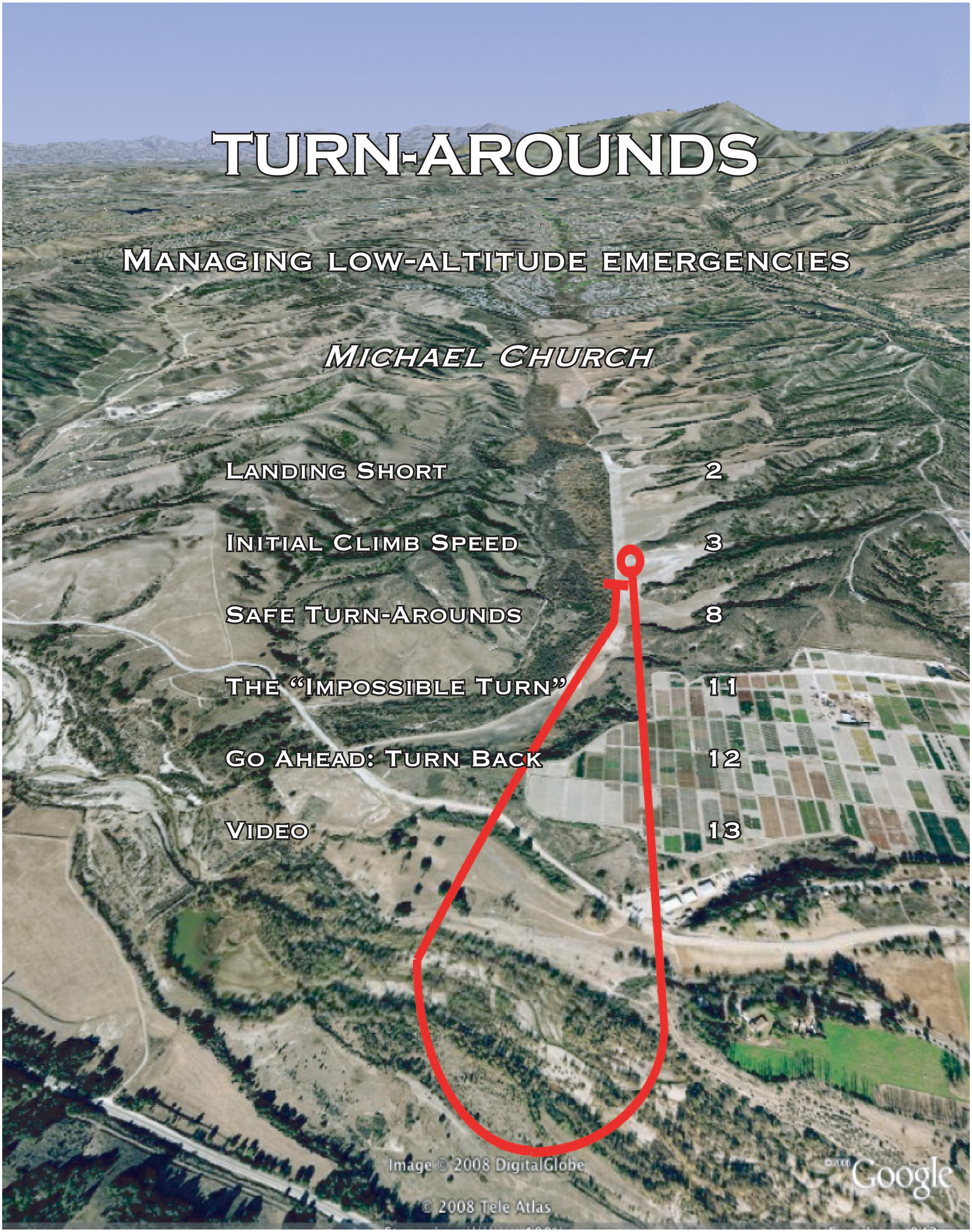
TURN-AROUNDS

Managing low-altitude emergencies

Michael Church



Sensible management of risk in aviation first and foremost centers around altitude management. For obvious reasons, this is most important in single-engine operations.

An engine failure in a twin has its challenges, but should be a relatively minor event if handled correctly. If this were not so, multi-engine training itself would be quite exciting: a fair portion of the teaching is done with one engine shut down.

Engine malfunctions and complete failures in a single, on the other hand, are cause for real concern. Without any engine at all, you're going down, and you need time to find a place to do it safely.

Unless the problem occurs directly over a runway, the only friend you have when faced with an engine emergency is altitude. Only altitude will buy you the time to find a landing area, get to it, and set up to use it.

This simple set of observations is at the root of my dismay when I see pilots mismanage altitude close to the airport: don't they know that flawless engine operation is not part of the guarantee?

Every Mercedes and Range Rover pulled off to the side of the road is an indication that even the most expensive machines fail from time to time; your flying should demonstrate respect for that reality.

Here is a story aimed at stirring new resolutions for the year unfolding ahead of us.

THE PAST

I was holding short for takeoff at the St. Thomas (U.S.V.I.) airport. Beside me in the left seat was a student prospect: a man I intended to interest in flight instruction.

A Bonanza departed a couple of minutes ahead of us, and my prospect seemed interested in how it all worked. The takeoff and turn to crosswind were uneventful, and the plane eventually disappeared out of sight as the pilot started his downwind departure somewhere behind us.

At this point, it is necessary to get a good visual image of the runway setup. The airport is close to the shore, and both the right downwind leg and the final approach are flown over water. The threshold itself is only a hundred feet or so from the waves.

