Federal Aviation Administration

On Landings Part II

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Introduction

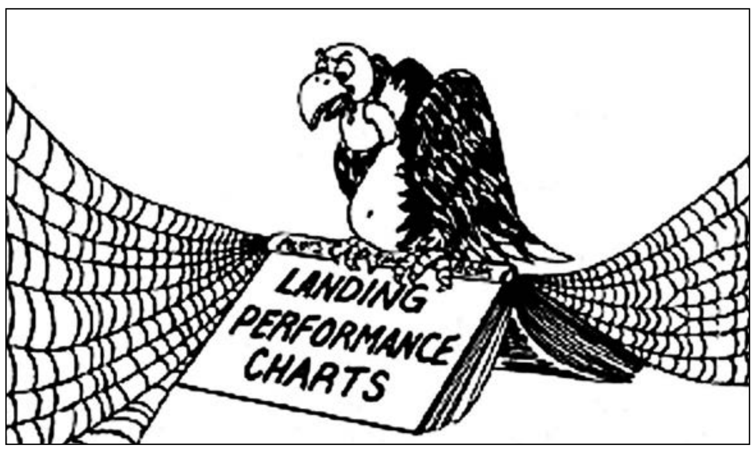
Having reviewed the material in Part I of this On Landings series, now we will look at two kinds of landing accidents that are "complementary." By that, we mean that, in some cases, "If the first one doesn't get you, the second one will." These accidents are **landing long** and the **poorly executed go-around.**

Landing Long

When was the last time you looked at the landing performance charts for the aircraft you fly?

Aircraft performance charts are presented in one of two formats: graphical or tabular. Some performance charts provide different approach speeds for different landing weights, while others provide only the maximum weight approach speed.

How many factors affect the length of your landing roll? Of course, there are **landing speed** and **landing weight,** and there are also **wind** and **density altitude** (which is the combination of pressure altitude and temperature). Did you remember **runway slope** and **runway surface?** These factors affect braking. **Runway length** itself is also a factor because it affects where you locate your aim point.



These factors must be thoroughly understood and controlled to avoid the hazards of landing long.

Airspeed Control

Airspeed control is the most important factor in achieving landing precision. The secret of precise airspeed control begins in the traffic pattern with the stabilized approach.

Begin mastering airspeed control by checking the numbers in your Pilot's Operating Handbook (POH) or owner's manual. You should know and use the appropriate airspeeds for each segment of your approach. If you cannot locate them, get help from a knowledgeable flight instructor. Manufacturer-recommended airspeeds should be used when available.

On short final with the aircraft's wings level, your airspeed should be at the recommended approach speed. If that speed is not stated, use 1.3 Vso.

Although the official definition of Vso is qualified in many ways, for purposes of this discussion, Vso is the calibrated power-off stall speed of the airplane in the landing configuration and usually with a forward center of gravity (CG).

There are a few times when the use of 1.3 Vso on short final is not acceptable. First, the recommended approach speed for twin-engine airplanes is at or above Vyse, the best single-engine rate-of-climb speed, which may be more than 1.3 Vso. Second, the presence of strong, gusting winds is a problem and will be discussed later.

ROLL-OUT DISTANCE RATIO

EQUALS. . .

$$\left(\frac{\text{ACTUAL TOUCHDOWN SPEED}}{\text{NORMAL TOUCHDOWN SPEED}}\right)^2$$

Also, if you are unfortunate enough to be trying to land with an unwanted load of ice, the stall speed will be much higher than normal. If you carry too much airspeed at the moment of touchdown, your roll-out distance ratio will increase by the square of the ratio of your actual touchdown speed over your normal touchdown speed.

$$\left[\frac{\text{V ACTUAL TOUCHDOWN SPEED}}{\text{V NORMAL TOUCHDOWN SPEED}}\right]^2 = \text{ROLL OUT DISTANCE REQUIRED}$$

EXAMPLE:

55 KNOTS — ACTUAL TOUCHDOWN SPEED

50 KNOTS — NORMAL TOUCHDOWN SPEED

OR, $\frac{60}{55}$ — A FACTOR OF 1.1 OR 10% FASTER

$(1.1)^2 = 1.21$

21% MORE RUNWAY REQUIRED FOR ROLL OUT.

For example, if an airplane that should be landed at 50 knots touches down at 55 knots (10 percent faster, or a factor of 1.1), the ground roll-out distance will be increased by the square of this factor, or a factor of 1.21, if all other factors are constant. The distance used from touchdown to a full stop will then be 21 percent greater than for the minimum touchdown speed. This scenario could be ample justification for a go-around.

$$\left(\frac{70}{50}\right)^2 = (1.4)^2 = 1.96$$

OR . . .

