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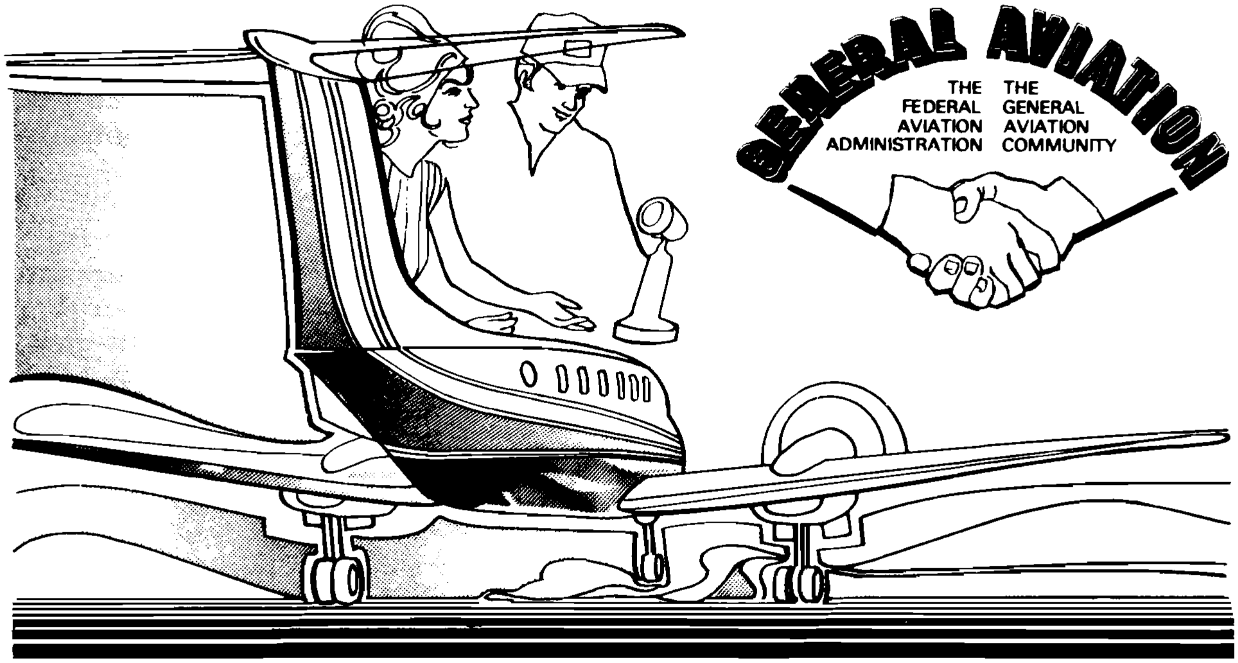


accident prevention program

ON LANDINGS

PART II

U.S. Department of Transportation
Federal Aviation Administration
Washington D.C.

FOREWORD

The purpose of this series of publications is to provide the flying public with safety information that is handy and easy to review. Many of the publications in this series summarize material contained in FAA General Aviation Accident Prevention Program audio-visual presentations. Each of the three "On Landings" handouts (Part I, Part II, and Part III), contains material intended to supplement the "On Landings" audio-visual presentation.

Comments regarding these publications should be directed to the Department of Transportation, Federal Aviation Administration, General Aviation and Commercial Division, Accident Prevention Program Branch, AFO-810, 800 Independence Avenue, S.W., Washington, D.C. 20591.

Acknowledgement

Handout preparation "thanks" go to William K. Kershner, technical advisor, Drew Steketee and Cassandra John, writing and editing, James Gross, illustrations and graphics, layout and design, Gary S. Livack, overall project coordinator, and Ken Johnson, executive producer. Additional copies of this handout are available from any FAA Flight Standards District Office.

