A Landing Forced Upon You

Keeping current with forced-landing techniques is an extremely important aspect of safety in general aviation. It helps to ensure that we give ourselves the best possible chance of walking away, uninjured, from an aircraft after an engine failure. The following article provides a revision of the basic techniques for a forced landing without power for pilots of light single-engine aircraft and then goes on to consider engine failure options when over less hospitable types of terrain.

Successfully handling an engine failure, or partial power loss, requires decisive pilot action combined with well rehearsed forced-landing cockpit drills. The ability to respond quickly by selecting a suitable landing site, and then conducting the forced-landing drills, are absolutely essential survival skills.

The first section of this article is dedicated to basic forced-landing-without-power (FLWOP) techniques. It assumes an engine failure in a light single-engine aircraft from above 2000 feet over an area that offers reasonable forced-landing possibilities. Since we know that this type of scenario is not always reality, the last section of the article deals with the options associated with more difficult types of terrain. Refer to *Vector* 1998, Issue 3 for information on engine failures under 1000 feet agl.

Immediate Actions

Prioritising your time after an engine failure will help you to accomplish as many of the critical drills as are possible. The 'immediate actions' are the first part of the FLWOP sequence. They help ensure that the aircraft is trimmed for its best glide speed and that the engine is given sufficient time to respond to carburettor (or induction system) ice and fuel starvation checks. The immediate actions are summarised below.

Excess Speed to Height

At the first sign of engine trouble convert any excess airspeed, above the best glide speed, to valuable height. (In many light aircraft with relatively modest cruise speeds this simply means preventing unnecessary loss of height by holding the nose up until glide speed is reached.) Care must be taken not to reduce airspeed too much, thereby bringing the aircraft close to the stall.

Trim for best glide speed and apply the appropriate rudder to remain in balance. Note that, although drag can be reduced by stopping the propeller, it is not recommended practice as it requires bringing the aircraft close to the stall. It is also doubtful whether the reduction in drag will compensate for the height lost in the subsequent recovery to the best glide speed. In addition to this it may also cause pilot distraction.

When the aircraft propeller is fitted with a constant-speed unit, the selection of coarse pitch will reduce drag and improve gliding performance.

Carburettor Ice and Fuel Checks

Carburettor heat or alternate air should be applied as soon as possible. In the case of normally aspirated engines, this will allow the remaining heat from the engine to be utilised in melting any carburettor ice that may have formed. The electric fuel pump should also be turned ON, fuel tanks changed (if possible), and the throttle closed.

Determining Wind Direction

The first criterion for selecting a landing area must be the wind direction, particularly if the wind is strong. Knowing the wind direction will allow you to narrow down the possible landing sites. Wind direction is an extremely important piece of information, as an into-wind landing ensures the lowest possible landing speed. Landing with a tailwind could be fatal – it not only reduces your chances of achieving your planned aiming point, but also it could mean a much higher impact speed in the case of an overrun. Note that it is generally a good idea to keep track of the wind direction **at all times** while flying.

Wind direction and speed can be determined from many cues:

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- **Smoke**. If there is any within your vicinity, it will provide the best indication of the surface wind speed and direction.
- **Dust**. Like smoke, this provides a very good indication of the surface wind. Watch for vehicles moving along shingle roads, tractors working paddocks, fertiliser spreading and even dust from river beds.
- **Tree or crop movement**. Movement of large trees and wind ripples moving across the top of crops can give a good indication of surface wind direction. Movement in the tops of large trees, in moderate to strong winds, can be quite pronounced – even from altitude.
- **Wind lanes or wind shadow**. In moderate to strong winds, water movement or waves can give an indication of surface wind direction, especially over large bodies of water. On the other hand, wind shadow is the result of water at the upwind end of a body of water being protected by the shoreline, creating an area of calm. This effect is most noticeable in light wind conditions on small lakes or ponds.
- **Cloud shadow**. The movement of cloud shadow over the ground gives the wind direction at altitude. Care should be taken to ensure that there is not a marked difference between this indication and what is happening on the ground.
- **Local knowledge**. If you have local knowledge of the weather conditions relating to the area you are operating in, then make full use of such information. The windsock indication and known takeoff direction at your aerodrome of departure (if nearby) may give an indication of wind direction.
- **Aircraft drift**. By looking at any drift angle that you might be experiencing you can gain a limited indication of the wind direction at the aircraft's present altitude – but not at surface level. Using drift angle to determine wind direction works best in strong wind conditions.
- **Weather reports**. If operating in close proximity to an aerodrome about which you have recently heard weather information such as an ATIS, TAF or METAR, then this could be used to help give you an approximate idea of the surface wind. This information should be used only to supplement that received by the methods above – methods which should always be used anyway.