96% MORE ROLL-OUT DISTANCE REQUIRED

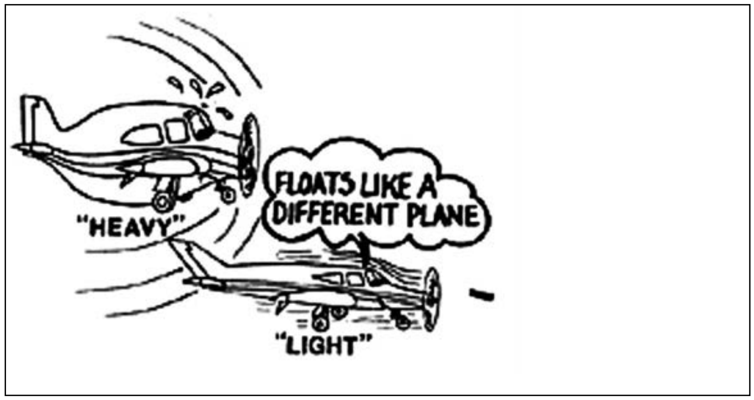
An approach flown at 70 knots, or 20 knots faster than your normal approach speed, will require 96 percent more roll-out distance, or nearly double the runway length for roll-out alone.

At anytime, if you happen to be carrying extra airspeed in the flare, the airplane will float; that is, it will glide from over your aim point, past the intended touchdown point, until that excess airspeed dissipates.

Sometimes at a busy airport you are asked to keep the speed up, land short, and then turn off quickly. This scenario can be difficult and requires concentration and control. There may be situations where your best and safest option is to tell the air controllers “unable to comply.”

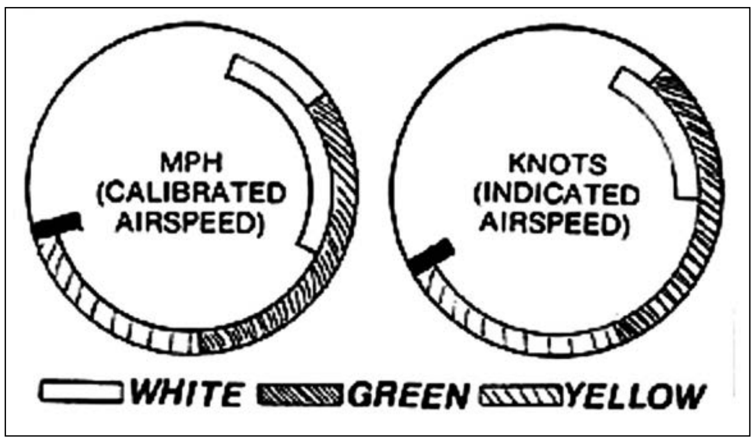
Landing Weight

Other factors also lead to landing long. Did you know that landing light can also mean landing long?



Remember, the 1.3 Vso formula is based on the actual weight of the aircraft, not the maximum landing weight. If you use your customary maximum weight 1.3 Vso number all the time, the aircraft will float as it dissipates the excess energy. Assuming that you will want to land at or close to the stall speed, runway distance will be eaten up during the process.

Many pilots assume that the lower end of the white arc on the airspeed indicator is Vso for all landing weights, but this assumption is incorrect. The lower end of the white arc on the airspeed indicator is actually the stall speed for maximum landing weight at the most unfavorable CG within the allowable loading range. Depending on the aircraft's year of manufacture, this lower end of the white arc could be marked in either calibrated airspeed (CAS) or indicated airspeed (IAS).



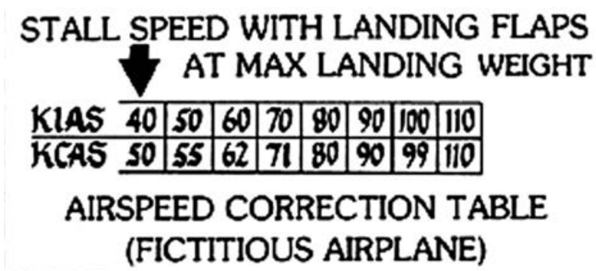
Larger aircraft that weigh more than 12,500 pounds have detailed and very specific information to determine V-ref for all landing weights as well as other approach speeds at various flap settings. This information is needed because all aircraft stall at slower speeds when they are lighter. In the case of an airliner, that difference in weight can be measured in tons. In a light aircraft, the difference of a few hundred pounds in landing weight can make a similar difference.

The Airspeed Indicator—Beware!

