Accelerate Stop for Single Engine Airplanes

by Paul Wiley

This article discusses the concept of Accelerate Stop (and briefly the associated Accelerate Go) for pilots flying single engine land airplanes under FAR part 91 General and Operating Flight Rules.

The concept of Accelerate Stop/Accelerate Go is usually thought of as applicable only to multi-engine airplanes; normally, a pilot is first introduced to this concept during multi-engine training. However, I believe pilots flying single engine airplanes can also benefit from understanding Accelerate Stop/ Accelerate Go. The distance you calculate to accelerate to liftoff speed and then stop is useful in determining how much runway you may need for the airplane you are flying, i.e., helpful in making the Go/No Go decision. Knowing this distance is also important for other reasons as explained further in the article.

Accelerate Stop Distance - The distance required to accelerate an airplane to a specified speed and, assuming failure of an engine at that instant that speed is attained, to bring the airplane to a stop.

Accelerate Go Distance - The distance required to accelerate an airplane to a specified speed and, assuming failure of an engine at that instant that speed is attained, to continue the take-off and climb over a 50-foot obstacle. Obviously, Accelerate Go does not apply to a single engine airplane. Since Accelerate Go does not apply to single engine airplanes, it will not be discussed further in this article.

The Scenario:

Let's assume you own a Cessna Turbo Centurion Model 210. You want to fly into an airport with a well-maintained level grass runway that is 3,000 feet long and at an elevation of 2,500 feet above sea level. There are 50-foot-high trees on each end of this runway. On the day and time you wish to fly into this airport, the temperature is 70 degrees Fahrenheit and there is no wind. Your gross weight for both take-off and landing will be 3,400 pounds. You will use the manufacturer's recommended

short field procedures for both take-off and landing. The technique you use will be as specified by the airplane manufacturer for short field operations.

In this Accelerate Stop scenario, 1) the airplane will be accelerated to lift-off airspeed, 2) a decision will be made to abort the take-off and 3) the airplane will be brought to a stop straight ahead as quickly as possible using proper technique. In a "real life" situation, this can be necessary for several reasons such as 1) a suddenly rough running engine during the take-off ground run, 2) a door or window that pops open, 3) bird strike or 4) some other distraction that happens at just the wrong time.

<u>Take-off Performance Calculations</u>:

Referring to the definition of Accelerate Stop, we see that the airplane is accelerated to a "specified speed" and then brought to a stop as quickly as possible. What is this specified speed? In our case, with a single engine airplane, it will be the rotation speed (V_R) which for a short field take-off is just slightly less than the Best Angle of Climb Speed (V_X)

The Take-Off Data table (Figure 6-3), which was taken from the Cessna Centurion Owner's Manual, specifies that at a gross weight of 3,400 pounds V_X is 77 MPH indicated airspeed (IAS) shown in the

TAKE-OFF DATA

TAKE-OFF DISTANCE WITH 10° FLAPS FROM HARD SURFACE RUNWAY

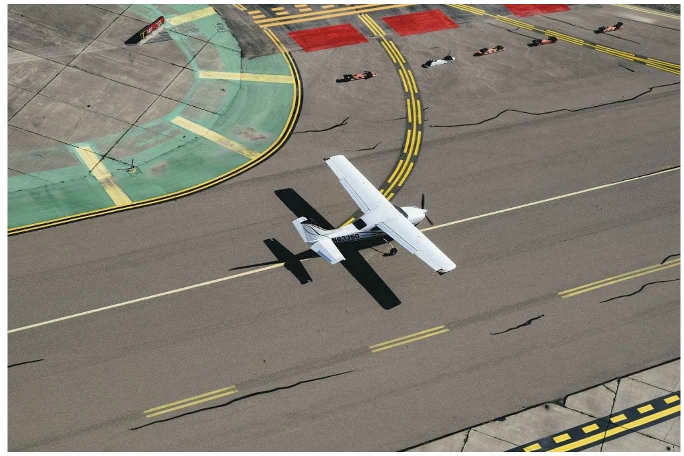
GROSS WEIGHT POUNDS	IAS @ 50 FT.	HEAD WIND KNOTS	@ SEA LEVEL & 59° F.		@ 2500 FT. & 50°F.		@ 5000 FT. & 41°F		@ 7500 FT. & 32°F	
			GROUND RUN	TOTAL TO CLEAR 50.FT.OBS.	GROUND RUN	TOTAL TO CLEAR 50 FT.OBS.	GROUND RUN	TOTAL TO CLEAR 50 FT.OBS.	GROUND RUN	TOTAL TO CLEAR 50 FT.OBS.
3800	82	0	1170	2030	1305	2210	1465	2425	1645	2665
		10	870	1610	985	1765	1115	1950	1270	2155
		20	615	1225	705	1360	810	1515	935	1695
3400	77	0	905	1605	1010	1745	1135	1905	1275	2085
		10	660	1255	745	1375	850	1510	965	1670
		20	455	945	520	1040	600	1160	695	1290
3000	72	0	680	1270	760	1375	850	1495	960	1635
		10	485	985	550	1070	625	1175	715	1290
		20	325	725	370	795	430	885	500	980