Selecting a Landing Site

Here we deal with the selection of a landing site when an engine failure occurs over reasonably flat types of terrain at approximately 2500 feet agl. This is similar to that which many of us are accustomed to during forced-landing practice.

The area of likely landing sites **must be within easy gliding distance** before any other selection criteria are applied. The aircraft should be turned in the general direction of the area so as not to drift away and lose valuable height. Landing site selection can then be best achieved by using the mnemonic such as 'the seven Ss' which stand for size, shape, slope, surface, surroundings, stock, and sun. They are listed in an order of importance so as to help you narrow down the options:

Size. Look for the longest possible landing site that faces into wind. Get to know what sort of distance your particular aircraft is capable of landing in (consult your aircraft flight manual and your instructor).

"... it is generally a good idea to keep track of the wind direction at all times while flying."

Shape. Do not limit your selection to sites that resemble a rectangular runway. The perfect shape for a FLWOP is in fact a circle, as it allows approaches to be made from many different directions over obstacles and ensures a landing into wind. Bear in mind that it may be beneficial to land diagonally across landing sites that are rectangular, as this provides the longest possible landing distance.

Slope. An uphill slope for landing is preferred, so as to reduce the landing roll. A downhill slope should be avoided unless the wind strength negates the disadvantages of landing on a very gradual downhill slope. A downhill landing should be attempted only when there is a **strong headwind** present and the gradient of the slope is **known to be slight**. It can be difficult to judge the gradient of a slope from altitude – rivers and creeks running downhill, however, may give you some clues.

Surface. A firm landing surface is preferred to prevent the aircraft from digging in, possibly causing it to flip over. As with determining slope, determining what kind of surface you are looking at has its problems. The colour and texture of the surface foliage can indicate how firm a potential landing site might be. The presence of surface water is always an indication that the site might be soft. A comparison of what each surface looks like in relation to a grass aerodrome runway can be useful.

Surroundings. Where possible, it is advisable to select a landing site that has a clear approach path at the into-wind end. The ideal approach should be void of tall trees, power lines and buildings that will prevent you from achieving an unimpeded profile to your landing site. It will also mean that undershooting your landing site is less likely to result in collision with a solid obstacle. Some consideration should be given to the presence of obstacles at the top end of the landing site, as a landing overrun could occur.

Stock. Try to avoid landing sites where stock are present. If, however, they are concentrated in one end of the paddock and are not tending to move around too much, then consider using the site – if there are no other more suitable alternatives.

Sun. This is normally a problem only twice a day, sunrise and sunset. Under these conditions an approach in the direction of the sun may blind the pilot on final. Try to avoid this if possible

Note that if an opportunity exists to land towards nearby buildings, which might have a telephone and people to assist you, then take it. If your forced landing does result in injuries, then you know that medical help will hopefully be only a phone call away.

Planning Your Approach

Now that you have selected the most suitable landing site that is into wind, you must plan your approach to it. This is probably one of the most important phases of the FLWOP process. A well planned approach profile will put you into a position from which you can turn onto a base leg, at the correct height, and continue with a landing approach from which a successful outcome is likely. Note that the approach should be planned **from the ground up**. The following sequence is suggested for planning an approach to a landing site:

Aiming point. You must select an aiming point that is approximately one third of the way into the landing site. This gives you a constant point to aim for and helps ensure that you do not undershoot the landing site (see diagram).

Circuit direction. This should preferably be lefthand, so that the pilot in command may obtain the optimum view of the landing site – unless there is a specific reason to fly a righthand pattern. (Righthand pattern FLWOP practice is important, however, because some landing sites may offer no alternative.)