A Cooperative Project by the:

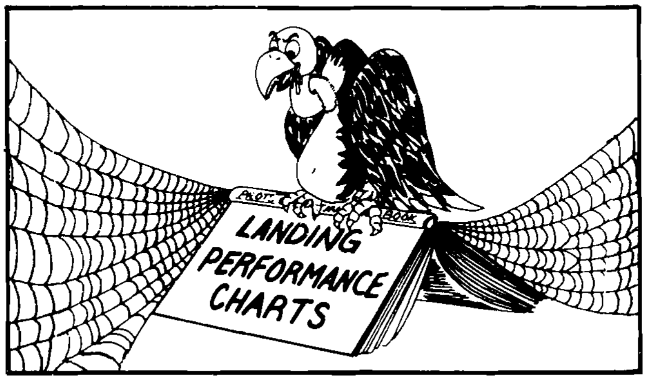
AVCO Lycoming Williamsport Division
Federal Aviation Administration
General Aviation Manufacturers Association
Transport Canada

ON LANDINGS
Part II

Now let's look at two kinds of landing accidents that are "complementary." By that, we mean that, in some cases, "If the first one don't get you, the second one will." These 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 different formats: graphical and 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's landing speed and landing weight. There's also wind and density altitude (which is the combination of pressure altitude and temperature). Did you remember runway slope and runway surface? They affect braking. Runway length itself is also a factor, since it affects where you locate your aim point.

These eight factors must be thoroughly understood and controlled to avoid the hazards of landing long. Let's start with airspeed control.

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 can't locate them, get help from a knowledgeable flight instructor. But again, manufacturer's numbers should be used when available.

On short final with 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 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 to be discussed later.

Also, if you are unfortunate enough to be trying to land with an unwanted load of ice (did anybody ever land with a *wanted* 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.

ROLL-OUT DISTANCE RATIO

EQUALS. . .

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

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 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 could be ample justification for a go-around.

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

EXAMPLE:

60 KNOTS — ACTUAL TOUCHDOWN SPEED

50 KNOTS — NORMAL TOUCHDOWN SPEED

OR, $\frac{60}{50}$ — A FACTOR OF 1.1 OR 10% FASTER

$(1.1)^2 = 1.21$

21% MORE RUNWAY REQUIRED FOR ROLL-OUT.

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 for roll-out alone.

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

OR . . .

96% MORE ROLL-OUT DISTANCE REQUIRED

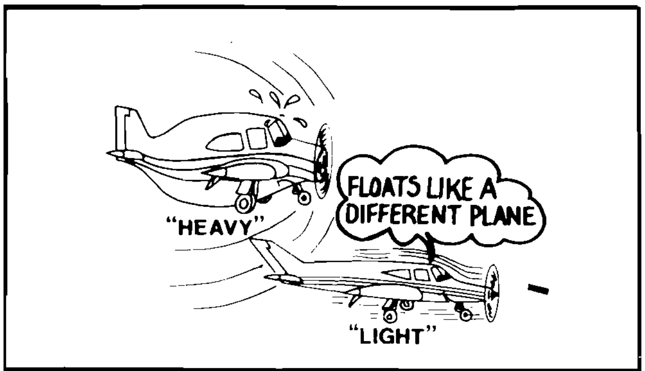
However, at anytime, if you happen to be carrying extra airspeed in the flare, the airplane will float, that is, glide from over your aim point, past the intended touchdown point, until that excess airspeed has dissipated.

Sometimes at a busy airport you're asked to keep the speed up, then land short, and turn off quickly. This can be tough 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

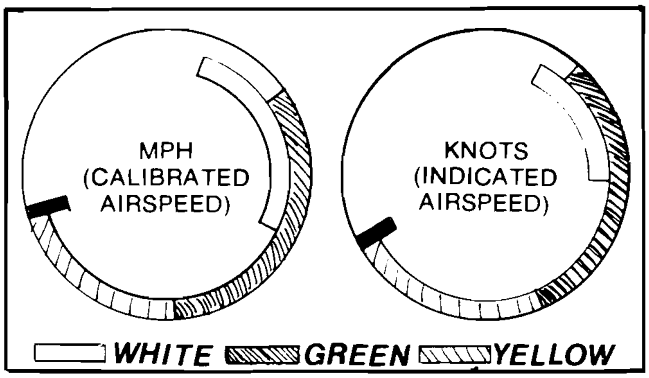
There are other factors that also lead to landing long.