St. Thomas Airport: takeoff direction →

I was getting our plane through the final stages of the runup when the Bonanza pilot called with a Mayday: an engine failure. I turned somewhat to get him in sight and was then able to assure my prospect that this was going to work out OK: the pilot was just past midfield and despite being wide on downwind looked as though he would have no problem setting up to land. I tried to sound reassuring, but on a personal level it was clear I faced an uphill battle if I was to keep this student.

WHAT'S HE DOING?

To my amazement, the Bonanza continued to fly a "normal" downwind, extending more than a half mile past the threshold. By the time the pilot turned base, it was clear that there was no hope of making it to dry land. I told all this to my increasingly unhappy passenger, as I thought it best he not be surprised by the splash.

The Bonanza pilot had the wit to retract his gear before splashdown, and the water landing went smoothly, not more than a quarter-mile away from where we sat. We soon saw occupants pop out and start to tread water as they waited for rescue.

My prospect agreed to continue our flight, but I'm sorry to report that was the last I saw of him.

What was the Bonanza pilot thinking? He handled the plane well, remembered to pick up his gear, made an orderly and safe water landing, and killed no one. Obviously, he could fly.

Just as obviously, he had never effectively practiced engine-out situations, never experimented adequately with glide angles, never spent time forming the judgment needed for the most predictable of all the bad things that might happen in a single-engine airplane.

I don't wish to make single-engine flight sound as dangerous as walking into a lion's cage, but there are parallels. A little common sense should prevail: you are betting your life on a single engine, dozens of interconnected parts operating at high speed under extreme stresses of pressure and temperature; it would be prudent to know how to open the lion cage from the inside: it's an obvious step toward risk management.

CHAPTER 2: INITIAL CLIMB SPEED

The goal that should be foremost in every piloting decision is risk reduction.

I have in mind a very specific piece of aviation wisdom: “Altitude is your friend.” Given the obvious nose-on-your-face quality of this little homily, it amazes me that so many pilots fly without attention to what will happen if they fail to follow its advice.

My analysis starts where it should, at the very beginning: initial climb after takeoff.

A basic assumption is that climbout is the most dangerous of all flight segments: it exposes pilots to the greatest combination of risk factors. A second assumption is that pilots should always manage initial climb to minimize risk and maximize the chances of a safe landing in the event of an early engine malfunction.

VARIABLES

During the first seven or eight hundred feet after takeoff in a single-engine airplane, there are only two items worthy of much attention: can I still land safely straight ahead if the engine falters, or if not, can I turn around and land?

The answers rest on two variables: available landing area and climb performance.

If we were blessed on every takeoff with runways like the ones offered by Edwards Air Force Base, the answers to both questions would require no computation at all (and this would be a very short column). With anything less than twelve thousand feet of landing area, however, you’re going to need to do some planning.

Throughout this presentation, assume I am discussing single-engine airplanes and that “landing area” refers to all unobstructed airport surfaces, including runways, taxiways, overruns and other cleared spaces.

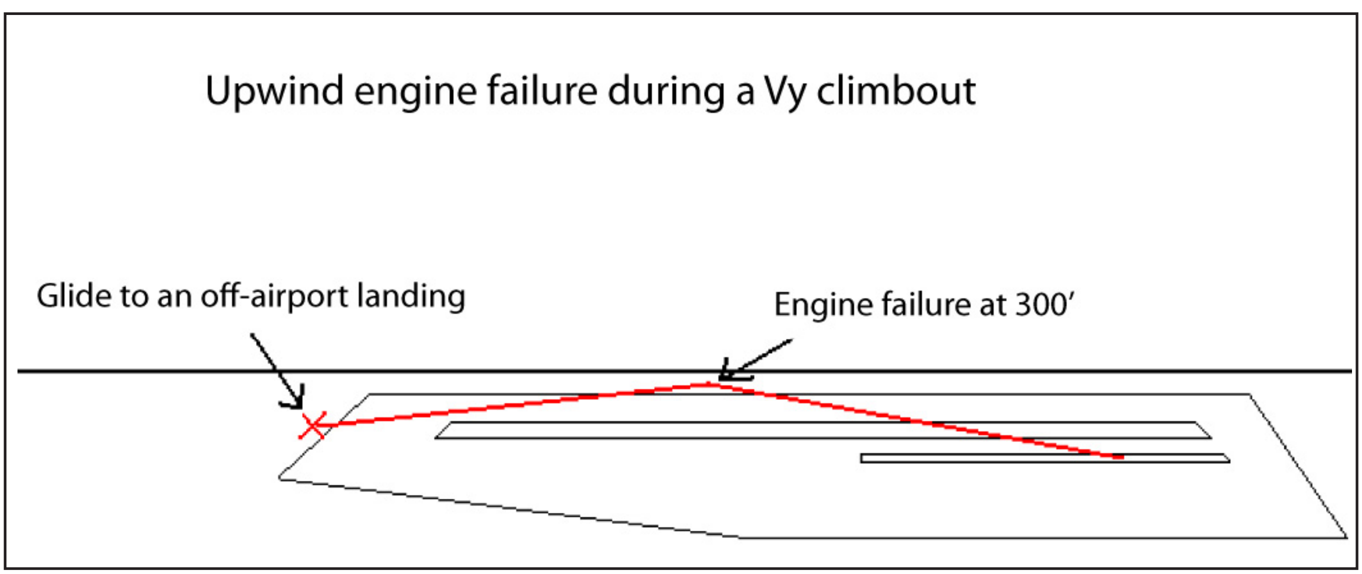
TURN-AROUND

Every airplane/pilot combination has a “safe turn-around altitude,” an AGL value sufficient to allow a 180° course reversal before altitude is consumed. This value varies wildly with bank angle, pilot skill, and aircraft performance, but those variables are the subject of another set of articles. For this analysis, I’ll assume ideal performance.