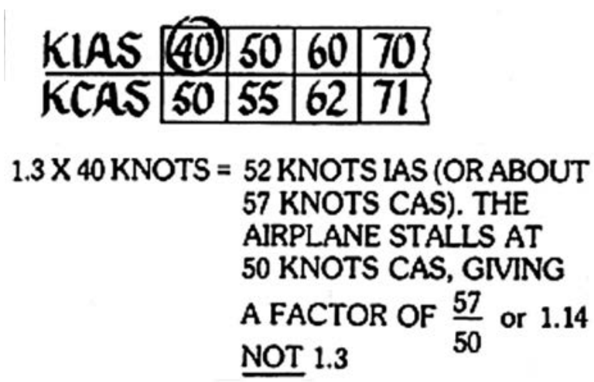
Airplanes manufactured *before* the mid-1970s had their airspeed indicator color-coded speed range arcs marked in *CAS* and shown in miles per hour (mph). (Some were marked in both mph and knots.)

To determine 1.3 Vso at maximum landing weight for airplanes built before the mid- to late 1970s, multiply the calibrated Vso airspeed (given in the owner's manual or marked at the bottom of the white arc) by 1.3.

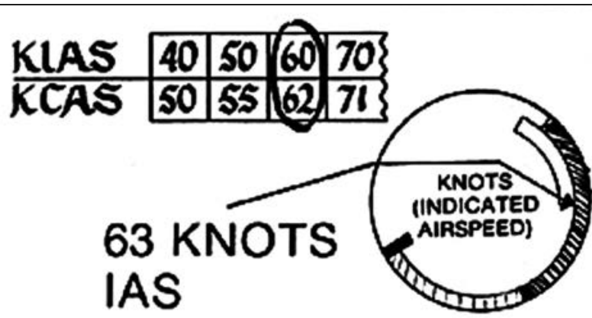
Most airplanes built *after* the mid-1970s had their airspeed indicators marked in *IAS*. Check the manufacturer's information about this for your specific airplane.



For most aircraft built after the mid- to late 1970s, you must use the CAS values as published in your POH because CAS is IAS corrected for position and instrument error (or what the perfect airspeed indicator system would show). CAS should always be used to calculate the proper approach speed at any landing weight and then converted to IAS for practical use.



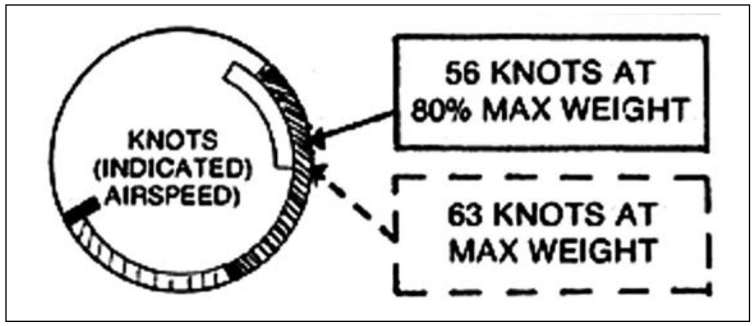
You should perform this conversion because, for some airplanes, the IAS near the stall has a significant error. For example, if IAS is used as the maximum weight stall speed Vso by mistake (here, it is shown as 40 knots), 1.3 Vso would be 1.3 times 40, or 52 knots IAS, or about 57 knots CAS (using the table), given a margin of only 7 knots above the 50-knot CAS stall speed.



If you use CAS as Vso, however, 1.3 x 50 = 65 knots CAS. Referring to the correction table, the IAS for an approach (at maximum landing weight in smooth air) would be 63 knots IAS, given an actual safety margin of 15 knots above the real, or calibrated, stall airspeed. The safety margin, however, will look like a margin of 23 knots on your airspeed indicator.

The following text explains how you can estimate the approach airspeed for airplanes that do *not* provide approach speeds as a function of reduced landing weight. For airplanes *without* a table of approach speeds as a function of reduced weight, a rule of thumb is to reduce the *calibrated* approach airspeed for the maximum weight of your aircraft *by one-half of the percentage of the weight decrease.* For example, if the airplane's weight is 20 percent below maximum, you would decrease the approach-calibrated airspeed by one-half of that amount, or by 10 percent.

For an airplane with an approach speed of 65 knots CAS at maximum landing weight (calculated by multiplying the landing speed Vso by 1.3 [that is, 1.3 x 50 knots = 65 knots CAS]), if you fly an approach with a 20-percent decrease in weight (or at 80 percent of the maximum landing weight), the new approach speed would be 65 knots minus 6 knots (10 percent of 65), or 59 knots CAS, or 56 knots IAS, according to the correction table.



Remember, 1.3 Vso gives you a safety margin, but only after all maneuvering is completed. Use 1.3 Vso on *short final only*.

A warning about setting up your own approach speeds: The aircraft manufacturer may require a particular approach speed for *all* weights because it found during certification flight testing that a fixed speed is required for stability and control reasons or for go-around safety. Check on this point for your airplane.