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 max weight 1.3 Vso number all the time, you'll "float" as the airplane dissipates the excess energy. Assuming that you'll want to land at or close to the stall, runway distance will be eaten up during the process.

There has been a lot of confusion about this. Many pilots assume that the "lower end of the white arc" on the airspeed indicator is Vso for all landing weights. It is not! It's really the stall speed for maximum landing weight at the most unfavorable CG within the allowable loading range. Depending upon the aircraft's year of manufacture, this "lower end of the white arc" could be marked in either calibrated, or indicated airspeed.



Larger aircraft above 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 for the simple reason that 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!!

A fine point, but a very important one—airplanes manufactured *before* the mid-1970's had their airspeed indicator color-coded speed range arcs marked in *calibrated* airspeeds, and shown in miles per hour. (Some were marked in both mph and knots.)

To determine 1.3 Vso at maximum landing weight for airplanes built *prior* to the mid- to late 1970's, 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* that the mid-1970's had their airspeed indicators marked in *indicated* airspeed. Check the manufacturer's information about this for *your* specific airplane.

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

STALL SPEED WITH LANDING FLAPS AT MAX LANDING WEIGHT

KIAS	40	50	60	70	80	90	100	110
KCAS	50	55	62	71	80	90	99	110

AIRSPEED CORRECTION TABLE (FICTITIOUS AIRPLANE)

You should do this because, for some airplanes, the indicated airspeed near the stall has a significant error.

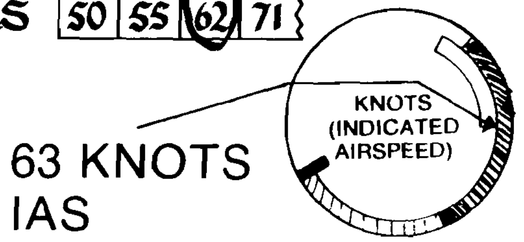
As an example: if, by mistake, indicated airspeed is used as the maximum weight stall speed Vso (here it's shown as 40 knots), 1.3 Vso would be 1.3 times 40, or 52 knots IAS, or about 57 knots, CAS (using the table), giving a margin of *only* seven knots above the 50 knot CAS stall speed.

KIAS	(40)	50	60	70
KCAS	50	55	62	71

1.3 X 40 KNOTS = 52 KNOTS IAS (OR ABOUT 57 KNOTS CAS). THE AIRPLANE STALLS AT 50 KNOTS CAS, GIVING A FACTOR OF $\frac{57}{50}$ or 1.14 NOT 1.3

However, using calibrated airspeed as Vso . . . 1.3 × 50 = 65 knots CAS. Referring to the correction table, the indicated airspeed for an approach (at max landing weight in smooth air) would be 63 knots IAS, giving an actual safety margin of 15 knots above the "real", or calibrated stall airspeed. However, it will *look* like a margin of 23 knots on your airspeed indicator!

KIAS	40	50	(60)	70
KCAS	50	55	(62)	71



This is 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.*

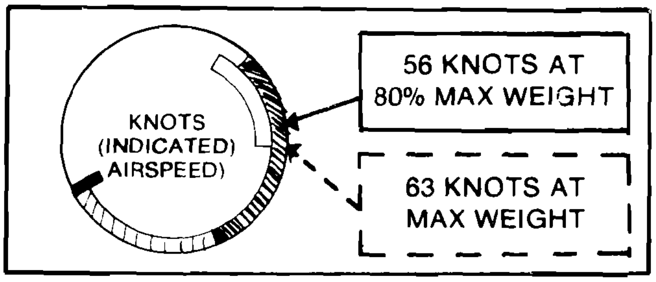
For example, if the airplane's weight is 20 percent below maximum, you would decrease the approach calibrated airspeed by one-half of that, or by 10 percent.

