

Ups and Downs of Retractable Landing Gear

As a senior CFI, I get asked many interesting questions. Many questions come up regarding retractable landing gear both on land and sea.

Let us begin where gear issues begin, takeoff. I recently watched a couple of YouTube videos where one experienced CFI told the audience to always delay raising the gear until there is no longer any runway to land on if an engine quits. Yet another CFI told another audience to always raise the gear as soon as the aircraft shows positive rate on departure.



Let's discuss the first situation where we delay the gear retraction. I must admit this procedure trips me up all the time. I have over 23,000 hours of retractable time and most of it was flown using the "Positive Rate, Gear up" method. That is not to say delaying gear retraction for the sake of safety, isn't a valid technique. Again, the purpose is to preserve an option to land straight ahead if the engine quits. The catch here is having runway available. Having that runway depends completely on the aircraft being flown and the length of the runway. Let us look at two common planes the Bonanza F33 and the Baron 58 and assume a 6000-foot runway for all calculations.

The F33A POH, shows takeoff distance of 1769 feet over a 50-foot obstacle at full gross weight. What happens if you get airborne and now need to abort for a failed engine? The POH shows landing distance over a 50 obstacle of 1324 feet. So, our diligent pilot takes off, climbs to 50 feet, loses an engine, and returns to earth. The whole maneuver takes 3093 feet, a combination of the 50-foot takeoff and landing distances. So how high can you go and still land on the runway? Doing a little math in public, at 561 lateral feet per 50 feet of altitude, a pilot has until approximately 300 feet before landing on the pavement isn't an option. In an F33A that would be less than 10 seconds after liftoff. All these numbers are zero wind, sea level, max gross weight by the way. This seems doable and safe. In fact, if you refer to the F33A POH, Normal Procedures section on takeoff, it prescribes the pilot; *"3. Landing Gear-RETRACT (When positive rate of climb is established, and insufficient runway remains for landing.)"*

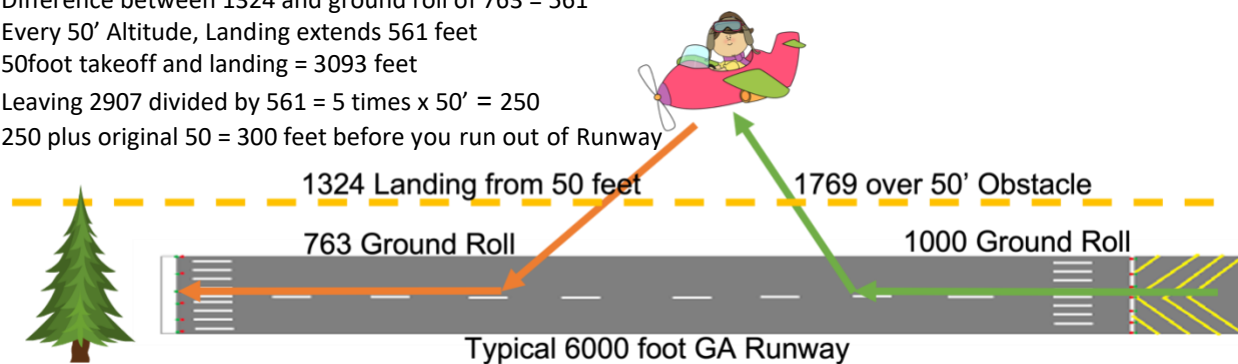
Difference between 1324 and ground roll of 763 = 561

Every 50' Altitude, Landing extends 561 feet

50foot takeoff and landing = 3093 feet

Leaving 2907 divided by 561 = 5 times x 50' = 250

250 plus original 50 = 300 feet before you run out of Runway



Now let us take a short look at the Baron. Takeoff over the 50 obstacle is 2350 feet. Landing ground roll is 1425 and over that 50-foot tree it is 2500 feet. So, the same math gives us 4850

feet to abort from 50 feet and you could only climb to 100 feet and still stop on a 6000-foot runway. Time to 100 is less than 3 seconds. It would be time to say, “positive rate, gear up” and you would be above 100 feet. The numbers here demonstrate that little is to be gained by waiting on the gear retraction in a Baron. The landing numbers are probably going to be longer since you no doubt accelerated during the delay and are above an approach speed used to create the numbers. It also brings up another concern with delaying the gear retraction, gear speed. Some aircraft accelerate quickly once airborne, and the gear needs to be raised to prevent an over speed. So, in this case raising the gear at positive rate would be wise.