Impact of Wind on Landing Long

Wind is another major factor in landing long. To determine the effect of wind on landing roll-out, consult your performance charts. You might be surprised to learn that a light headwind is not to be counted in rule-of-thumb computations for a decreased landing roll unless it exceeds 10 percent of your *touchdown* speed.

Any tailwind does have a significant impact on your landing roll-out and has the same effect as excess airspeed on touchdown in no-wind conditions, so beware.

A tailwind compounds your landing roll-out distance by the square of the ratio of the tailwind component plus your actual touchdown speed over your normal touchdown speed.

INCREASE IN ROLL-OUT DISTANCE

EQUALS. . .

$$\left[\frac{\text{TAILWIND COMPONENT + ACTUAL TOUCHDOWN SPEED}}{\text{NORMAL TOUCHDOWN SPEED}}\right]^2$$

For example, if your normal landing speed is 50 knots CAS, you have a 10-knot tailwind, and you touch down 10 knots too fast (that is, at 60 knots CAS), you will almost double your landing roll-out distance, if all other factors are equal.

$$\left(\frac{60 + 10}{50}\right)^2 = 1.96$$

OR . . .

96% MORE ROLL-OUT DISTANCE REQUIRED

If all that sounds too complicated, just don't land downwind.

Rule of Thumb To Estimate Landing Roll-Out Distance With a Headwind

EXAMPLE:

TOUCHDOWN SPEED (CAS) .....50 KNOTS
WIND (LESS THAN 10%)......... 0-5 KNOTS

ASSUME THAT THE RUNWAY DISTANCE REQUIRED IS THE SAME AS FOR "NO-WIND" CONDITIONS

Here is how you can estimate your landing roll-out distance when landing with a headwind component:

$$\left(\frac{\text{HEADWIND}}{\text{TOUCHDOWN SPEED}}\right) = \frac{5}{50}$$

$$= 10\%$$

THEREFORE . . . TREAT AS "CALM"

For headwind components below 5 knots, treat all winds as calm.

EXAMPLE:

"NO-WIND" LANDING ROLL-OUT ..... 1000 FEET
TOUCHDOWN SPEED (CAS)..........50 KNOTS
HEADWIND COMPONENT............10 KNOTS

$$0.9 - \frac{10}{50} = 0.9 - 0.2 = 0.7$$

ESTIMATED LANDING ROLL-OUT = 0.7 X 1000 = 700 FEET

For a headwind component greater than 10 percent of the normal touchdown speed (in CAS), the rule of thumb is 0.9 minus (the head wind component divided by the normal touchdown speed). This number multiplied by the no-wind landing roll-out distance then equals the new, estimated landing roll-out.

EXAMPLE:

"NO-WIND" LANDING ROLL-OUT ..... 1000 FEET
TOUCHDOWN SPEED (CAS)..........50 KNOTS
TAILWIND COMPONENT ....10 KNOTS

THEREFORE, GROUND SPEED AT TOUCHDOWN = 60 KNOTS

$\frac{60}{50}$ = 1.2 TIMES NORMAL TOUCHDOWN SPEED

$(1.2)^2 = 1.44$

1.44 X 1000 = 1440 FEET EXTRA RUNWAY ROLL-OUT DISTANCE REQUIRED

If you land with a tailwind, as the following example shows, a 10-knot tailwind will increase your touchdown speed from 50 knots (your normal touchdown speed) to 60 knots, or by 20 percent, a factor of 1.2. Squaring this number gives 1.44, and multiplying 1.44 by your no-wind ground roll-out distance gives an expected ground roll of 1,440 feet. Thus, if a 10-knot headwind in the previous example had shifted to a 10-knot tailwind, the expected landing roll-out distance of 700 feet (again, from the previous example) would be *more than doubled*.

CAUTION: Remember that these rules of thumb are just that. They are intended to teach you the advantages of landing with a headwind and, conversely, the hazards of landing with a tailwind. They are not intended to substitute for manufacturer's information. Consult your POH or owner's manual for specifics.

Wind Gusts

The gust factor, the difference between the steady state wind and the maximum gust, should be factored into your short final approach airspeed in some form. It should also be added to your various approach segment airspeeds for downwind, base, and final.

One recommended technique many pilots use is to divide the gust factor by two and add this to the normal approach speed.