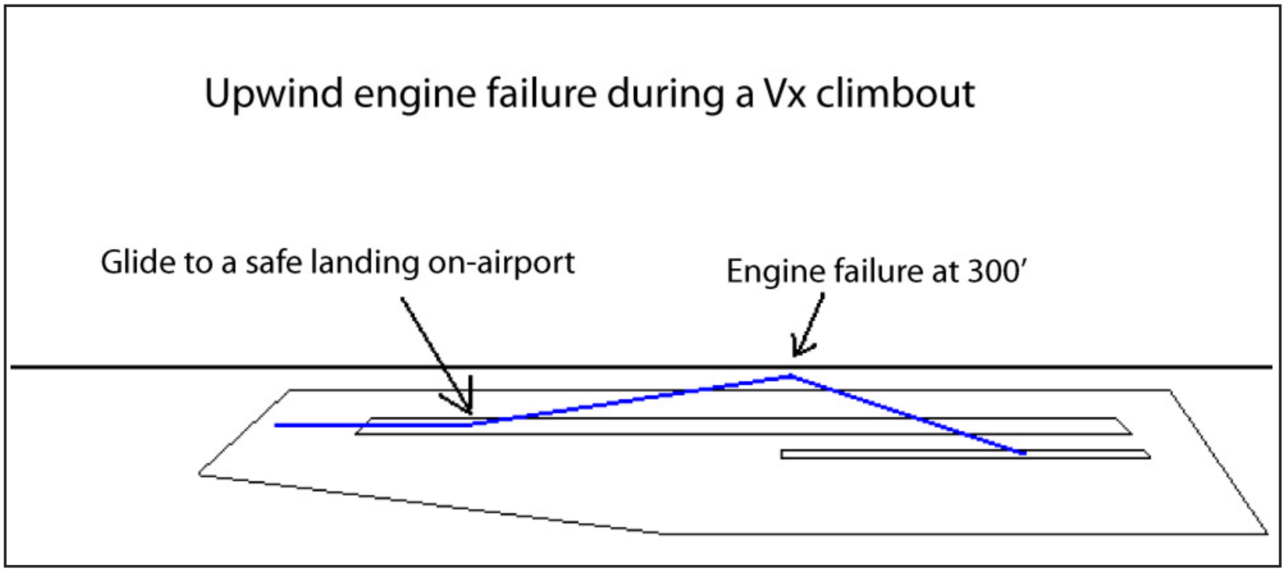
Put simply, the initial goal on every climbout is to reach the safe turn-around altitude before running out of options to land straight ahead. After that point, the goal is to be able to turn around and make it back safely to the airport. Here is the crux: what climb speed, or combination of speeds is most likely to provide the best chances for success in an emergency.

EARLY ENGINE FAILURE

If your engine falters before you reach your safe turn-around altitude (STA), your only emergency options involve the landing areas in front of you. At what speed should you have climbed up to this point, best rate (Vy), or best angle (Vx)?



The right choice is the one that consumes the least length of airport as you climb, thus preserving the most landing areas ahead: Vx.



Now I know there will be objections, and I believe I've heard them all: the nose will be too high for a safe transition to glide, it's too hard on the engine (!), Vx is not as efficient as Vy, Vx is only for "short fields," and the most interesting: if what you say is true, why doesn't it say so everywhere?

"Nose too high:" Not so, it just requires forward elevator and a bit of practice to make a smooth transition from Vx to glide.

"Hard on the engine:" Nonsense, the engine doesn't have a clue how fast you're flying.

"Not as efficient:" The efficiency for which we are aiming is preservation of landing options ahead, Vx is the only efficient speed; Vy covers too much ground.

"Vx is for short fields:" True, I am simply redefining what is meant by "short."

"Not everybody says this:" Somewhat true. I can only speculate that manufacturers don't like to talk much about engine failures. Learn to make your own decisions.

Next, the second phase: planning for an engine failure at or after reaching safe turn-around altitude.

CLIMB-OUT—THE SECOND HALF

Once you arrive at STA, the runway behind becomes an option.

It's an attractive temptation, but can you make it? Given the number of pilots who have proven that emergency turn-arounds often have tragic consequences, it might seem the answer is "NO." Certainly, the majority of "experts" caution against the attempt: every one of my own CFIs told me not to think of trying.

A shame really, when you think how inviting a runway is to a pilot forced to fly without an engine.

There is a bright spot: a little experimentation is all that is required to prove these experts wrong. The problem is not the "impossible" nature of the turn-around maneuver, but the lack of specific instruction on how to make it work.

HOW HIGH?

