SAFETYSENSE LEAFLET 7
AEROPLANE PERFORMANCE

1 INTRODUCTION

a) Accidents such as failure to get airborne, collision with obstacles after take-off and over-run on landing occur frequently to light aeroplanes. Many have happened at short licensed runways, as well as strips, often when operating out of wind or where there was a slope. Poor surfaces such as long or wet grass, mud or snow, were often contributory factors. Many, if not all, of these performance accidents could have been avoided if the pilots had been fully aware of the performance limitations of their aeroplanes.

b) The pilot in command has a legal obligation under Article 52 of the Air Navigation Order 2005, which requires the pilot to check that the aeroplane will have adequate performance for the proposed flight. The purpose of this leaflet is to remind you of the actions you need to take to ensure that your aeroplane's take-off, climb and landing performance will be adequate. It may not of course, be necessary before every flight. If you are using a 3000 metre runway a cursory check of performance will do, but where is the dividing line – 700, 1000 or 1500 metres? This will be decided by a large number of variables and only by reference to performance data, including climb performance, can the safety, or otherwise, of the particular flight be properly determined.

2 WHERE TO FIND INFORMATION

The data needed to predict the performance in the expected conditions may be in any one of the following:

- The UK Flight Manual, or for a few older aeroplanes, the Performance Schedule.
- The Pilot's Operating Handbook or Owner's Manual. This is applicable to most light aeroplanes and sometimes contains CAA Change Sheets and/or Supplements giving additional performance data which may either supplement or override data in the main document, e.g. a ‘fleet downgrade’.

- For some imported aeroplanes, an English language Flight Manual approved by the airworthiness authority in the country of origin, with a UK supplement containing the performance data approved by the CAA.

3 USE OF PERFORMANCE DATA

a) Many light aeroplanes are in Air Navigation (General) Regulations (ANGR) performance group E, and certificated with UNFACTORED data, being the performance achieved by the manufacturer using a *new aeroplane and engine(s) in ideal conditions* flown by a highly experienced pilot. The CAA does not verify the Performance Data on all foreign aeroplanes; in some cases a single spot check is made.

b) To ensure a high level of safety on UK **Public Transport** flights, there is a *legal* requirement to apply specified safety factors to un-factored data (the result is called Net Performance Data). It is strongly recommended that similar factors be used for private flights in order to take account of:

- Your lack of practice
- Incorrect speeds/techniques
- Aeroplane/engine wear and tear
- Less than favourable conditions.

c) Performance data in manuals for UK manufactured aeroplanes certificated for the purposes of Public Transport may include the Public Transport factors (i.e. Net Performance), but manuals and handbooks for the smaller aeroplanes often do not. For foreign manufactured aeroplanes the Net Performance may be included as a Supplement. Manuals usually make it clear if factors are included but if in any doubt you should consult the CAA Safety Regulation Group (see paragraph 9(e)).

d) 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. (Note that there can be a UK Limitation contained in a Supplement which is not referred to in the text of the main document.)

e) If any advice/information given in this leaflet differs from that given in the Flight Manual, (or Pilot's Operating Handbook), then you must always comply with the manual or handbook – these are the authoritative documents.

4 PERFORMANCE PLANNING

a) A list of variables affecting performance together with Factors for non-Public Transport operations are shown in tabular form at the end of this leaflet. These represent the increase to be expected in take-off distance to a height of 50 feet, or the increase in landing distance from 50 feet, and are intended to be carried for easy reference. When specific Factors are given in the aeroplane's manual, handbook or supplement, they must be considered the minimum acceptable. The primary source is the Flight Manual or Pilot's Operating Handbook but cross check using this leaflet and use this if no other information is available.

b) European regulations require more specific calculations for public transport operations, which student professional pilots are taught and are expected to use.