1000-foot AGL area. The 1000-foot area should be at 90 degrees to the landing site threshold and about three quarters of the normal circuit distance out. Arriving at the 1000-foot area will then allow you to position onto a base leg depending on the wind strength and direction. The stronger the wind the earlier you will need to turn on to a square base leg (see diagram). Extending downwind in windy conditions would mean a very slow groundspeed on final approach, causing an undershoot. If you are unsure of what the various angles and perspectives from the 1000-foot area to the landing site look like, then it can be useful for an instructor to show you next time you take a dual flight.

1500-foot AGL area. The 1500-foot area is situated at the upwind end of the landing site and helps you to position yourself correctly at the start of the downwind leg. The 1500-foot area works on the assumption that you will lose around 500 feet in the downwind leg (depending on aircraft type) meaning that you should arrive at the 1000-foot area at the correct height (see diagram).

Assessing Your Approach

You must now try to make your approach fit these reference areas.

Estimate the elevation of the landing site above sea level. This is where keeping track of the ground elevation that you have been flying over comes in handy. Then, using your altimeter, work out how much height you will have to glide to achieve the 1500-foot area.

You can then make decisions, based on this information, as to whether to fly a direct line to the 1500-foot area or purposely manoeuvre to lose height. Constantly assessing how your approach profile is going is crucial. Cross-check your visual height judgement with your altimeter. Estimate the distance-to-run to achieve each reference point – and don't forget the effect wind will have on each segment of your approach pattern.

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If too high relative to either the 1500-foot or 1000-foot areas, you **should not** commence an orbit to lose height. In turning your back on the chosen landing site, you may lose too much height and also lose sight of the landing site. Rather than orbit, it is better to make a series of S-turns (medium turns that will increase the rate of descent).

When faced with turbulent and gusty conditions, it may be necessary to increase your airspeed a little above the aircraft's best glide speed to provide a greater margin above the stall. The same technique should also be applied when trying to make headway to a landing site into a strong headwind – it provides better forward penetration to the landing site relative to the amount of height lost. If there is a considerable amount of sinking air around (such as during northwesterly wave conditions) then try and fly out of the 'sink' as fast as possible to more favourable conditions. Sinking air can rapidly erode the precious height you have and make judging your approach extremely difficult indeed.

Subsequent Actions

Once you have planned your approach to a landing site, and you feel that it is progressing well, then the next priority is to carry out the subsequent actions. You can do this knowing that you have a definite plan to achieve your landing site. It is very important to maintain **good situational awareness** relative to your chosen landing site while conducting any of the subsequent actions. You should **fly the aircraft first and foremost**, and then worry about completing the cockpit drills. Your pilot scan should be directed **outside the aircraft cockpit on a regular basis** so that small adjustments in heading can be made that ensure you are sticking to your planned approach.

Engine Trouble-Checking

Engine trouble-checking allows you the opportunity to assess what has caused your engine to lose power and to see if you can rectify the situation. There is obviously little point in continuing with a forced landing if you are simply suffering from fuel starvation in one tank, when there is plenty in the other, for example. If there is any doubt about whether your engine will continue to run, then you should **stick with the forced-landing approach that you have planned**.

Trouble checks are based upon the mnemonic FMIIP priority system and should be learned so that they are absolutely automatic. Refer to *Vector* 1998, Issue 3 for details of engine trouble-checks – alternatively consult your instructor or pilot briefing notes.

Check your progress to the landing site and make any necessary adjustments.

Emergency Radio Call

If you have a radio, it is important to get a Mayday call out while squawking 7700 on your transponder before you lose too much altitude for these transmissions to be effective. Details of distress calls can be found on the back cover of the VFG. If time is limited, then at least transmit your present position and intentions to give authorities the best possible chance of finding you.

"... likely landing sites must be within easy gliding distance ..."

Once you have landed safely, remember to cancel any emergency radio call that you have made – aircraft owners or operators should also be contacted as well. This will save Search and Rescue costs.

Check your progress to your landing site and make any necessary adjustments – by now you may be nearing the 1500-foot area.