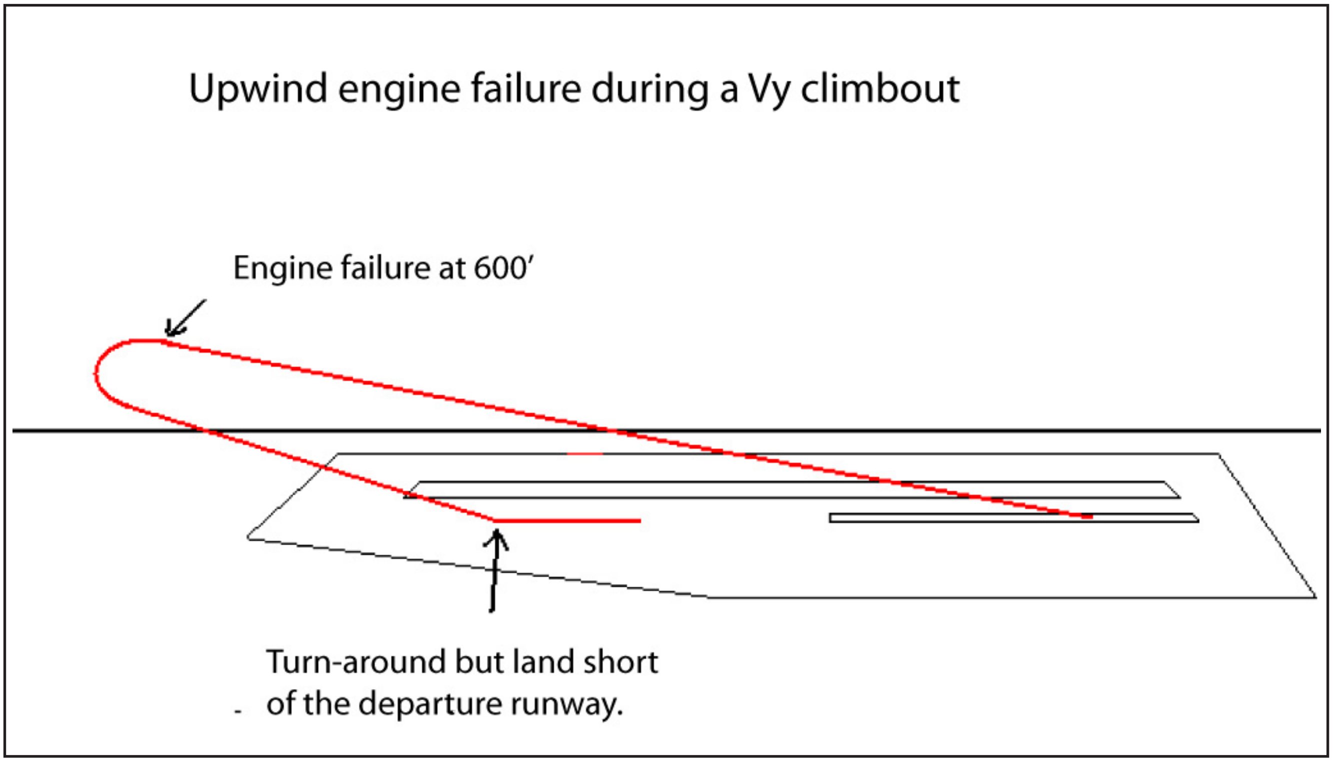
This is the question almost everyone asks: how high do I need to be in order to turn around successfully?

In part, the answer depends on variables of pilot skill and airplane glide performance, issues standardly discussed in all analyses of turn-arounds. But before either can be addressed, the entire concept must be re-examined.

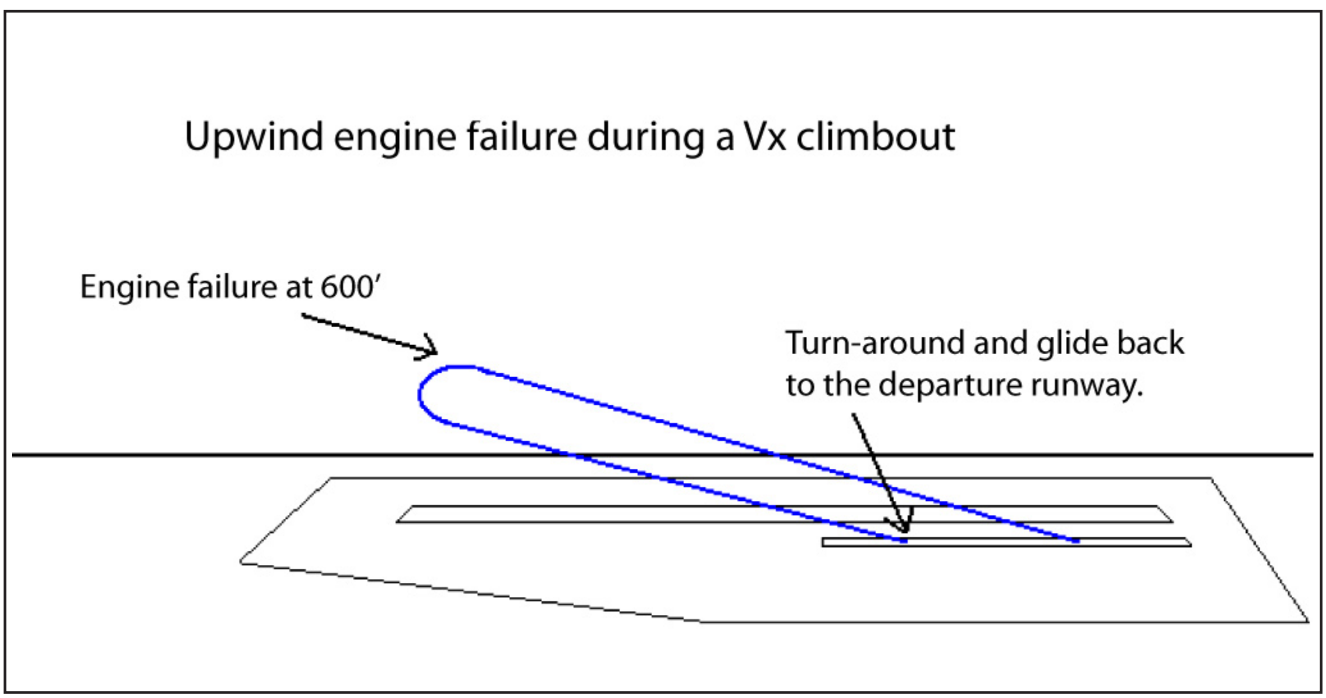
"How high?" is the wrong starting point: altitude alone is not the key. It does no good to be high enough to turn around successfully only to find at the end of the turn you are too far away to glide back to the airport.