EXAMPLE:

WEIGHT DOWN — 20% $\frac{20\%}{2} = 10\%$

THEREFORE DECREASE APPROACH SPEED 10% (FROM THE APPROACH SPEED OF 1.3 VSO AT THE MAXIMUM LANDING WEIGHT).

Example: for an airplane with an approach speed of 65 knots CAS at maximum landing weight (found earlier by multiplying the landing speed Vso by 1.3, i.e., 1.3 × 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) (10% 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. So use 1.3 Vso on *short final only.*

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

Wind and its Impact 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. But 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 ten 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, and you have a 10 knot tailwind, and you also touchdown 10 knots too fast, that is, at 60 knots CAS, you will almost double you 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

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

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

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

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

$$= 10\%$$

THEREFORE . . . TREAT AS "CALM"

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 over the normal touchdown speed) . . . all this times the no-wind landing roll-out distance, which then equals the new, estimated landing roll-out.

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

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 20 percent, a factor of 1.2. Squaring this gives 1.44, and multiplying 1.44 times your no-wind ground roll-out distance gives an expected ground roll of 1440 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.*

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

CAUTION:

Remember, though, these rules-of-thumb are just that, they're to teach you the advantages of landing with a headwind, and conversely, the hazards of landing with a tailwind. They aren't intended to substitute for manufacturer's information. Consult your Pilot's Operating Handbook 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 =

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

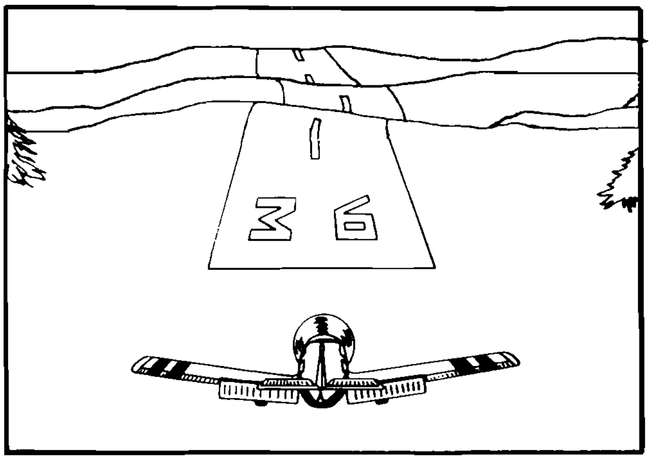
Some pilots add all of the steady wind and half the gust, or all of the gust and no steady wind.

To increase safety, your final approach airspeed needs to be precisely calculated, then precisely flown. But 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 two percent—or about 1.2 degrees of slope. For these airports, runway slope is a relatively minor factor. But runway slope can be a *real* 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

You'll remember that 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, Pilot's Operating Handbooks provide tables or graphs that allow 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 first to determine density altitude, then use density altitude to determine the effects on aircraft and engine performance.

Although density altitude doesn't 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 assure good engine performance in case of a go-around.

Figure on adding about five percent to the landing roll-out for each additional one thousand feet of density altitude.

Runway Surface

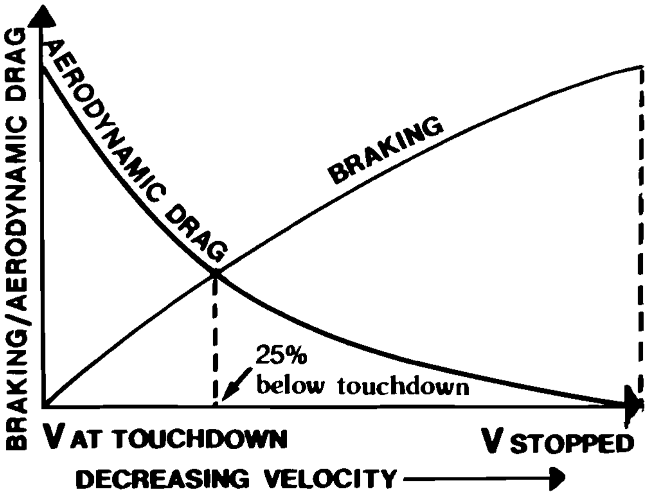
Runway surface makes a big difference on landing long because it plays a big role in braking.