Passenger Briefing

A passenger briefing is of great value to calm your passengers down and to give them the confidence that you have the situation well under control. It will not only remind them of what you told them during the preflight passenger briefing, but also enables you to stress **that you need to concentrate** on the rest of the forced-landing approach. This is really important as it is next to impossible to accurately fly an aircraft with hysterical passengers asking questions. Consult your instructor or pilot briefing notes for details of passenger briefing content (see also *Vector* 1997, Issue 7).

Check your progress to the landing site and make any appropriate adjustments.

Downwind Checks

Downwind checks (BUMPFH) need to be completed before landing. Apart from being the normal pre-landing checks, they act as a reminder to check that everyone's harness is tight and to think about when hatches or doors should be unlocked. BUMPFH checks also provide a cue to consider when to put the undercarriage down. Leave the undercarriage 'UP', however, until you are certain of reaching your landing site.

By now you should be approaching the 1000-foot area that you selected. If too high, then shallow S-turns can be made to bleed off the extra height. If too low, you will need to consider flying a closer base leg (see diagram).

Final Actions

The final actions are to carry out the 'off checks' and to land the aircraft using techniques that will produce the best possible result. It is extremely important that you do arrive overhead the 1000-foot area as accurately as possible. This will then set you up for a fairly normal type of landing approach. Refer to *Vector* 1998, Issue 3 for details of 'off checks' – alternatively consult your instructor or pilot briefing notes.

Judging Your Final Approach

After having completed the 'off checks' it is possible then to focus totally on judging the base leg and final approach to your aiming point. Note that the 'off checks' can be carried out before turning onto a base leg (ie, during the downwind leg) so that your full attention can be given to judging the approach. It is extremely important that you **do not**

extend downwind (especially in strong wind conditions) or you will run the risk of undershooting the landing site. It is better to fly a slightly wider base leg and use it to adjust your height as required. This can be achieved by turning slightly away from the landing site if too high, or turning towards the landing site if too low. This means that at no time are you committed to a final approach where there is insufficient space to control your height (see diagram).

Note that final approaches directly into strong wind will mean low groundspeed and thus require greater judgement – otherwise an undershoot of the landing site may result. In very strong headwind situations, it may be worth considering flying faster than the aircraft's best glide speed to avoid an undershoot. On the other hand however, light wind conditions can result in ending up too high. The use of flap, side-slipping (if approved for your aircraft type or S-turns are all effective ways of bleeding off extra height – but flap should not be selected too early.

When you are absolutely certain that you can achieve your aiming point, then you can use flap (or sideslip if permitted) to touch down earlier than your aiming point. If necessary, touchdown can now be attempted as close to the threshold as possible.

Landing the Aircraft

There are several recommended techniques that can maximise your chances of a successful landing. Assuming that you have chosen a reasonable landing site, there is no reason why you can't put the aircraft on the ground intact. Refer to Vector 1998, Issue 3 for details on suggested techniques for landing an aircraft in a confined area – alternatively consult your instructor or pilot briefing notes.

Difficult Terrain

So far we have dealt with basic forced-landing techniques over an area that offers reasonable forced-landing possibilities. But what happens when you are faced with less favourable options? You may have been in situations, flying over rough terrain, where you have thought "what would I do if the engine failed now?" Your answer may not always be one which would provide a 'plan of attack' that will achieve a successful outcome.

When faced with an engine failure over such uninviting areas, there are several other FLWOP techniques that can be applied to help improve your chances of survival. These are discussed below.

Bush-Covered Areas

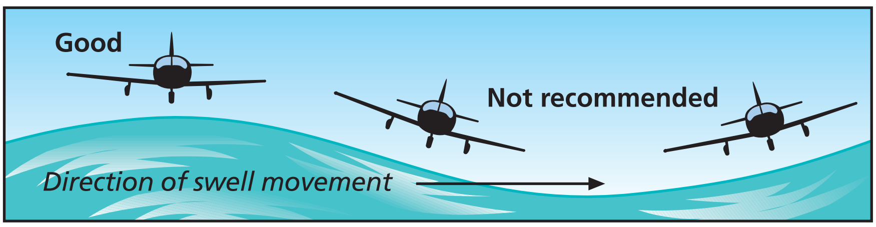
Although a landing into trees is not an attractive option, it is a survivable one. Landing in trees should never be ruled out as an option, because it may be better than other areas of very rough terrain. The following general guidelines should improve the odds of surviving:

- Use the normal approach configuration – full flap and landing gear down.
- Keep the groundspeed as low as possible by heading into wind. Using the movement in the tops of trees will help to determine the wind direction.
- Manoeuvre towards areas of bush that contain as few large trees as possible – this will reduce the chances of contacting a large tree trunk. Low, closely spaced trees, with wide dense crowns (branches) close to the ground are much better than tall trees with thin tops – this reduces the free-fall to the ground afterwards.
- Make contact with the tree foliage at the minimum possible airspeed, taking care not to stall, and aim to 'hang' the aircraft in the tree branches in a nose-high attitude. This helps to preserve the cockpit area by allowing the underside of the fuselage and wings to absorb much of the initial impact energy.

Mountainous Terrain

A landing in mountainous terrain is probably the most difficult a pilot can be faced with. Flying over large areas of mountainous terrain should be avoided, where possible, to reduce the probability of ending up in such a situation. Try to plan alternative routes that take your flight-path away from large expanses of mountains, or fly at a higher altitude to give yourself more time in the event of an engine failure – even it means adding extra time onto the flight. The following points should help to improve your chances of survival:

- Valleys and riverbeds are often a good option. It will depend on how tortuous is the valley or riverbed. It may be the best option when the valley sides are heavily wooded compared with more open parts on the valley floor.
- The top of mountain ridges can provide useful landing sites as they are often reasonably wide, may have less rock out-crops, and are more likely to be of a constant gradient. Ridge-top landings also make it easier to assess wind direction (something that can be very difficult to do in the mountains) – as opposed to valley landing sites where the wind tends to be multi-directional.
- Landing on a ridge line will also mean that ELT transmissions are more likely to be received than from landing sites lower in the valley. Your aircraft will also be more visible to Search and Rescue. The one disadvantage with landing on a ridge line is that temperature and wind-chill will be less favourable to survival.
- Try to avoid sites that have particularly large rock out-crops or drop-offs. These may become difficult to manoeuvre around if the approach and landing are misjudged.
- A landing site should be selected that allows an up-slope landing.
- When landing on a pronounced up-slope, care should be taken to ensure that enough speed can be maintained to change the aircraft's descending flight-path, just before touchdown, to match that of the slope. Note that it is possible to land an aircraft successfully on relatively steep slopes if enough speed is maintained.



A ditching should be made along the crest of the swell when faced with large swell conditions.

Ditching

Assuming that you have a choice, a well executed water landing – ditching – such as onto a lake or along a coastline, can provide less deceleration than a touchdown on rough terrain or into trees. Many pilots are reluctant to ditch, even though this might be a better option than the land-based alternatives. This is probably because of the fear of becoming trapped

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in the aircraft and the fact that it will, more than likely, be lost. An aircraft that has been set down on the water at minimum speed, and remains intact, may float for several minutes. The buoyancy provided by air trapped inside of the wing (eg, fuel tanks) and fuselage will probably allow sufficient time to vacate the aircraft, and this will apply even with high-wing aircraft.

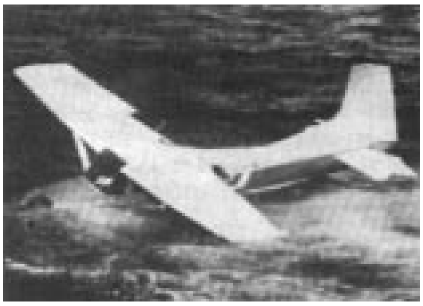
If you have a choice between a ditching and a forced landing, you should consider the following factors:

- The water temperature. Survival times may not be very long in the sea or a cold alpine lake. If you know the water to be extremely cold, then it may be wise to avoid ditching altogether.
- The proximity of the ditching area to land.
- How well your passengers can swim, and if there are enough lifejackets to go around – this is something that should be checked before the flight.
- Swell condition and the surface wind direction – it is generally not advisable to ditch in very rough swell conditions.