APPROACH SPEED WITH GUSTING WINDS =

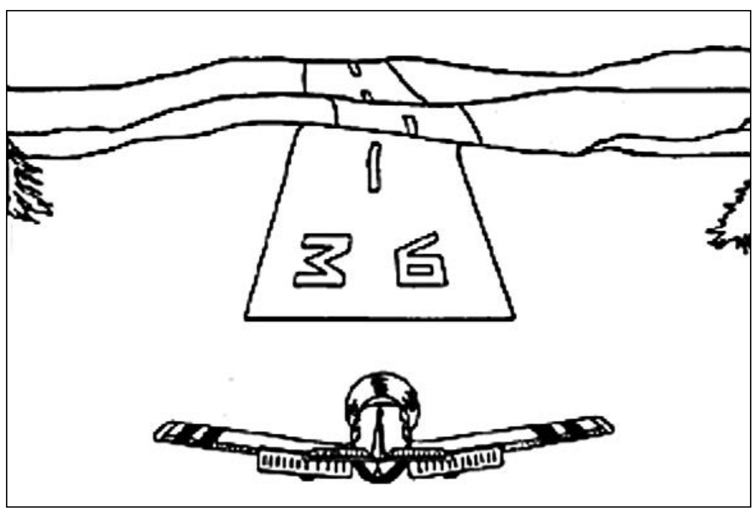
$$\frac{\text{WIND GUST}}{2} + \text{NORMAL APPROACH SPEED}$$

Some pilots add all of the steady wind and half the gust, or all of the gust and no steady wind. To increase safety, your final approach airspeed needs to be precisely calculated and then precisely flown. Don't forget—your approach airspeed and whatever gust factor you select to add to your final approach airspeed should be flown only *after* all maneuvering has been completed and the aircraft has been lined up on the final approach.

Runway Slope

FAA utility airport design standards allow maximum grades of up to 2 percent, or about 1.2 degrees of slope. Runway slope is a relatively minor factor at these airports, but it can be a major factor at an airport not built to government standards.

If you do attempt a landing on an inclined runway, the rule of thumb is to always land uphill, wind and obstacles permitting.



Density Altitude

Density altitude is the combination of pressure altitude and temperature. These two variables can be read directly from the altimeter (at the 29.92 Hg setting) and the outside air temperature (OAT) gauge.

Once you know pressure altitude and temperature, POHs provide tables or graphs that enable you to determine the effects of density altitude in one step.

Older airplane publications use a two-step method requiring the use of pressure altitude and OAT to first determine density altitude and then use density altitude to determine the effects on aircraft and engine performance.

Although density altitude does not have a great effect on landing roll-out as it has on take-offs, remember that high-density altitude means higher true airspeeds and, therefore, longer runway requirements. High, hot, and humid means that there may be a potential need to lean the fuel-air mixture on landing to ensure good engine performance in case of a go-around.

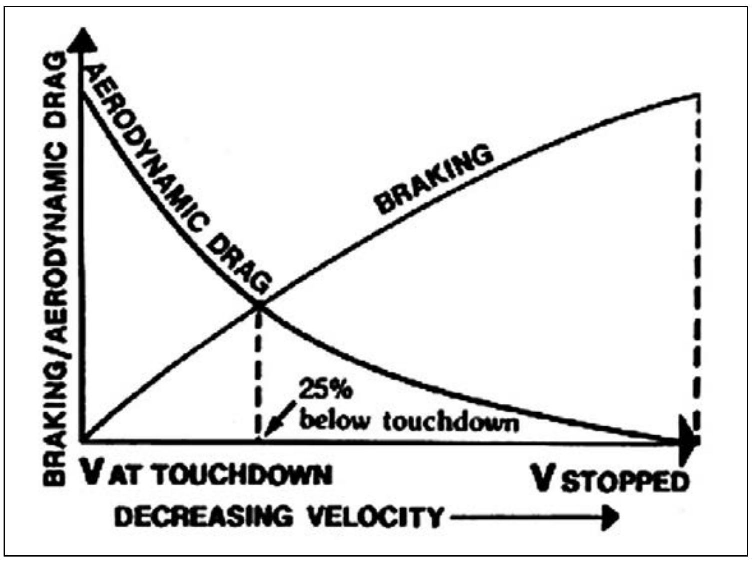
Figure on adding about 5 percent to the landing roll-out for each additional 1,000 feet of density altitude.

Runway Surface

Runway surface makes a big difference on landing long because it plays a big role in braking.

A dry, concrete runway offers one of the best braking surfaces; a runway covered with wet, clear ice offers one of the worst braking surfaces. Most other conditions fall somewhere between the two.

How should you brake on dry surfaces? Don't begin to brake as soon as you touch down. Right after touchdown, the airplane is still producing lift and a premature application of brakes does nothing more than leave two expensive skid marks on the runway.



Apply brakes after all three wheels are on the runway and the airplane has slowed to at least 25 percent below touchdown speed. In fact, for most airplanes, aerodynamic drag is the single biggest factor in slowing the aircraft in the first quarter of its speed decay. Brakes become increasingly effective as airspeed and lift decrease.

