sometimes contain CAA Supplements giving additional performance data which may either supplement or override data in the main document, are the ones applicable to many light aeroplanes;

(c) the Performance Schedule (applicable to a few of the older aeroplanes);

(d) for some imported aeroplanes, an English language flight manual approved by the Airworthiness Authority in the country of origin, but with a UK Supplement containing the performance data approved by the CAA.

3 Use of Performance Data

3.1 The majority of modern, light aeroplanes were originally classified in Performance Group E for the purposes of public transport. The performance information contained in the Manuals and Handbooks of these aeroplanes is UNFACTORED. This means the data represents the performance achieved by the manufacturer using a new aeroplane in ideal conditions. This level of performance will not be achieved if the flying techniques used by the manufacturer are not followed closely or if the meteorological conditions are not as favourable as those encountered during testing. It is therefore PRUDENT TO ADD SAFETY FACTORS to the data in order to take account of less favourable conditions.

3.2 To ensure a high level of safety on public transport flights, there is a legal requirement to add specified safety factors to the data. It is RECOMMENDED that at least the same factors be used for private flights. When a pilot planning a private flight chooses to accept aerodrome distances or climb performance less than that required for a public transport flight, he should recognise that the level of safety is lowered accordingly.

3.3 Performance data in Manuals for aeroplanes certificated in Performance Groups C, D or F for the purposes of public transport normally include public transport factors. These Manuals usually make it clear if factors are included, but if in any doubt the user should consult the Safety Regulation Group of the CAA.

3.4 It should be remembered that any 'limitations' given in the Certificate of Airworthiness, the Flight Manual, the Performance Schedule or the Owner's Manual/Pilot's Operating Handbook, are MANDATORY ON ALL FLIGHTS.

4 Performance Planning

4.1 A list of variables affecting performance together with guide line factors is summarised in tabular form at the end of this Circular. These represent the increase in take-off distance to a height of 50 ft or the increase in landing distance from 50 ft. It is intended that the tabular form will be suitable for attaching to a pilot's clipboard for easy reference. WHEN SPECIFIC CORRECTIONS ARE GIVEN IN THE AEROPLANE'S MANUAL, HANDBOOK OR SUPPLEMENT, THESE MUST BE CONSIDERED THE MINIMUM ACCEPTABLE.

5 Take-off

5.1 Aeroplane Weight: it is important that the actual weight stated on the weight and balance sheet for the individual aeroplane is used as the basis for calculations. The weight of individual aeroplanes of a given type can vary considerably dependent on the level of equipment. Using the example weight shown in the weight and balance section of the handbook is not satisfactory.

5.1.1 Guide line factor: take-off distance will be increased by 20% for each 10% increase in aeroplane weight (a factor of x 1.20).

5.2 Aerodrome Altitude: aeroplane performance deteriorates with an increase in altitude and the pressure altitude at the aerodrome of departure should be used for calculations. This equates to the height shown on the altimeter on the ground at the aerodrome with the sub-scale set at 1013 mb.

5.2.1 Guide line factor: take-off distance will be increased by 10% for each 1000 ft increase in aerodrome altitude (a factor of x 1.10).

5.3 Temperature: aeroplane performance deteriorates with an increase in ambient temperature.

5.3.1 Guide line factor: take-off distance will be increased by 10% for a 10°C increase in ambient temperature (a factor of x 1.10).

5.4 Wind: a tailwind increases the take-off distance.

5.4.1 Guide line factor: the take-off distance will be increased by 20% for a tailwind component of 10% of the lift-off speed (a factor of x 1.20).

Note: Where the data allows adjustment for wind, it is recommended that not more than 50% of the headwind component and not less than 150% of the tailwind component of the reported wind be assumed. In some Manuals this factoring is already included and it is necessary to check the relevant section.

5.5 Slope: an uphill slope increases the ground run.

5.5.1 Guide line factor: the take-off distance will be increased by 10% for each 2% of uphill slope (a factor of x 1.10) (see also paragraph 8.3).

5.6 Surface: grass, soft ground or snow increase rolling resistance and therefore the ground run.

Guide line factors: for dry grass (under 8 inches), the take-off distance will be increased by 20% (a factor of x 1.20).

For wet grass (under 8 inches), the take-off distance will be increased by 30% (a factor of x 1.30).

Note 1: A take-off should not be attempted if the grass is more than 10 inches high.
For soft ground or snow the take-off distance will be increased by 25% or more (a factor of at least 1.25).

Note 2: For surface and slope factors remember that the increases shown are to the take-off distance to a height of 50 ft. The correction to the ground run will be proportionally greater.

5.7 Flap Setting: read carefully any Supplement attached to your Manual, the take-off performance with or without the use of take-off flap shown in the main part of the Manual may not be approved for use by aeroplanes on the UK register.

5.8 Humidity: high humidity has an adverse affect on performance and this is usually taken into account during certification, however, there may be a correction factor applicable to your aeroplane. Consult the Manual.

5.9 The above factors are cumulative and where several factors are relevant they must be multiplied. The resulting corrected distance required can seem surprisingly high.