5 GENERAL POINTS

a) **Aeroplane weight:** use the actual aircraft Basic Empty weight stated on the Weight and Balance Schedule for the *individual* aeroplane you plan to fly. The weight of aeroplanes of a given type can vary considerably dependent upon the level of equipment, by as much as 77 kg (170 lb) – the "invisible passenger" - for a single-engined aeroplane. Do not use the 'example weight' shown in the weight and balance section. Remember, on many aeroplanes it may not be possible to fill all the fuel tanks, all the seats and the baggage area. Safety Sense Leaflet 9 (Weight and Balance) provides further guidance.

b) **Airfield elevation:** performance deteriorates with altitude and you should use the pressure altitude at the aerodrome for calculations. (This can be found by setting the altimeter sub-scale to 1013 mb on the ground at the aerodrome.)

c) **Slope:** an uphill slope increases the take-off ground run, and a downhill slope increases the landing distance. Any benefit arising from an upslope on landing or a downslope on take-off will be minor and should be regarded as a 'bonus'. There are a few 'one way strips' where the slope is so great that in most wind conditions it is best to land up the hill and take off downhill.

d) **Temperature:** performance decreases on a hot day. On really hot days many pilots have been surprised by the loss of power in ambient temperatures of 30°C and above. Remember, temperature may be low on a summer morning but very high in the afternoon.

e) **Wind:** even a slight tailwind increases the take-off and landing distances very significantly. Note that if there is a 90° crosswind there is no beneficial headwind component and aircraft controllability may be the problem. Where 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 these factors are already included; check the relevant section.

f) **Cloudbase and visibility:** if you have to make a forced landing or fly a low-level circuit and re-land, you **MUST** be able to see obstacles and the ground. Thus, cloudbase and visibility have to be appropriate.

g) **Turbulence and windshear:** will adversely affect the performance, you must be aware of these when working out the distances needed.

h) **Surrounding terrain:** if there are hills or mountains nearby, check that you will have a rate or angle of climb sufficient to out-climb the terrain. This is particularly important if there is any wind, it may cause significant down draughts.

i) **Rain drops, mud, insects and ice:** these have a significant effect on aeroplanes, particularly those with laminar flow aerofoils. Stall speeds are increased and greater distances are required. Note that **any** ice, snow or frost affects all aerofoils, including the propeller, and also increases the aircraft's weight – you must clear it **all** before flight. (AIC 106/04 (Pink 74) – Frost, Ice and Snow on Aircraft, refers.)

j) **Tyre pressure:** low tyre pressure (perhaps hidden by grass or wheel fairings) will increase the take-off run, as will wheel fairings jammed full of mud, grass, slush, etc.

k) **Engine failure:** since an engine failure or power loss (even on some twin-engined aircraft) may result in a forced landing, this must be borne in mind during all stages of the flight.

l) **Manoeuvre performance:** variations in aeroplane weight will directly affect its performance during aerobatics (even, for example, steep turns) and outside air temperature/ altitude will similarly affect engine power available. Hot day aerobatics in a heavier than normal aeroplane require careful planning and thought.

6 TAKE-OFF – POINTS TO NOTE

a) **Cross-wind:** a cross-wind on take-off may require use of brakes to keep straight, and will increase the take-off distance.

b) **Decision point:** you should work out the runway point at which you can stop the aeroplane in the event of engine or other malfunctions, e.g. low engine rpm, loss of ASI, lack of acceleration or dragging brakes. Do NOT mentally programme yourself in a GO-mode to the exclusion of all else.

If the ground is soft or the grass is long and the aeroplane is still on the ground and not accelerating, stick to your decision-point and abandon take-off. If the grass is wet or damp, particularly if it is very short, you will need a lot more space to stop.

c) **Twin engines:** if there is an engine failure after lift-off on a twin, you will not reach the scheduled single engine rate of climb until:

- the landing gear and flaps have retracted (there may be a temporary degradation as the gear doors open)
- the best single engine climb speed, 'blue line speed', has been achieved.

Under limiting conditions an engine failure shortly after lift-off may preclude continued flight and a forced landing will be necessary. Where the performance is marginal, consider the following points when deciding the best course of action:

- while flying with asymmetric power it is **vital** that airspeed is maintained comfortably above the minimum control speed, V_{MCA}. A forced landing under control is infinitely preferable to the loss of directional control with the aircraft rolling inverted at low altitude. If there are signs you are losing directional control, lower the nose as much as height permits to regain speed and if all else fails reduce power on the operating engine. (Care must be taken to maintain normal margins above the stall.)
- performance and stall speed margins will be reduced in turns. All turns must be gentle.