NOTES: 1. Increase distance 10% for each 20°F above standard temperature for particular altitude.
2. For operation on a dry, grass runway, increase distances (both "ground run" and "total to clear 50 ft. obstacle") by 5% of the "total to clear 50 ft. obstacle" figure.

6-3

Figure 6-3.

table as IAS @ 50 ft. Here is where the NOTES are important. Note 1) states: Increase distance 10% for each 20 degrees above standard temperature for a particular altitude. Standard temperature is 50 degrees F at 2,500 feet MSL. Note 2) states: For operation on a dry, grass runway increase distances (both “ground run” and “total to clear 50 ft.



<u>Take-off Performance Calculations - continued</u>:

obstacle”) by 5% of the “total to clear 50 ft. obstacle” figure. Applying the Notes to the figures in the table we get: 1,198 feet of ground run. That is: 1,010 ft ground run from the table * 1.1 (+10% to account for the +20 degrees above standard temperature) = 1,111 + 87 ft. (+5% of the total to clear 50 Ft. obstacle figure to account for the grass runway) = **1,198 Ft.** total ground run to reach V_R, and the decision point.

<u>The “Decision Period” Calculations</u>:

Now you are traveling at 77 MPH IAS, and you decide to abort the take-off. The period of time it takes a pilot to realize he needs to abort take-off and actually start the process of reducing power and to initiate braking is called, appropriately enough, the decision period. While studies have shown the time to make this decision can range from 2 up to 8 seconds, most manufacturers allow for a period of 3 seconds to make the decision to abort the take-off and start taking action to stop the plane. At 77 MPH (approximately 107 feet per second), the plane will travel a total of approximately **321** feet in the 3 seconds of the decision period. The decision to abort take-off having been made, we now turn our attention to stopping the plane.

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LANDING DISTANCE TABLE

LANDING DISTANCE WITH 30° FLAPS ON HARD SURFACED RUNWAY

GROSS WEIGHT POUNDS	APPROACH IAS MPH	@ SEA LEVEL & 59°F		@ 2500 FEET & 50°F		@ 5000 FEET & 41°F		@ 7500 FEET & 32°F	
		GROUND ROLL	TOTAL TO CLEAR 50 FT.OBS.	GROUND ROLL	TOTAL TO CLEAR 50 FT. OBS.	GROUND ROLL	TOTAL TO CLEAR 50 FT. OBS.	GROUND ROLL	TOTAL TO CLEAR 50 FT. OBS.
3800	82	765	1500	815	1595	865	1695	920	1805

NOTES:
1. Distances shown are based on zero wind, power off, and heavy braking.
2. Reduce landing distances 10% for each 5 knots headwind.
3. For operation on a dry, grass runway, increase distances (both "ground roll" and "total to clear 50 ft. obstacle") by 20% of the "total to clear 50 ft. obstacle" figure.

Figure 6-7.