Very few airplanes glide and climb at the same angle: the glide angle is nearly always steeper. The decision to attempt the turn-around cannot therefore rest on a single value. It must be based on two factors: altitude and distance from the airport.

Seen this way, success in any turn-around attempt will depend on how well the flight was managed prior to the emergency. Since the key to a successful return glide is proximity to the field, the choice of climb speed takes on senior importance.



The ideal climb-out should concentrate on gaining altitude while limiting forward progress across and then away from the airport. This leads naturally to the conclusion that Vx, not Vy, should be your choice of climb speeds for as long as you are thinking of using the airport as an emergency option. Put simply, it's a good rule to stay as close to the airport as you can while you climb.



BOTH "HALVES" OF THE CLIMB

Returning for a moment to the early climb-out phase, I argued earlier for Vx climbs from the moment you leave the ground. At this point I am now advocating Vx all the way to the point that you are high enough to have developed emergency options beyond the airport itself, certainly to a minimum of 1000' AGL.

"SHORT" FIELDS

Vx is classically discussed only when considering the challenges of short runways and problems with obstacle clearance. The unanswered question has always been, what exactly is "short?"

Informed answers calculate start-stop distance, reaction times and healthy "fudge" factors designed to increase margins. Students are then persuaded to rotate early and climb steeply until the CFI says with authority, "obstacles cleared." *The entire exercise is virtual.*

The potential benefits of these procedures are never discussed in terms of engine malfunctions, and since most pilots never actually use short runways, the entire exercise fades into the category of "things I had to do on the checkride I will never need."

I hope I have persuaded you to dust off the rust and start using Vx as it is intended: altitude gain without excessive forward progress.

CHAPTER 3: SAFE TURN-AROUNDS

In the last chapter I made frequent mention of a controversial number: "safe turn-around altitude, or STA" Many pilots, perhaps most, say it does not exist.

They go even further: attempts to turn around after an early engine malfunction are invariably dangerous, usually fatal.

Have you heard this? "If your engine fails on early climbout, you have no choice: you cannot turn around and you must continue straight ahead." It is said with impressive seriousness; after all, this is the stuff of life and death.

It is also, in my opinion, said by pilots who have never experimented with the reality.

Safe turn-around altitude forms the cornerstone of my analysis of altitude management during initial climb. Faced with a low-altitude engine failure, it is my contention that every combination of pilot and single-engine airplane can have such a number: an altitude below which there is insufficient height to turn around, but at and above which it is not only practical, but advisable, to turn back.

I say it can be done. Why do so many others deny the possibility?

The answer is complex, based primarily on emotion. Turn-around rejection is a mixture of entrenched opinion, a long history of tragic turn-around failures, and stubborn refusal to engage in personal experimentation.

WHAT NOT TO DO

Creation of a safe turn-around altitude is a matter of technique, not belief. In defense of entrenched opinion, one thing is certainly true: if you climb at Vy (or even faster) and believe also that the best way to conserve altitude when turning is to use very shallow bank angles, you do not have a safe turn-around altitude. In fact, it is safe to say that no matter how high you climb, five hundred or five thousand feet, you will never be able to return to your departure runway without power.

So, you're stuck: an early engine malfunction will inevitably find you searching anxiously ahead for a suitable place to put down: a street, unimproved field, railway grade or postage-stamp parking lot. If you do succumb to temptation and start to turn, you will quickly run out of altitude and possibly try to do the impossible, then stall and crash.

Grim, isn't it? It's hardly any wonder so many experts caution sagely against turning around: you're far better off taking a chance on a straight-ahead crash than giving in to the foolish lure of the runway behind you.

Fortunately, straight-ahead may not be your only option, and you need to change only two aspects of your technique to alter the outcome. The first, start climbing at Vx, not Vy. The second, make your turn-around with a minimum 45° bank (60° would be even better). Finally, you should go out and actually practice, so that you develop the necessary skills before you need them.

The argument for Vx climbs follows in subsequent chapters. In a nutshell, it is safer to climb as close as possible to the airport (Vx) than to stretch the climb out over a greater distance (Vy). Put another way, the increase in climb efficiency provided by Vy climbs is of no benefit if your angle of climb takes you so far away from the runway you cannot glide back.

As to the 45°-60° bank angle, that will be the focus of the next chapters. In the interim, I'd like to recommend a ten minute video presentation. It's short on production values, but long on insight. If you're interested in seeing footage that might well change your mind about turn-arounds, watch the attached video.

"NEVER TURN BACK"

This advice is usually the sum total of the instruction provided for handling low-altitude engine failures.

As I have said before, there is a lot of emotion attached to this subject. Any engine failure requires accurate decisions and prompt action. Low altitude failures are the most severe, and no one wants to be guilty of giving wrong advice and perhaps making things worse. In consequence, instructors, experts and authors have all traditionally embraced the most conservative approach, a "do nothing—just crash straight-ahead" policy.

The problem with this "solution" is that it is not the safest option.

While it is true that many attempts to turn back after an engine failure have had tragic consequences, it is important to recognize that few pilots have ever been trained to perform the maneuver correctly. With no preparation, there is little wonder attempts to turn often wind up in disasters: you might as well expect students to go out and do spins on their first solo.

Is there a better option than "NEVER TURN BACK!" and can it be taught? The analysis that follows proceeds from personal experience in two successful emergency turn-arounds.