When I was flying the F-15C Eagle, I didn’t have time to say Positive rate, gear up or I would have been past the gear retraction speed. As soon as I felt the wheels off the ground, we slapped the gear handle up and if I looked at the airspeed, I was already over 200 knots with a maximum retraction speed of 250, accelerating to 300 knots by the end of the runway.



Since I have devolved into war stories let’s talk about the North American T-6 and my warbird buddies. Not all, but certainly the majority of this group is the, wait until the runway is no longer useable, before raising the gear side of this discussion. Gear speed isn’t a factor as the plane was built like a tank. But when is the runway no longer useable? Ok so let us do that math again. Takeoff over a 50-foot obstacle is 1700 in the nearly 70-year-old document. Landing roll over

that tree again it is 1600. These are the hard surface numbers, on turf and soggy ground its longer to takeoff and shorter to land. OK That gives us the 50-foot exercise distance of 3300 feet. So, you can get 200 feet in the air before the runway is not going to be there for you even though it is probably still visible to the side of the nose. I am used to the positive rate gear up routine, so it was hard to adjust to the way they were instructing me. Worst case I would reach for the gear, hesitate, get distracted doing other tasks and forget the gear all together. Much to the amusement of my warbird buddies who snickered on downwind, “well no need to put the gear down” that’s covered.

What are the down sides of delaying gear retraction? I just related the story which included waiting and distraction. When raising the gear is not an automatic response to getting airborne, distraction can cause you to forget it all together. Forgetting can cause real problems in two cases, Amphibious planes, and IMC operations.

If you are flying into IMC, do you really want to be waiting on the gear as you are watching the departure procedure turn point coming up? It makes for a lot of mental gymnastics and waiting on the gear might not be decreasing your workload. But you are ready for the engine to cough. Getting into IMC and having the decreased performance of dragging your gear could lead to significant problems, especially should you encounter ice and need the performance to climb quickly. My take on this is that deciding to delay the gear in the case of a light single engine aircraft depends, are you VFR or IFR? Another question, do you want to have a different procedure in the same plane for different conditions? In the T6 world we raise the gear

immediately during formation takeoffs but not single ship. Personally different procedures in the same plane assaults my safety backbone.

The Seaplane Pilots Association has a big push to get amphibious pilots to always use the “positive rate, gear up” method and not delay putting the gear up. If operating a seaplane with wheels, and you forget to raise the gear like I did in the T6 it can mean that according to SPA you are 88% more likely to land in the water with your gear down. Over a 13-year period there have been 195 seaplane accidents in the US. 27 of them were inadvertent gear down water landings. 21 of them were fatal. In Canada, the National Transportation Safety folks say 34 to 31% of their accidents occur because of the wrong configuration for water landings. These gear down water landings are nearly always fatal because in a split second after contacting the water the wheels cause the aircraft to flip violently forward and upside-down putting the pilot and passengers in the water and usually unconscious due to head trauma.

Yet another downside of waiting on the gear is creating a false sense that you could safely abort without damaging the aircraft. If you are in a single engine craft and lose an engine you still have a problem. Since you are below the turn back altitude you are committed to landing straight ahead. If you are in that very narrow 100-to-300-foot range discussed above with your gear down, it is still a “maybe” that you could land on the runway. Remember you are accelerating and may be above approach speed making the distances greater. All those book numbers were created by test pilots, knowing ahead of time what they were going to do to max perform the plane to get the numbers looking good for marketing. As the old car commercials said, “your mileage may vary”.