5.10 Safety Factors: it is recommended that at least the public transport factors should be applied for all flights. Unless otherwise specified in the aeroplanes manual, handbook or supplement, as factor of 1.33 for take-off is recommended, and should be applied after the application of the corrections for the variables.

5.11 Example:

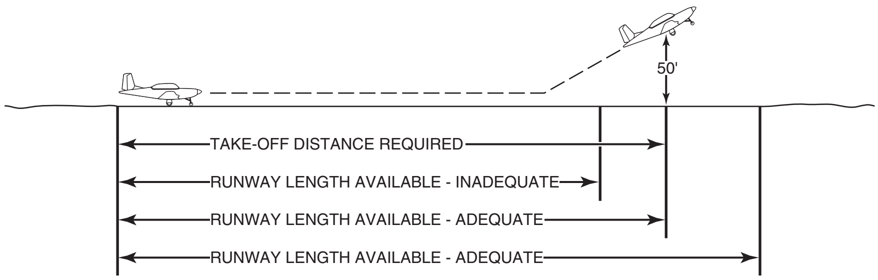
In still air, on a paved level dry runway at sea level with an ambient temperature of 15°C, an aeroplane requires a take-off distance to a height of 50 ft Take of Distance Required of 390 m. This should be multiplied by the safety factor of 1.33 giving a Take of Distance Required of 519 m.

The same aeroplane in still air on a dry, grass strip (factor x 1.20) with a 2% uphill slope (factor x 1.10), 500 ft above sea-level (factor x 1.05) at 20°C (ie 5°C warmer, therefore factor x 1.05) will have a corrected take-off distance to a height of 50 ft of:

390 x 1.20 x 1.10 x 1.05 x 1.05 = 568 m.

The safety factor (x 1.33) should then be applied, giving a Take off Distance Required of 755 m.

5.11 The pilot should always ensure that, after applying all the relevant factors including the safety factor, the take-off distance to a height of 50 ft Take of Distance Required does not exceed the runway length available (or TODA if known).



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6 Climb

6.1 So that the aeroplane climb performance does not fall below the prescribed minimum, some Manuals give take-off and landing weights that should not be exceeded at specific combinations of altitude and temperature (WAT limits). Unless included in the Limitations section, these weight restrictions are mandatory only for public transport flights. THEY ARE HOWEVER RECOMMENDED FOR PRIVATE FLIGHTS and are calculated using the altitude and temperature at the relevant aerodrome. Where WAT limits are not given the following procedures are recommended:

(a) At the expected take-off and landing weights the aeroplane should be capable of a rate of climb of 700 ft/min if it has a retractable undercarriage, or 500 ft/min if it has a fixed undercarriage. The rates of climb should be assessed at the relevant aerodrome altitude and temperature in the en-route configuration at the en-route climb speed and using maximum continuous power;

(b) for an aeroplane with more than one engine, if conditions are such that during climb to, or descent from, the cruising altitude obstacles cannot be avoided visually, the aeroplane should be able to climb at 150 ft/min with one engine inoperative, at the aerodrome altitude and temperature.

7 Landing

7.1 Aeroplane Weight: See paragraph 5.1.

7.1.1 Guide line factor: landing distance will be increased by 10% for each 10% increase in aeroplane weight (a factor of x 1.10).

7.2 Aerodrome Altitude: aeroplane performance deteriorates with an increase in pressure altitude.

7.2.1 Guide line factor: landing distance will be increased by 5% for each 1000 ft increase in aerodrome pressure altitude (a factor of x 1.05).

7.3 Temperature: aeroplane performance deteriorates with an increase in ambient temperature.

7.3.1 Guide line factor: landing distance will be increased by 5% for a 10°C increase in ambient temperature (a factor of x 1.05).

7.4 Wind: a tailwind increases the landing distance.

7.4.1 Guide line factor: landing distance will be increased by 20% for a tailwind component of 10% of the landing speed (a factor of x 1.20).

Note: Where the data allows adjustment for wind, it is recommended that not more than 50% of the headwind component and notless than 150% of the tailwind component of the reported wind be assumed. In some Manuals this factoring is already included and it is necessary to check the relevant section.

7.5 Slope: a downhill slope increases the landing distance.

7.5.1 Guide line factor: landing distance will be increased by 10% for each 2% of downhill slope (a factor of x 1.10).

7.6 Surface: grass or snow increase the ground roll, despite increased rolling resistance because brake effectiveness is reduced.

Guide line factors: for dry grass (under 8 inches) the landing distance will be increased by 15% (a factor of x 1.15).

For wet grass (under 8 inches) the landing distance will be increased by 35% (a factor of x 1.35).

Note 1: When the grass is very short, the surface may be slippery and distances may increase by up to 60% (a factor of x 1.60)

For snow, the landing distance will be increased by 25% or more (a factor of at least x 1.25).

Note 2: For surface and slope factors, remember the increases shown are to the landing distance from a height of 50 ft. The correction to the ground roll will be greater.

7.7 Safety Factors: it is recommended that the public transport factor should be applied for all flights. For landing, this factor is x 1.43.