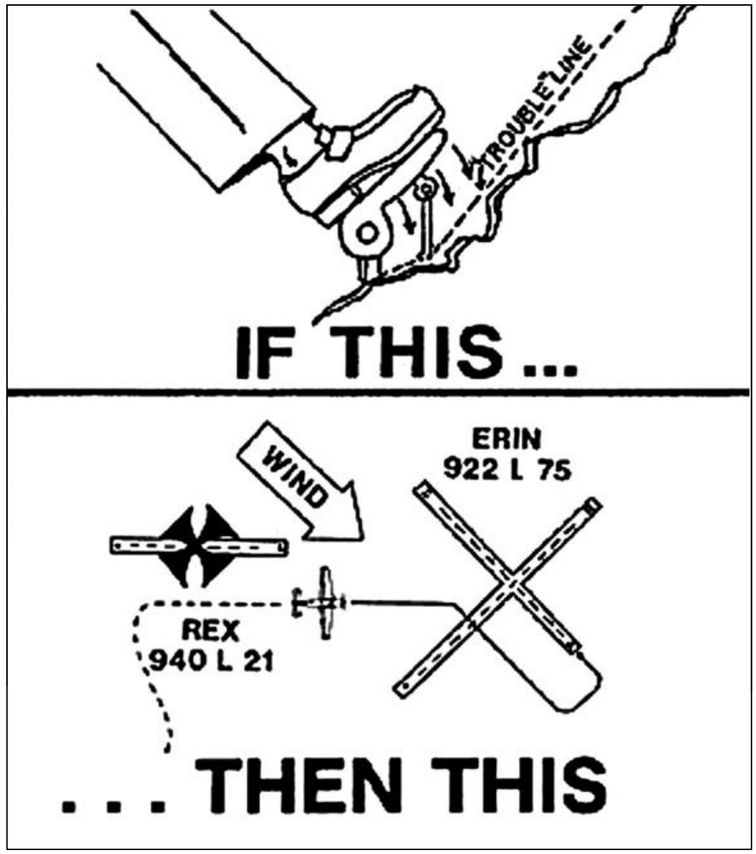
There are two ways to increase braking effectiveness on landing roll-out. Some POHs and owner's manuals suggest that retracting the flaps will decrease lift and put more weight on the gear. It is really best, however, to wait on flap retraction until you are clear of the runway and less busy, especially in retractable-gear aircraft, where a misidentified control could lead to a gear-up landing.

Instead, the safest way to increase braking effectiveness is to hold the wheel or stick full back as you firmly and smoothly apply brakes. Back pressure is needed because the airplane tends to lean forward with heavy braking. Back pressure is especially important in tail-draggers, but it is important for nosewheel types as well.

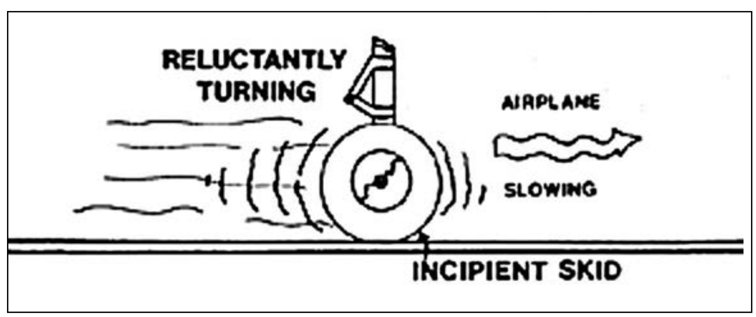
Grass is a much less effective braking surface. Wet or frost-covered grass is even worse.

Of course, be sure to avoid surprises by checking brake pedal pressure before entering the traffic pattern. Make it a habit.

If brakes are soft, mushy, or they "floor-board," land on a longer runway and on one as nearly aligned into the wind as possible.



Best braking results are always achieved with the wheels in an "incipient skid condition." That means a little more brake pressure would lock up the wheels entirely. In an incipient skid, the wheels are turning, but with great reluctance.



Whatever you do, don't lock the wheels. Braking effectiveness drops dramatically in a skid, and tires could be damaged.

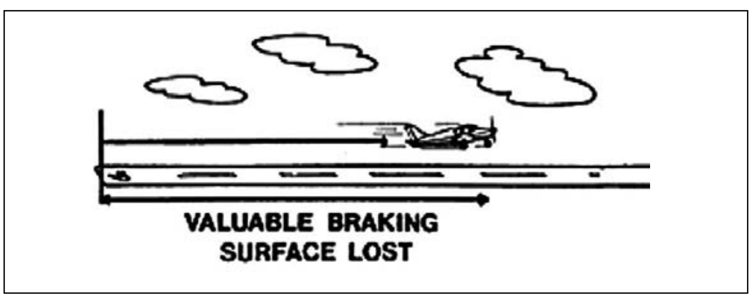
Airline flight crews routinely inspect the condition of their aircraft's tires before each flight. You should, too. Don't just check for depth of tread and proper inflation; look for cuts, bald spots, dry rot, and so on.