Landing Distance Calculations:

The Landing Distance Table (Figure 6-7), which was also taken from the Cessna Centurion Owner's Manual, specifies that at a gross weight of 3,800 pounds and an approach speed of 82 MPH IAS, the landing distance at 2,500 feet elevation and 50 degrees F is 815 feet of ground roll. Again, the NOTES are important. The only Note applicable to our scenario here is Note 3) which states: For operation on a dry, grass runway, increase distances (both "ground roll" and "total to clear 50 ft. obstacle") by 20% of the "total to clear 50 ft. obstacle" figure. Applying the notes to the figures in the table we get: **1,134** feet of ground roll. That is 815 ft ground roll from the table + 319 ft. (+20% of the total to clear 50 ft. obstacle figure) to account for the grass runway) = 1,134 feet of total ground roll from the decision point to a full stop. Proper technique means flaps retracted and heavy braking. Note that the airspeed should be slightly less than the 82 MPH speed used to calculate landing distance and the 3,800 pounds gross landing weight is the only option given in the table. The heavier gross weight means a "worse case" situation for landing. That is a slightly slower speed and lighter landing weight equates to a better situation since landing at a lighter weight and slower speed would take less distance to stop. However, we will use the figures based upon a 3,800 pound gross landing weight and 82 MPH because this is the only reliable information we have and it is conservative.

Putting It All Together:

The total distance to accelerate to liftoff airspeed, decide to abort the take-off and then stop the plane is the sum of these 3 factors:

Take-off distance = **1,198** feet of ground run

Travel during the decision period = **321** feet

Landing distance = **1,134** feet of ground roll

Summing these 3 factors equates to a total distance of **2,653 feet** of runway required as calculated from the Owner's Manual in this scenario for accelerate stop. This seems OK because our intended runway is 3,000 feet long.

However, we are not quite finished with our calculations. The AOPA Air Safety Institute recommends adding 50% to these calculations derived from the Airplane's Owner's Manual or Approved Flight Manual as a "safety factor". Adding 50 % to our calculations of 2,653 feet of runway required means that to be conservatively safe

Putting It All Together - continued:

we need **3,980** feet of runway. Not good because

this exceeds the 3,000 feet of runway we intend to use by a significant amount.

But, if we use just the Take-off and Landing distance calculations separately, i.e., with no "decision period", we can see that the numbers are more favorable. Effectively, this means we will consider the distance we need to take-off and the distance we need to land separately and NOT the 'decision period", which by the way could be more than the 3 seconds in this scenario depending upon the pilot's reaction time. We will not consider the scenario where the take-off is aborted at or near liftoff. This could potentially be a problem if the take-off does need to be aborted and a prudent pilot would not take such a chance. So, let's look at the take-off and landing distances required with the 50% safety factor added to the manufacturer's data.

Take-off and Landing distances computed with 50% Safety Factor:

- Take-off distance = 1,198 feet of ground run. With 50% safety factor = **1,797** feet
- Take-off distance total to clear 50 ft. obstacle = 2,007 feet. With 50% safety factor = **3,011** feet
- Landing distance total to clear 50 ft. obstacle = 1,914 feet. With 50% safety factor = **2,871** feet
- Landing distance = 1,134 feet of ground roll. With 50% safety factor = **1,701** feet

Some Other Factors affecting Take-off and Landing distances:

Wind:

Of all the factors affecting take-off and landing distances, a headwind is the most common factor working for the pilot and having an appreciable positive impact on take-off and landing distances. With just 10 knots of headwind, the take-off ground run in the table decreases from 1,010 feet to 745 feet, or approximately a 26% decrease in distance required. Likewise, a tailwind will dramatically increase take-off and landing distances. Remember that landing distance is a function of ground speed, not airspeed. A tailwind will increase the groundspeed (perhaps dramatically if strong enough), thus requiring more runway to stop. Additionally, a combination of crosswind and tailwind when taking off or landing can make directional control difficult and hinder good technique. A quartering tailwind is generally considered to be the most problematic to deal with when landing or taking off as it negatively affects both distance required and controllability.

Airplane Weight:

Takeoff distance varies as the square of the gross weight. As shown in table, notice that as the gross weight increases (approximately 10%) from 3,400 to 3,800 lbs. the takeoff distance increases approximately 30% from a ground run of 1,010 to 1,305. Distance to clear a 50 ft. obstacle and climb performance will also be similarly affected. Landing distance will also be longer for increased weight and shorter for decreased weight.