If the above factors are favourable, then ditching may be the best option.

Whether ditching by choice – or by having no alternative – the following techniques should be applied:

- Retractable landing gear should be kept up to provide the least drag in the water. This should prevent the aircraft from nosing over.
- Ensure that all occupants have their harnesses tight – you do not want anyone to be knocked out during the ditching for fear they may drown. Note that lifejackets can be donned during the descent, if there is time, but should be inflated only when clear of the aircraft.
- Avoid using full flap on a low-wing aircraft, as it will cause excessive drag under the water line and possibly result in an asymmetric failure of the flaps and slewing of the aircraft.
- Except when the water surface is relatively smooth – in which case a normal into-wind touchdown can be made – the ditching direction should be determined by the major swell system, rather than by wind direction. The danger of nosing into a swell is generally greater than that involved in ditching with a crosswind. It is best to aim for the crest of the swell and land along it. Note that with very strong wind conditions (ie, over 35 knots) it is better to plan the approach back into wind, as this will probably outweigh the danger posed by the swell system.
- It should be noted that depth perception can be difficult – or impossible – when landing on smooth water. There is a risk either of flying into the water, or of stalling at some height above the water and nosing-in. To minimise this hazard, set up the approach at minimum rate of descent – and be prepared not to realise exactly when you are going to hit the water.



This Cessna 185 remained afloat for 15 minutes after a successful touchdown.

Landing on Snow

A landing on snow should be executed like a ditching, with the same aircraft configuration (except that low-wing aircraft should use full flap), and the same regard for the loss of depth perception. While landing on snow can provide a cushioning effect, it can also hide dangerous obstructions with a light covering of snow. A snow covering will also make it more difficult to judge the surface gradient and general topography of the landing area. Try to avoid areas where there might be patches of ice, as these will cause the aircraft to slide for much greater distances, increasing the chances of colliding with a solid object.

Built-Up Areas

An engine failure while flying over a built-up area is somewhat more complicated as it generally involves the safety of people below. Civil Aviation Rule 91.311 requires that you **must not** fly over a built-up area at less than 1000 feet above the highest obstacle present (when operating within a 2000 foot horizontal radius of it) and that you **must always** remain within gliding distance of a suitable emergency landing site. With this in mind, you should avoid flying over built-up areas that do not have favourable emergency landing options and also resist the temptation to operate at heights where you are unable to glide clear – its not worth the risk. Get to know the forced-landing possibilities around your city before going flying.

If you do find yourself facing an engine failure while operating over a large built-up area, turn immediately towards a known emergency landing area, eg, a park, a golf course or school grounds (note that it is your responsibility as pilot in command to consider the safety of people on the ground when making this selection). If this is not a favourable option, then a motorway which has double-lane traffic will allow you to touch down moving in the same direction as the traffic. It will also help you to pick a space between moving traffic more easily. If none of these options are available to you, then try to find any other open space where you will pose the least amount of danger to people on the ground.

Summary

The FLWOP has always been an important part of pilot licence training. For many of us, these forced-landing skills may have diminished slightly over the years. It is therefore important that we remain familiar with them. Being totally familiar with the FLWOP drills not only allows you make the most appropriate landing site selection, but also means that you can **concentrate on the task of successfully flying the aircraft** to that site. This sort of familiarity allows you to focus your attention **outside the cockpit**, where it should be, and reduces the tendency of becoming distracted inside the cockpit.

Minimise the time you spend flying over extensive areas of inhospitable mountainous terrain, large expanses of water, large areas of bush, and substantial urban areas. It is not worth taking the risk when an alternative route is available. The extra time and cost involved in selecting a safer alternative route, or higher altitude, is often not as much as you might expect.

Probably the best piece of advice that this article can give on a FLWOP is to always have a plan. This involves being aware of the wind direction, ground elevation, and possible landing sites below you. It involves knowing – as you are flying along – how you would execute an approach to them. The rougher the terrain, the more you need to carry out this assessment. The more you can ask yourself the question "what would I do if the engine failed now", the better prepared you will be to respond quickly if it ever happens to you. ■