7.8 The above factors are cumulative and when several factors are relevant they must be multiplied. As in the take-off case the total distance required may seem surprisingly high.

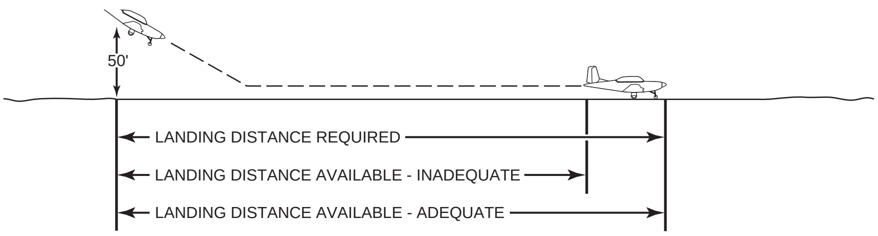
For example:

In still air on a paved level, dry runway with an ambient temperature of 15°C an aeroplane requires a landing distance from a height of 50 ft (LDR) of 350 m. This should be multiplied by the safety factor of 1.43 giving a LDR of 501 m.

The same aeroplane landing in still air at a wet grass strip (factor x 1.30) 500 ft above sea-level (factor x 1.025) at 25°C (ie 10°C warmer, therefore factor x 1.05), including the safety factor (factor x 1.43) will require a landing distance of:

350 x 1.30 x 1.025 x 1.05 x 1.43 = 700 m

7.9 The pilot should always ensure that after applying all the relevant factors including the safety factor the landing distance required from a height of 50 ft (LDR) does not exceed landing distance available.



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8 Additional Information

8.1 Engine Failure: the possibility of an engine failing during any phase of the flight should also be considered. Considerations should include the one engine inoperative performance of multi-engined types and the glide performance of single engined types. In the latter case, the ability to make a safe forced landing should be borne in mind throughout the flight.

8.2 Obstacles: it is essential to be aware of any obstacles likely to impede either the take-off or landing flight path and to ensure there is adequate performance available to clear them by a safe margin. The AD section of the UK AIP includes obstacle data for a number of UK aerodromes.

8.3 Aerodrome Distances: for many aerodromes, information on available distances is published in some form of aerodrome guide such as the AD section of the UK AIP or commercially available flight guides. At aerodromes where no published information exists, distances should be paced out. The pace length should be established accurately or assumed to be no more than 2.5 ft. Slopes can be calculated if surface elevation information is available, if not they should be estimated. Prior to take-off it might be helpful to taxi the aeroplane from one end of the strip to the other and take an altimeter reading at each end. Most altimeters will show differences down to 20 ft and to find the slope, simply divide altitude difference by strip length and give the result as a percentage. For example an altitude difference of 50 ft on a 2500 ft strip indicates a 2% slope. Be sure not to mix metres and feet in your calculation.

8.4 Operations from strips covered in snow, slush or extensive standing water should not be attempted without first reading AIC 15/2006 (Pink 92).

8.5 Where doubt exists on the source of data to be used or its application in given circumstances, advice should be sought from:

Flight Test Section
Flight Department
Safety Regulation Group
Civil Aviation Authority
Aviation House
South Area
London Gatwick Airport
Gatwick
West Sussex
RH6 0YR

Tel: 01293-573113.

This Circular is issued for information, guidance and necessary action.

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ANNEXE

TAKE-OFF

Condition	Increase In Take-off Distance To Height 50 ft	Factor
A 10% increase in Aeroplane Weight	20%	1.20
An increase of 1000 ft in Aerodrome Altitude	10%	1.10
An increase of 10°C in Ambient Temperature	10%	1.10
Dry Grass*- Up to 20 cm (8 in) (on firm soil)	20%	1.20
Wet Grass*- Up to 20 cm (8 in) (on firm soil)	30%	1.30
A 2% Uphill Slope*	10%	1.10
A Tailwind Component of 10% of Lift-off Speed	20%	1.20
Soft Ground or Snow*	25% or more	1.25 +

*Effect on Ground Run/Roll will be proportionally greater

LANDING

Condition	Increase In Landing Distance To Height 50 ft	Factor
A 10% increase in Aeroplane Weight	10%	1.10
An increase of 1000 ft in Airfield Altitude	5%	1.05
An increase of 10°C in Ambient Temperature	5%	1.05
A Wet paved runway	15%	1.15
Dry Grass*- Up to 20 cm (8 in) (on firm soil)	15%	1.15
Wet Grass*- Up to 20 cm (8 in) (on firm soil) See Note 3	35%	1.35
A 2% Downhill Slope*	10%	1.10
A Tailwind Component of 10% of Landing Speed	20%	1.20
Snow*	25% or more	1.25 +

*Effect on Ground Run/Roll will be proportionally greater

Note 1: After taking account of the above variables it is recommended that the relevant safety factors 1.33 or take-off; 1.43 for landing are applied.

Note 2: Any deviation from normal operating techniques is likely to result in an increase in the distance required.

Note 3: When the grass is very short, the surface may be slippery and distances may increase by up to 60% (a factor of 1.60).