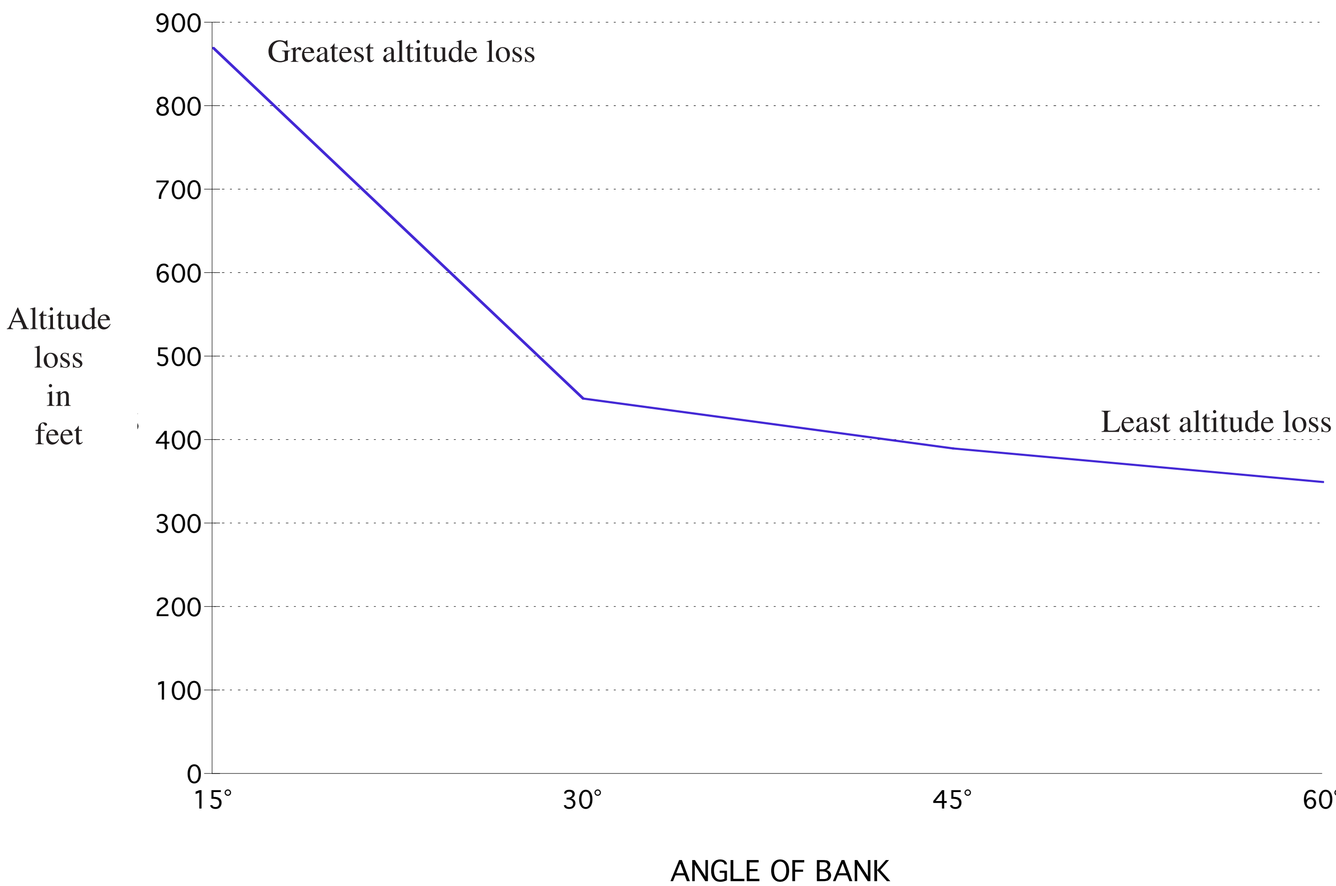
THE FLAW

To start with, it is clear that turning by itself does not lead to stalls and spins. The failure obviously lies in the attempt to stretch gliding performance beyond what is possible. This much is generally acknowledged, but the next step, the conclusion that turn-arounds are impossible, is false.

There are two fatal flaws that guarantee failure: the first is a shallow angle of climb (Vy) before the malfunction; the second is the bank angle chosen for the turn itself.

What angle of bank would you use in attempting a low altitude emergency turn-around? My experience suggests that most pilots naturally assume mild angles would be best, perhaps 15°, or 30° at most, on the theory that steeper banks will waste altitude. I have met dozens of CFIs who agree, an indication that many instructors will teach you just about anything.

ALTITUDE LOSS IN A 360° TURN PLOTTED AGAINST ANGLE OF BANK



The graph illustrates the truth: if you limit the bank to anything less than 45°, your turn-around is doomed to failure, very likely a worse choice than a straight-ahead crash.

You have to experiment to learn the truth: the shallower the bank, the greater the altitude loss in a gliding 180° turn. Although rate of descent is lowest in shallow banks, the additional time consumed in getting turned around ensures the greatest altitude loss.