Runway Length

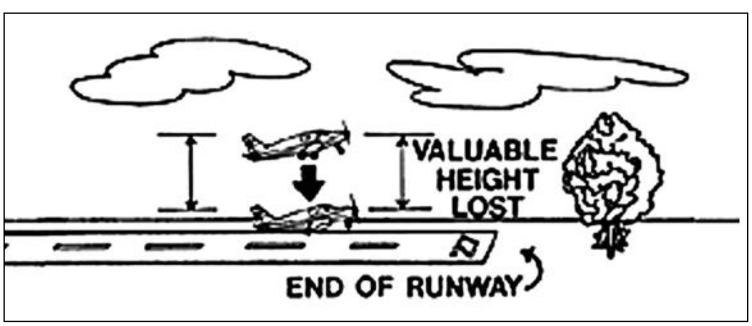
Runway length is also a factor in landing long. Did you know that an otherwise helpful nonstandard VASI can turn a 2,100-foot runway into an 1,800-foot runway? In this situation, the airport operator who installed the nonstandard VASI will locate the aim point for you, and it may be several hundred feet down the runway to start. Be alert for this, because a displaced aim point associated with a nonstandard VASI will not be identified in airman publications.

When Things Don't Go Right: The Go-Around

A properly executed go-around is one of the best accident avoidance procedures available to pilots, even though it is one of the least used. If a go-around is not properly executed, however, it can result in an accident—and one much more serious than landing long.

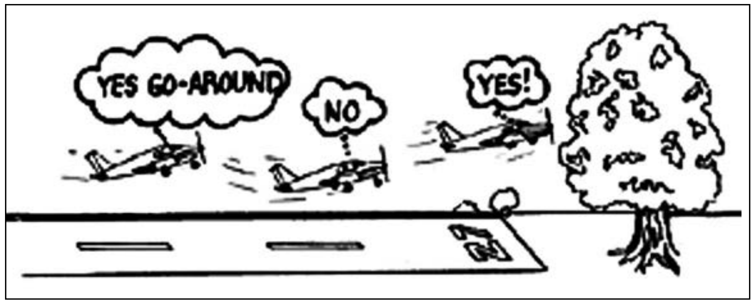


Official reports concerning go-around accidents frequently cite pilot indecision as a cause. What usually happens is pilot fixation—trying to make a bad landing good, resulting in a late decision to go-around.



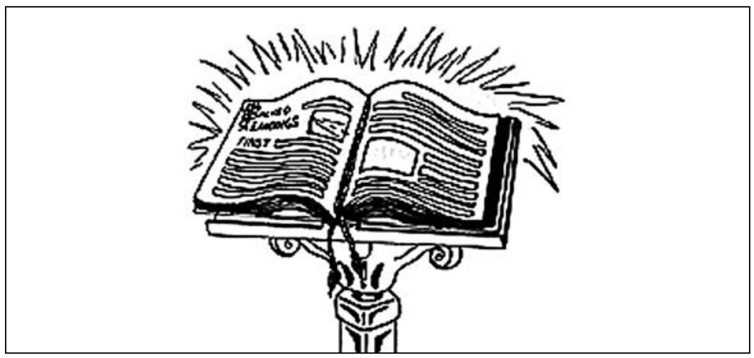
Delay costs valuable runway stopping distance and causes loss of valuable altitude as the approach continues.

If there is any question about making a safe touchdown and roll-out, take the airplane around—and do it early.



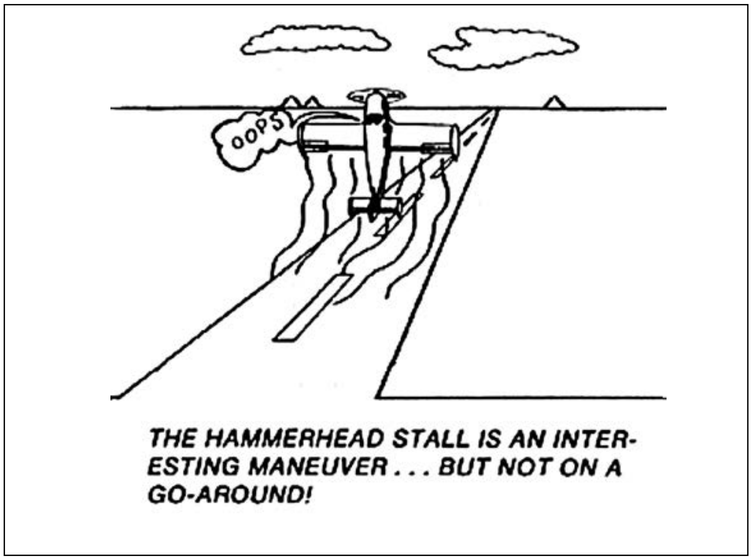
Treat the go-around as a normal procedure, not an abnormal or emergency action. Always be prepared to go around. Experienced pilots always determine in advance a go-around point on the runway. If they have not touched down by that point, it is go-around time.