KEEP IN ASYMMETRIC PRACTICE

d) **Use of available length:** make use of the full length of the runway, there is no point in turning a good length runway into a short one by doing an 'intersection' take-off. On short fields use any 'starter strip'.

e) **Rolling take-off:** although turning onto the runway and applying full power without stopping can reduce the take-off run, it should only be used with great care (due to landing gear side loads and directional control) and your propwash must not hazard other aircraft. If you are having to do this sort of thing, then the runway is probably TOO SHORT.

f) **Surface and slope:** grass, soft ground or snow increase rolling resistance and therefore the take-off ground run. On soft ground, a heavy aircraft may 'dig in' and never reach take-off speed. Keeping the weight off the nosewheel or getting the tail up on a tail wheel aircraft may help. An uphill slope reduces acceleration.

For surface and slope, remember that the increases shown are the take-off and landing distances to or from a height of *50 feet*. The correction to the ground run will usually be proportionally greater.

g) **Flap setting:** use the settings recommended in Pilots Handbook/Flight Manual but check for any Supplement attached to your Manual/Hhandbook. The take-off performance shown in the main part of the manual may give some flap settings which are not approved for Public Transport operations by aeroplanes on the UK Civil Aircraft register. Do not use settings which are 'folk- lore'.

h) **Humidity:** high humidity can have an adverse effect on engine performance and this is usually taken into account during certification; however, there may be a correction factor applicable to your aeroplane. Check in the Manual/Handbook.

i) **Abandoned take-off:** Manuals may include data on rejected take-off distances. Some quote a minimum engine rpm that should be available during the take-off run.

j) **Engine power:** check early in the take-off run that engine(s) rpm/manifold pressure are correct. If they are low, abandon take-off when there is plenty of room to stop. Use of carb heat at the hold should reduce the risk of carb ice (*see SSL 14*).

7 LANDING – POINTS TO NOTE

a) When landing at places where the length is not generous, make sure that you touch down on or very close to your aiming point (beware of displaced thresholds). If you've misjudged it, make an early decision to go around – don't float half way along the runway before deciding.

b) Landing on a wet surface, or snow, can result in increased ground roll, despite increased rolling resistance. Tyre friction reduces, as does the amount of braking possible. Very short wet grass with a firm subsoil will be slippery and can give a 60% distance increase (1.6 factor).

c) When landing on grass the pilot cannot see or always know whether the grass is wet or covered in dew.

d) Landing distances quoted in the Pilot's Operating Handbook/Flight Manual assume the correct approach speed and technique is flown, a higher speed will add significantly to the distance required whilst a lower speed will erode stall margins.

8 SAFETY FACTORS

a) **Take-off**

It is strongly recommended that the appropriate Public Transport factor, or one that at least meets that requirement, should be applied for all flights. For take-off this factor is x 1.33 and applies to all single-engined aeroplanes and to multi-engined aeroplanes with limited performance scheduling (Group E). Manuals for aeroplanes in other Performance Groups may give factored data.

Pilots of these latter Performance Group aeroplanes and other complex types are expected to refer to the Flight Manual for specific information on all aspects of performance planning. It is therefore important to check which Performance Group your aeroplane is in.

The table at the end of this leaflet gives guidance for pilots of aeroplanes for which there is only UNFACTORED data. It is taken from AIC 127/2006 (Pink 110).

Where several factors are relevant, they must be **multiplied**. The resulting Take-Off Distance Required to a height of 50 feet (TODR) can become surprisingly high.

For example:

In still air, on a level dry hard runway at sea level with an ambient temperature of 10°C, an aeroplane requires a measured take-off distance to a height of 50 feet of 390 m. This should be multiplied by the safety factor of 1.33 giving a TODR of 519 m.

The same aeroplane in still air from a dry, short-grass strip (factor of 1.2) with a 2% uphill slope (factor of 1.1), 500 feet above sea-level (factor of 1.05) at 20°C (factor of 1.1), including the safety factor (factor of 1.33) will have TODR of: 390 x 1.2 x 1.1 x 1.05 x 1.1 x 1.33 = 791 m.

You should always ensure that, after applying all the relevant factors, including the safety factor, the TODR does not exceed the take-off run available (TORA) [or accelerate-stop distance available (ASDA]. If it does, you **must** offload passengers, fuel or baggage. Better a disappointed passenger than a grieving widow! Do not assume 'It will be alright'.

b) **Climb (and Go-around)**

In order that the aeroplane climb performance does not fall below the prescribed minimum, some manuals/handbooks quote take-off and landing weights that should not be exceeded at specific combinations of altitude and temperature ('WAT' limits). They are calculated using the pressure altitude and temperature at the relevant aerodrome.