Finally on the downside of delaying the gear, it just won't work on most high-performance aircraft. We determined it would not work on a relatively long general aviation runway for the Baron. The point that a turbojet aircraft could abort and stay on the runway is a calculation we made every time we took off in the airline business. The distance that you can accelerate, decide to abort, apply the brakes, and stop on the runway is the balanced field or accelerate-stop distance. Published for the F33a as 1740 feet and the Baron as 3000 feet. In high performance turbojet aircraft, it is published as a speed, V_1 . This is because if the pilot exceeds this speed they must take off since stopping above V_1 will cause the aircraft to go off the end of the runway. So that 50-foot exercise we calculated above for light single engine planes is zero for high performance aircraft and even below the rotate speed, V_r . I might add a bit of “inside baseball” here; Boeing and Airbus prescribe the “positive rate, gear up” method primarily for 2nd and 3rd segment climb performance to miss obstacles in the airport environment.

Ok now let's explore the other way, raise the gear as soon as the aircraft achieves a positive rate of climb. For my 31 years in the airline world, the safe and standard way of doing things was for the pilot not flying to verify “Positive rate”. Then the pilot flying verified the same and commanded “Gear UP” whereby the pilot not flying raised the landing gear. If you always remember and execute “positive rate, gear up” you are checking to ensure the aircraft is in a climb and it is the first thing you do after takeoff. It configures your aircraft into a low drag configuration. If flying a multi-engine aircraft and one engine decides to quit, you are now in a better position to keep it in the air. Did I tell you that over the past 20 years the most common

type of loss of control accident is a departure stall. "Positive rate, gear up" is simple and decreases your workload in the "danger zone" on departure.

I just remembered something, and it turns out I just lied to you. "Always", always gets you into trouble in aviation. In the Boeing 737 we did delay the gear when taking off a runway covered in slush or snow to allow the slipstream to blow contaminants off the gear before retraction. We also did this years ago when flying the gravel equipped 737-200 leaving a gravel runway for the same reason. Yeap, flew 737s off gravel runways in the great state of Alaska. This too might be a reason to delay the gear in general aviation.

That is all the whys and why-nots I can think of for both delaying and not delaying the gear on departure. So, if you landed gear up is it really a big deal? If the engine just quits, you are planning to give the plane back to the insurance company anyway. The most important consideration is surviving the runway or off-runway landing. Unintentional gear up landings are rarely injurious to the pilot and passengers if you don't consider pride and cost. The most expensive consideration in unintentional gear up landings is striking the prop and having to overhaul the engine. Well, we already settled that with the engine failure, so landing straight ahead off the end of the runway being your only option, gear up or gear down isn't going to change your destiny.

I would like to finish up by turning now to landing with retractable gear and avoiding that unintentional gear up disaster. According to Aviation Safety Magazine, there are on average 8 belly landings per week in the US. Many aviation articles say there are those who have and those that will, but I reject that kind of inevitability. I've been operating retractable gear aircraft for 50 years now and I have never landed gear up. How do I do it?

Looking over accident data there are three broad categories of gear-up landings; failure to put it down, after landing the gear fails or an action of the pilot causes it to retract, and mechanical failure of the gear. Mechanical failures represent less than five percent of gear up landings and really aren't the subject of this paper.

Failures of the landing gear can be caused by several issues; hard turns, sensor failures, but most of this type of gear up accident occurs during touch and go landings or when pilots try to reconfigure the plane while on the runway. Two disciplines or procedures prevent failures. First, pilots operating complex aircraft especially multi-engine complex aircraft must not practice touch and go landings. It is far too easy to reach for the flaps and select the gear handle up. Second, when operating any aircraft wait until clear of the active runway and stopped to accomplish checklists and reconfiguration of the aircraft. It is far too easy to select the wrong control when you are multi-tasking.