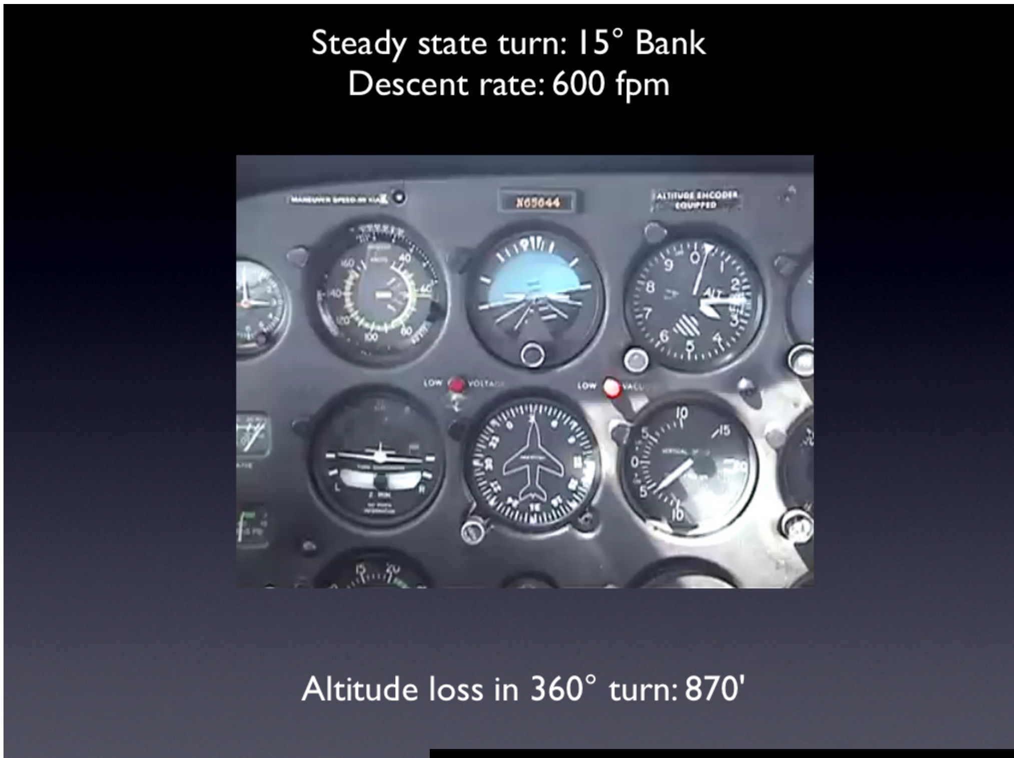
If that isn't enough to start you thinking, shallow banks have a second fatal flaw you must consider: they produce large radius turns that carry the plane impossibly far from the runway to which you are attempting to return.

TRY THIS

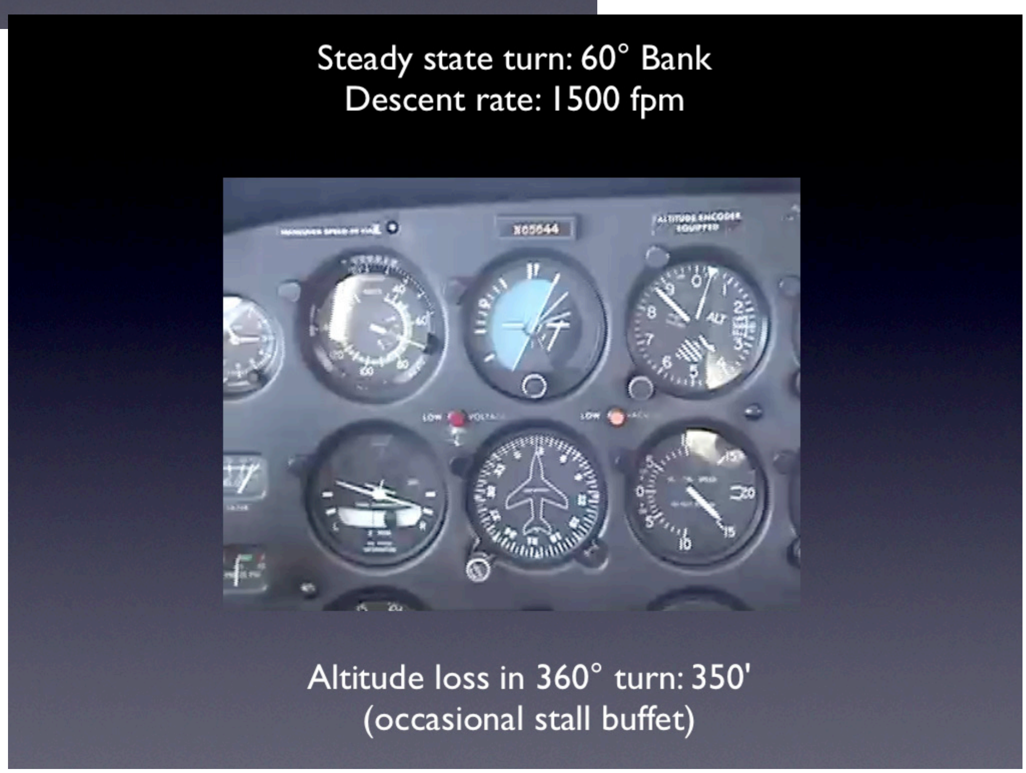
Over the years, I have heard a few instructors acknowledge there might be something to using a steep bank attitude in turn-around attempts, but that it would be foolhardy to recommend it: panic and lack of skill would inevitably make such attempts dangerous.

Nonsense. I would venture that pilots who cannot learn and master 45° or 60° banked turn-arounds shouldn't be flying.

What about panic? This is obvious: train through it. Give a pilot a task and the certainty that it will work, and panic recedes. It is shameful to use emotion as a justification for failure to train.



Worst choice



Best choice

CHAPTER 4: THE “IMPOSSIBLE” TURN (YOU CAN GO BACK)

In the last chapter I challenged the advice most often given student pilots: “NEVER TURN BACK!”

As fate would have it, the lecture showed up again very recently, newly dusted off by no less an expert than Bruce Landsberg, director of AOPA’s Air Safety Foundation. In his analysis of the recent USAir Hudson River landing, Mr. Landsberg was quoted as saying,

“If you have an emergency shortly after takeoff, the call of the runway behind you can be extremely strong, but time and again we see pilots desperately trying to make it back stall and spin into the ground instead. Look for the best option within a few degrees of your flight path.”

He went on to say, “...pilots need to remember that the ‘impossible turn’ back to the runway really is impossible.”

The “impossible turn” reference is to the intentionally ironic title of an article that set out to prove turning around after an engine failure is not impossible. First published in 1994, the piece has since gently made the rounds, convincing those who take the time to read it [The Possible `Impossible’ Turn, David F. Rogers, United States Naval Academy, Copyright 1994].