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

How to brake on dry surfaces? Don't begin to brake as soon as you touchdown. (We're not talking about a maximum "slam on" effort here.)

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.



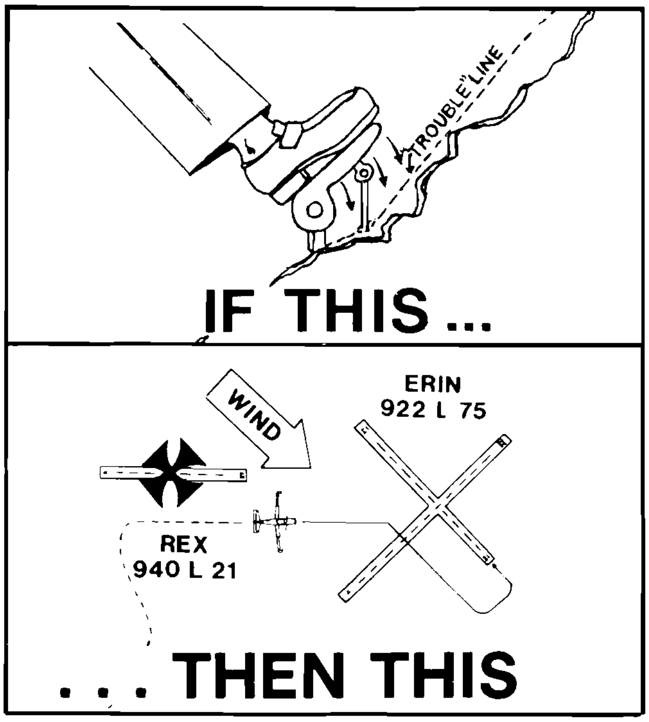
There are two ways to increase braking effectiveness on landing roll-out. First, some Handbooks and Owner's Manuals suggest that retracting the flaps will decrease lift and put more weight on the gear. It's really best, however, to wait on flap retraction until you're clear of the runway and less busy, 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. This is especially important in tail-draggers but is important for nosewheel types as well.

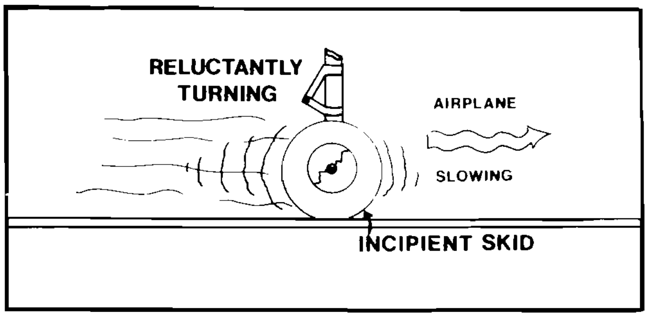
Grass is a much less effective braking surface. Wet or frost-covered grass is even worse.

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

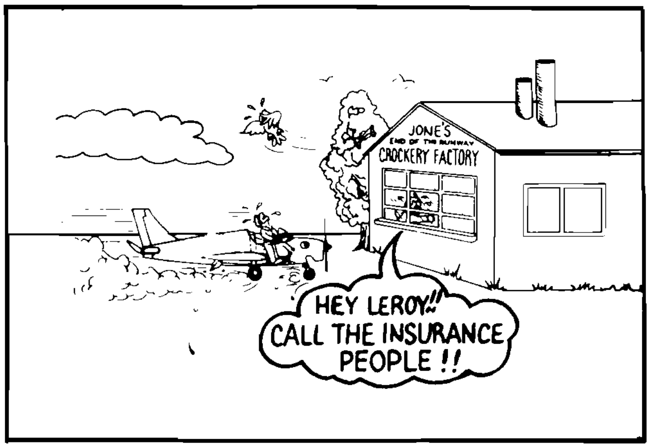
If brakes are soft, mushy, or they "floor-board," land on a longer runway and on one as nearly aligned into the wind as possible.