Remember rate of climb decreases with altitude – don't allow yourself to get into a situation where the terrain outclimbs your aeroplane!

c) **Landing**

It is recommended that the Public Transport factor should be applied for all flights. For landing, you should multiply your calculated landing distance required by a factor of 1.43.

Again, when several factors are relevant they must be **multiplied together**. As with take-off, the total distance required may seem surprisingly high.

You should always ensure that after applying all the relevant factors, including the safety factor, the Landing Distance Required (LDR) from a height of 50 feet does not exceed Landing Distance Available.

9 ADDITIONAL INFORMATION

a) **Engine failure:** bear in mind the glide performance, miles per 1000 ft, of single-engined types and the ability to make a safe forced landing throughout the flight. Where possible, the cruise altitude should be selected accordingly.

b) **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 'Aerodromes' section of the UK AIP includes obstacle data for most licensed UK aerodromes. Excessive angles of bank shortly after take-off greatly reduce rate of climb.

c) **Aerodrome distances:** for many aerodromes information on available distances is published in the Aerodrome section of the AIP or in one of the Flight Guides. At aerodromes where no published information exists, distances can be paced out. The pace length should be established accurately or assumed to be no more than 0.75 metres (2 ½ ft). It is better to measure the length accurately with the aid of a rope of known length.

Slopes can be calculated if surface elevation information is available; if not they should be estimated. For example, an altitude difference of 50 ft on a 750 metre (2,500 ft) strip indicates a 2% slope. Unless the Flight Manual gives specific figures, do not try to calculate any benefit from an advantageous slope.

Do not mix metres and feet in your calculation and remember that a metre is more than a yard. A conversion table is below.

Beware of intersection take-offs, displaced runway thresholds or soft ground which may reduce the available runway length to less than the published figures. Check NOTAMs, Local Notices etc.

d) **Surface:** operations from strips or aerodromes covered in snow, slush or extensive standing water are inadvisable. Do not attempt them without first reading AIC 3/2007 (Pink 111), 'Risks and Factors Associated with Operations on Runways Contaminated with Snow, Slush or Water'. A short wait may allow standing water, hail, etc. to clear.

e) **Advice:** where doubt exists on the source of data to be used or its application in given circumstances, advice should be sought from the Flight Department, Safety Regulation Group, Aviation House, Gatwick Airport South, RH6 0YR, Telephone (01293) 573113 Fax (01293) 573977.

Conversion Table:

1 kg	= 2.205 lb	1 lb	= 0.454 kg
1 inch	= 2.54 cm	1 cm	= 0.394 in
1 foot	= 0.305 m	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

10 SUMMARY:

FACTORS MUST BE MULTIPLIED i.e. 1.20 x 1.35				
	TAKE-OFF		LANDING	
CONDITION	INCREASE IN TAKE -OFF DISTANCE TO HEIGHT 50 FEET	FACTOR	INCREASE IN LANDING DISTANCE FROM 50 FEET	FACTOR
A 10% increase in aeroplane weight, e.g. another passenger	20%	1.20	10%	1.10
An increase of 1,000 ft in aerodrome elevation	10%	1.10	5%	1.05
An increase of 10°C in ambient temperature	10%	1.10	5%	1.05
Dry grass* - Up to 20 cm (8 in) (on firm soil)	20%	1.20	15%+	1.15
Wet grass* - Up to 20 cm (8 in) (on firm soil)	30%	1.3	35%+ Very short grass may be slippery, distances may increase by up to 60%	1.35
Wet paved surface	-	-	15%	1.15
A 2% slope*	Uphill 10%	1.10	Downhill 10%	1.10
A tailwind component of 10% of lift-off speed	20%	1.20	20%	1.20
Soft ground or snow*	25% or more	1.25 +	25%+ or more	1.25 +
NOW USE ADDITIONAL SAFETY FACTORS (if data is unfactored)		**1.33**		**1.43**

Notes: 1. * Effect on Ground Run/Roll will be greater. Do not attempt to use the factors to reduce the distances required in the case of downslope on take-off or upslope on landing.

2. + For a few types of aeroplane, e.g. those without brakes, grass surfaces may decrease the landing roll. However, to be on the safe side, assume the INCREASE shown until you are thoroughly conversant with the aeroplane type.

3. Any deviation from normal operating techniques is likely to result in an increased distance.

If the distance required exceeds the distance available, changes will HAVE to be made.