As I have made clear, I’m firmly on Mr. Rogers’s side: my personal experience is that given the right training and the right initial climb speed, turning back after an engine malfunction is not only practical, but is usually the best choice.

There is a double irony to Mr. Landsberg’s quote: first, the USAir pilot turned substantially more than a “few degrees” (about 120°) from his initial flight path in his successful bid for the river landing. Second, Mr. Landsberg indirectly references the “Impossible Turn” article, but appears to have misunderstood it: that analysis made a convincing argument for safe turn-arounds.

AIRLINE TRAINING

Following up on the AOPA quote, I quizzed a retired airline pilot with thousands of flight hours and hundreds of hours instructing in her airline training department. The upshot: her airline, at least, does not train for low altitude double-engine failures. There is no reference for the best glide speed, and practice turn-arounds are unheard of.

Given a complete absence of realistic low altitude engine-out training, it would be foolhardy to second-guess the USAir pilot’s decisions. When all is said and done, he made a series of choices that passed the ultimate test: everybody lived.

However, the incident does not support the NEVER-TURN-BACK thesis: there is a lot of difference between an attitude-controlled Airbus and a light single. If you’re playing the odds, turning around in a light airplane is a far safer bet than a water landing.

You need to experiment with turn-arounds in your own aircraft before you form your opinion, especially before you buy into data presented by those who have not themselves done the homework.

Here is something the “never-turn-back” experts fail to consider: pre-solo glider students are standardly given a simulated tow-rope break at 200’ AGL (that’s right: two hundred feet above the ground), then required to turn around and get back down on the field. The altitude can seem impossibly low, even to CFIs new to the maneuver, but it works.

How much more likely is a broken tow rope than a failed engine? 200%? 1000%? Whatever the number, if glider students prepare for the possibility of early power loss, so should you.

Let’s consider a Cessna 172 with a failed engine. Starting from Vx pitch attitude and airspeed, and using a 60° bank angle, it is possible to reverse course with less than a 300 foot altitude loss. Even allowing for several lost seconds of “disbelief time,” this translates into a very real safe turn-around target of 500’ AGL.

Do you believe me? If not, you should go out and try it.

I’ll detail the practice syllabus next.

CHAPTER 5: GO AHEAD—TURN BACK

Throughout this piece I have been chiseling away at the NEVER TURN BACK credo, the cast-in-stone rule that says you must not attempt to turn back to the airport in a low altitude takeoff emergency.

It has been tough going: NTB has long since passed into the realm of "things we just know and never need to question."

A few readers report they have watched the turn-around video I recommend (available at the end of this chapter and at www.aerobats.com/turn-arounds.html) with positive results. Still, fifteen minutes of video is a far cry from the depth of understanding required by a real emergency. Once the engine coughs and your heart rate doubles, certainty, not theory, is crucial.

PRACTICE

The first critical key to success in turn-arounds is practice and preparation. It is certain if you don't know that you can do the maneuver safely you won't be prepared to react as quickly as an emergency demands. Instead, you'll dither away the opportunity, then either settle for a straight-ahead crash, or conceivably attempt a turn that has by now become truly impossible.

Practice is simple: using a safe altitude, establish a stable climb at Vx (not Vy), then cut the power, noting the altitude. Allow for a couple of seconds lost in shocked disbelief, then lower the nose as you bank steeply and pull to a high angle of attack. Some level of buffet is acceptable, and inadvertent stalls are desirable as you learn where the limits are. You will be amazed at how quickly you can get turned around.

There are two fairly obvious prerequisites: one, you need to be able to make a gliding turn with a 45° or 50° bank angle without losing control of pitch.

Second, you have to be comfortable with the possibility of an inadvertent stall in a steeply banked attitude, a stall which will require recovery without rollout from the turn.

Now you see why turn-arounds are called "impossible": to the shame of the FAA and virtually the entire teaching community, few pilots are ever required to develop these two critical skills.

If this style of maneuvering is completely foreign to you, get a CFI to come along, first making sure that his or her credentials indicate they know how to do this themselves. If you get a blank look, go find another; they're out there, often identified as "aerobatic" CFIs.

ALTITUDE

Once you have developed the necessary turn-around skills, the second key to success is correct identification of a safe turn-around altitude. I'll call it SATA. The number changes with three important variables, pilot skill, airplane model and density altitude, and can only be determined through trial and error in a specific airplane model. Once your turn-around practice has become satisfactory, you can start the process of figuring out what is high enough and what isn't.

SET UP

The final key is climb management. If you insist at climbing at Vy, as you were almost certainly taught to do in primary instruction, no amount of skill in turning around is going to do much good. Given average runway lengths, Vy climbs are simply too flat and carry the plane too far upwind.

The liability of a flat climb is easy to see: if after a successful turn-around you find you are too far away to glide back, it is easy to argue the turn was a bad idea and only made things worse. One more win for the NTB bunch.

The bottom line: in single engine airplanes, unless you fly from Edwards AFB, forget Vy altogether below 1000' AGL. It's a poor choice.

WHY BOTHER?

My last comment: almost nobody flies as I have described, and even fewer are prepared to turn back. Yet almost everybody survives, so why bother with all this?

The answer lies in the very statistics that produced the NEVER TURN BACK credo in the first place: enough pilots have gotten killed trying the maneuver to indicate that takeoff emergencies do happen.

If you fly a single engine airplane long enough, you will experience an engine emergency. Luck plays a part, and your engine problem may occur at low altitude shortly after lift-off. If you aren't prepared, maybe you shouldn't be carrying around your family and friends .

Turn-Around Video