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 tires prior to each flight —you should, too. And don't just check for depth-of-tread and proper inflation. Look for cuts, bald spots, dry rot, etc.

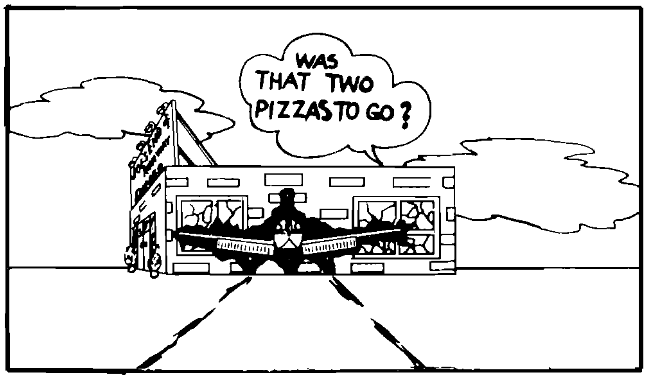
Runway Length

Length is also a factor in landing long. Did you know that an otherwise helpful non-standard VASI can turn a 2,100 foot runway into an 1,800 foot runway? That's because the airport operator who installed the non-standard 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 non-standard VASI will not be identified in airman publications.

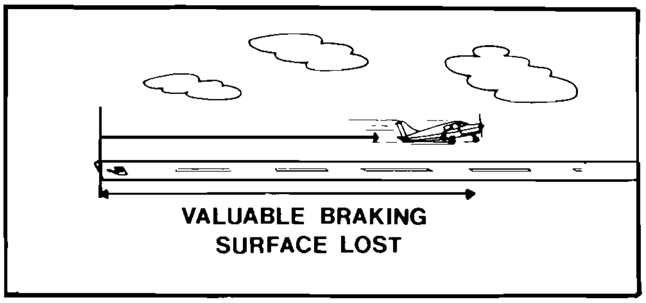
WHEN THINGS DON'T GO RIGHT—THE GO-AROUND

A properly executed go-around is one of the best accident avoidance procedures available to pilots, even though it's one of the least used.

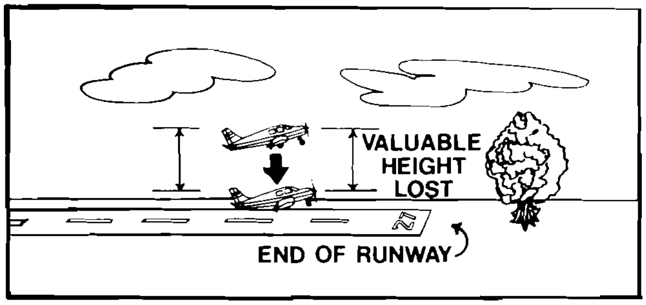
But, if not properly executed, it can result in an accident—and one much more serious than landing long.



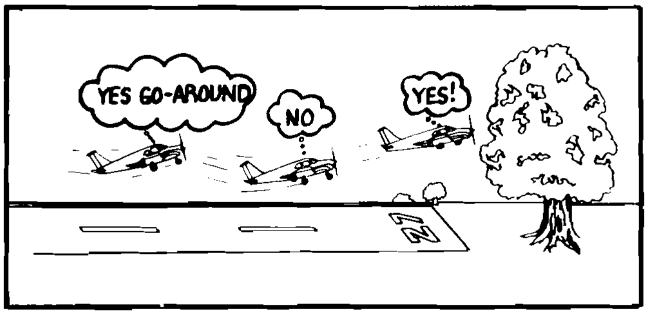
Official reports concerning go-around accidents frequently cite "pilot indecision" as a cause. What usually happens is pilot fixation—trying to make a bad landing good, resulting in a late decision to go around. It's natural, since the purpose of an approach is a landing.



But delay costs valuable runway stopping distance. It also causes loss of valuable altitude as the approach continues.