That brings us to the main, far more common type of gear up landing (or gear down water landing), failing to put the gear in the correct position for landing. In my experience, three disciplines must be followed to prevent the wrong configuration landing.

First, always put the gear down in the same place. What I mean is if flying an instrument approach always put the gear down intercepting the glide path or over the final approach fix. A

lot of distractions occur during an approach, discipline and regimen allows the pilot to complete the approach consistently. Flying, knowing normal pitch and power settings allows a pilot to recognize lower than normal power on final giving them a chance to trouble shoot or figure out why it is lower, hopefully realizing the gear isn't down. If flying a VFR pattern use the same spot in the pattern, for instance midfield downwind, always strive to put the gear down in your spot and create a regimen of it. The spot you pick, or that your POH dictates, should be good for normal and single engine operations for multi-engine planes.

Second, verbalize the landing checklist and planned configuration on every approach. When you get to "Gear" and say, "gear down", look, really look, at the gear indication and gear handle on every landing. You must make a regimen out of every landing. Visually confirm the handle is down and you have three green lights. Don't stop there, some aircraft have manual or mechanical gear indications out on the wing. If your plane has them, these indications must be checked as well. Most amphibious airplanes have these manual indicators out on the floats, look outside and confirm the position of the gear; gear down, three green for pavement, gear up, three blue lights for a water landing. In aircraft like the T-6 do the same as an amphibious plane, visually confirm the outside manual indications. Never take it for granted that you put the gear down. Gear handles get stuck part way down, gear do fail, and interior indications can be different than mechanical indications out on the wing. Not all aircraft have the mechanical or manual indications as backup, but if they are there use them.

Pilots of course need to follow the guidance in the POH for the landing checklist, in addition to that checklist the good 'ol GUMP check works to. GAS, UNDERCARRAGE, MIXTURE, PROP. Years ago, a lifelong friend and I were CFIs together. When we checked out clients in complex aircraft, we finished the endorsement with a lecture that they were now complex airplane pilots, making the client promise to continue using GUMPs, even in fixed gear aircraft to build the habit.

Later I joined military and grew up flying the military way which included a radio call including "gear down". We incorporated this call with turning base or cleared to land on a straight-in. When I fly any plane, I still say the words, as an example; "North American 72C right base runway 02, gear down". When you make the call or say GUMPs, it does no good to simply make the radio call. As you say the words you physically look at the gear handle and indications inside and out on the plane to ensure that you aren't lying. I spend a lot of time flying fixed gear aircraft and more than one of my clients will tell you I still make the call, I just release the mic button before I transmit, "gear down and welded". It's the regimen and habit pattern. No matter what you fly don't break the habit.

Third and finally, never allow the warning horn to become a distraction. Commonly the gear horn sounds when you reduce the throttle of a complex aircraft. Most often the horn sounds when practicing single engine approach or reducing power to slow for an approach. Each time it sounds the pilot must acknowledge the horn, why it sounded, and the plan to deal with it. If you begin to ignore it as a nuisance, it will catch up and bite you at some point. This doesn't have to be a lengthy distracting acknowledgment. Try this next time you reduce power, "gear warning for reduced power, power will increase at 90 knots". Or gear warning due to simulated

single engine, gear will be lowered at glideslope intercept". Then if you lower the gear at the same place every time you will not forget.

This has been a lot of information, but simply put regimen, discipline, and wise procedure prevent problems with the retractable gear. Delaying the gear retraction on departure in some narrow circumstances is safe and some POHs require it. Pilots must always follow the POH guidance. But don't delay too long as I have demonstrated with math in public the point at which you can no longer land comes very fast. Placing the gear up at a positive rate of climb has little downside and many positives. Putting the gear down in the same place, doing a gear check on final or base works only if you check the handle, lights, and manual indicators outside each time. Finally, don't change configuration on the runway in complex aircraft.

Fly for fun
Over and Out.