Runway Slope:

A runway that has an appreciable upslope or downslope will also decrease the take-off distance when taking off downhill and decrease landing distance when landing uphill. A good “rule of thumb” to use is when the wind (headwind component) is less than 10 knots take off downhill and land uphill.

Runway condition:

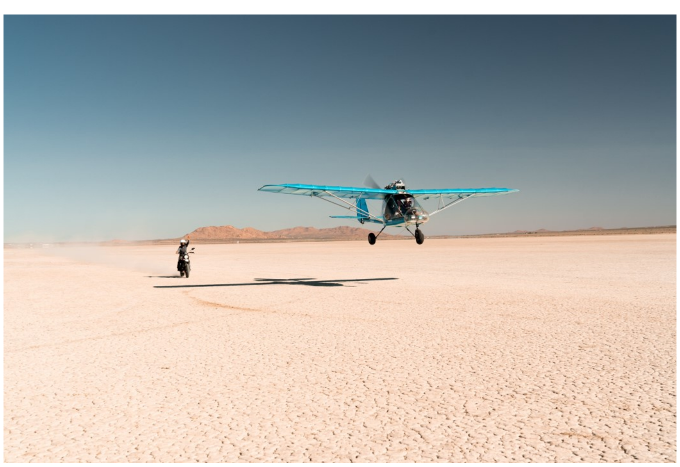
A wet or (especially) a contaminated runway can have a very negative effect on landing distance mainly due to the effect upon braking action. A grass runway that is wet or has not been mowed recently can also have a negative effect on take-off (tall grass) or landing (wet or contaminated).

Some Other Factors affecting Take-off and Landing distances - continued:

Note that some of these factors can be additive in a way to further impact performance, e.g., landing downhill with a tailwind, or taking off uphill with a tailwind.

Pilot Technique:

All the calculations made regarding take-off and landing distances provided by the airplane manufacturer are predicated upon the pilot using proper technique. Usually, factory pilots will test fly the airplane and confirm the distances and performance stated in the manual are accurate. You can be assured that these factory test pilots are using proper technique when flying these airplanes, which are new planes in excellent condition. Therefore, the distances and other data provided in the airplane manuals (either Owner’s Manual or Approved Flight Manual) should be considered “best case”. As a skilled and proficient pilot, you may be able to achieve these same numbers when you are flying, but you probably won’t do better. Unfortunately,



poor technique during either take-off or landing can wreck your most careful calculations and lead to significantly worse performance. Example: Landing too fast and/or downwind or using improper technique when braking will definitely increase landing distance required. The best way to fix poor technique is to fly occasionally with an instructor and to understand all the variables that can affect the airplane's performance. WINGS, the FAA's Pilot Proficiency Program, is an excellent way to stay proficient and to improve your piloting technique.

Conclusions:

Should a prudent pilot in this scenario go ahead and fly into and out of this runway? In my opinion, the answer is: "it depends". It depends upon several factors including, but not limited to 1) the pilot's skill, 2) total experience, 3) recent experience, 4) proficiency with this particular type of airplane, 5) knowledge of the weather and 6) exact runway and airplane condition. A skilled, proficient and high-time pilot with extensive total and recent experience in this airplane should be able to fly into and out of this airport safely in this scenario. A low-time pilot who has just been checked out in a complex and high-performance airplane should most likely not attempt to fly into this airport under these circumstances. The low-time or rusty pilot is the one who should especially pay close attention to the manufacturer's recommendations and add the recommended 50% safety factor to his/her take-off and landing calculations. Also, remember that the figures manufacturers use in their aircraft manuals are usually measured under "ideal" (and as documented) conditions including a new airplane being flown by a factory test pilot using proper technique, i.e., a very skillful pilot. There is risk involved in "eating into" the recommended 50% safety margin. This risk can be either mitigated or aggravated by the pilot's skill, experience and proficiency as well as the airplane condition.

References:

On Landings Parts I, II, III FAA-P-8740-48, 49 and 50 respectively. Very informative and entertaining as well!

The Advanced Pilot's Flight Manual, 9th Edition by William K. Kershner

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