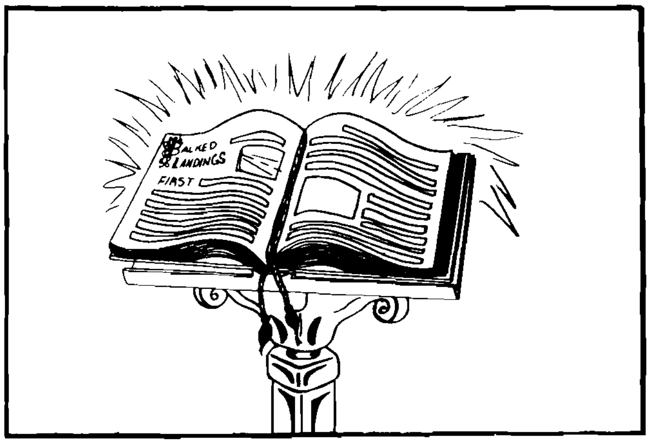
If there is *any* question about making a safe touchdown and roll-out, take the airplane around. And do it early.



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 haven't touched down by that point, it's go-around time.

But remember, 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 "Bible." So review it periodically.



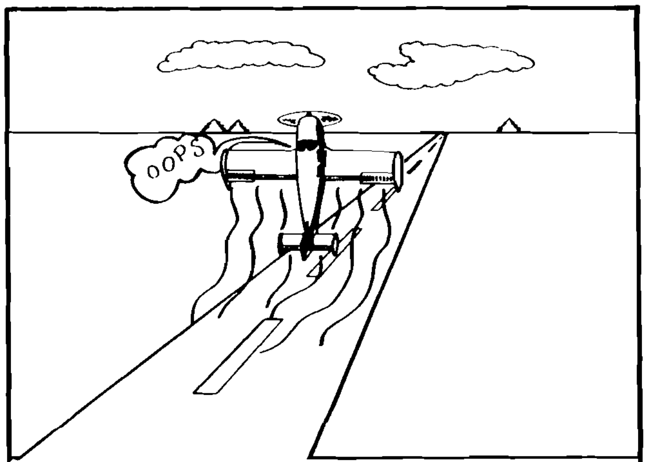
Follow these steps:

Power is the single most essential ingredient. Every precaution must be taken to assure 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 assure 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'll do in case of trouble and where and when you should do it.

Stick to your decision. Once you decide to go-around, stick to it! 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, 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.



THE HAMMERHEAD STALL IS AN INTERESTING MANEUVER . . . BUT NOT ON A GO-AROUND!

Trim to maintain proper pitch control.

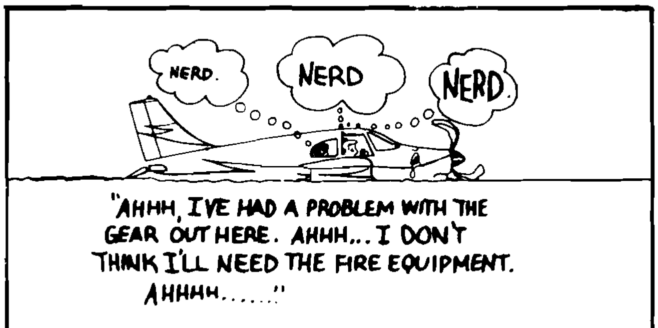
Establish a positive rate-of-climb and cross-check inside with outside references.

Then and *only* then, slowly retract flaps, further adjusting the pitch attitude. Only after establishing a positive climb, retract the gear if 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 with 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. There's stress. Normal tasks are out of order.

More than one pilot has landed gear-up after a go-around.



(NOTE: THE THREE PASSENGERS ARE ALSO MENTALLY DOING AN INVENTORY OF THE PILOTS ABILITY.)

Practice your go-around procedures so that when you really do have to go-around, you'll be on top of the airplane, rather than 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, maintain control. In all cases—when in doubt, go-around.

This is your go-around check list: power, pitch, fly the airplane, clean it up, then communicate. Then on your second attempt, strictly adhere to the landing check list items. You *have* been distracted!

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