Remember that high-density altitude or rising terrain may put your go-around point at some point before you even reach the runway, so plan ahead. As for go-around technique, your POH or owner's manual should be your primary source. Review it periodically.

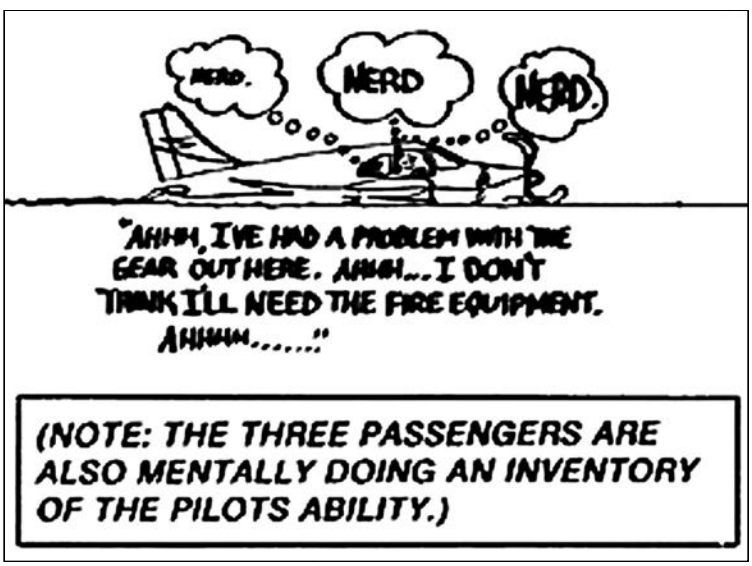


Follow these guidelines to execute a go-around:

- *Power* is the single most essential ingredient. Every precaution must be taken to ensure that power is available when you need it. For example, at a high-density altitude airport, be sure your mixture is leaned ahead of time. Other pre-landing checklist items to ensure that go-around power will be available include use of carb heat, as necessary, and full RPM on the prop.
- *Planning ahead* is another step. Know what you should do in case of trouble and where and when you should do it.
- Once you decide to go around, *stick to your decision*. Too many airplanes have been lost because a pilot vacillated, changed his mind, and tried to land after all.



- First and foremost, ***fly the airplane***. Forget UNICOM, and forget the passengers for the time being. Make sure maximum available power is applied and stays applied. Place the carb heat selector in the off position. Watch engine limits such as manifold pressure in turbocharged aircraft or EPRs and the like in turbines.
- Trim to maintain proper pitch control.
- Establish a positive rate of climb and cross-check inside with outside references.
- Then and only then, slowly retract flaps, further adjusting the pitch attitude. Only after establishing a positive climb, retract the gear if the aircraft is so equipped. As speed increases, accelerate past your best angle to your best rate-of-climb speed. Adjust cowl flaps as necessary.
- As you climb out, adjust your track over the ground to stay slightly to the right side of the runway so you can watch for departing traffic. Now, only after the aircraft is under control, communicate with tower or UNICOM.



- On the way around for another attempt, be especially sure to use your checklist. A go-around is the best time for a break in normal habit patterns. Stress occurs and normal tasks are out of order. More than one pilot has landed gear-up after a go-around.

- Practice your go-around procedures so that when you really do have to go around, you will be on top of the airplane instead of the other way around.
- Anytime you make an approach, be prepared to go around. If you do decide to go around, stick to your decision and maintain control. In all cases, when in doubt, go around.
- This is your go-around checklist: power, pitch, fly the airplane, clean it up, and then communicate. Then on your second attempt, strictly adhere to the landing checklist items. You have been distracted.

Note: The suggestions and "rules" given in this pamphlet are intended to be helpful aids only and are not intended to replace or supersede the aircraft manufacturer's recommendations.

About This Series

The purpose of this series of Federal Aviation Administration (FAA) safety publications is to provide the aviation community with safety information that is informative, handy, and easy to review. Many of the publications in this series summarize material published in various FAA advisory circulars, handbooks, other publications, and audiovisual products developed by the FAA and used by the FAA Safety Team (FAASTeam) for educational purposes.

Some of the ideas and materials in this series were developed by the aviation industry. The FAASTeam acknowledges the support of the aviation industry and its various trade and membership groups in the production of this series. We would like to acknowledge the contributions of the late William K. Kershner, technical advisor. Also, special thanks to Drew Steketee and Cassandra Bosco, writing and editing; James Gross, illustrations and graphics, layout and design; Gary S. Livack, overall project coordinator; and Ken Johnson, executive producer.

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