Procedure to Determine Minimum Turnback Altitude

*** Experimental ***

This procedure is used to make a chart which will tell a pilot the minimum altitude they should consider a turnback in the event of a loss of power on takeoff. The chart applies to a specific plane, at a certain weight. It considers the density altitude and headwinds at the time of flight and shows the minimum altitude before a turnback should be attempted. Another accompanying chart shows the minimum altitude to expect at the end of the runway. This altitude is used to ensure the plane is developing proper power and is climbing at the appropriate angle to make the turnback possible.

To develop the charts, the procedure outlines a series of steps used to measure the basic flight characteristics of your plane. These measurements will be entered into a form on a website and the charts will be sent back to you. The measurements can be performed during a single test flight. Read the entire procedure below and plan your flight. Alternatively, many of the measurements can be looked up in the POH (see Procedure Options below).

NOTE: This procedure is in its development phase and the results should NOT be used for aeronautical decision making during a flight. The provided charts are free of charge and the data collected will be used to further develop and verify the flight models. We thank you for your participation. If you have any questions, feel free to contact us using the contact information on the last page.

PROCEDURE OPTIONS

To calculate the minimum altitude for a safe turnback, basic aircraft performance information is needed. Specifically, you will need to provide:

- Takeoff roll distance
- Climbing rate and speed
- Gliding descent rate and speed,
- Altitude lost in a 180-degree turn

You can choose to supply these from one of three methods:

1. **Single Test Flight:** Follow the test procedures below (page 2). These procedures are based on those outlined in the "EAA Flight Test Manual – A Task-Based Approach to Phase I"[1] and will be the most accurate. However, they are a little more involved and require some calculations.
2. **Use Panel Instruments During Test Flight:** Calculate the climb and glide numbers by putting the plane in a climb (or glide) and recording the speed (KIAS) from the Airspeed Indicator and climb rate (ft/min) from the Vertical Speed Indicator. This method will only be as accurate as the instruments are calibrated, however may be much easier than the longer procedure in option 1.
3. **POH:** Look up most of the information in the POH. The results will only be as accurate as how closely your plane's performance matches the POH numbers. To use this method, see Appendix - Procedure to Use POH Data to Determine Turnback Altitudes.

To determine which option is best for you, first look at the final information that is required as input to the turnback model (see page 7).

PLANE CONFIGURATION

Procedure

- Note: Since the pilot needs to focus on flying the plane, a partner should be responsible for recording the measurements during flight.
- **Plane's Weight:** Before takeoff, fuel the plane with a typical amount of fuel, or full if you wish to study the "worse-case" climb performance. Because aircraft weight affects climb performance, load the plane with the typical baggage and fuel you normally use, or wish to study. The turnback results will only be applicable to the weight of the plane in the study.

  Record:

Line	Description	Your Information
1	Plane Make and Model (referenced by POH)	
2	Weight of Pilot, Passengers, Gas, and Baggage	
3	Empty Weight of Plane (see POH)	
4	Total Weight *(add lines 2 and 3)*	
5	Max Gross Weight of Plane (see POH)	
6	Percent Max Gross Weight (see POH) *(100 x line 4 / line 5)*	

TAKEOFF CONDITIONS

Procedure

Field Conditions

- Before taking off, record the Density Altitude. If you have ForeFlight, this is easily done by doing a screen capture of the METAR (Airports / Weather /METAR).

Line	Description	Your Information
7	Density Altitude on the test day on the field	
8	Field Elevation (MSL)	

Winds Aloft

- Record the Winds Aloft closest to the area you will be practicing the maneuvers. If you have ForeFlight, this is easily done by doing a screen capture of the Winds Aloft (Airports / Weather /Winds aloft).

Line	Description	Your Information
9	Winds Aloft at 3000 ft (Direction and Knots)	
10	Winds Aloft at 6000 ft (Direction and Knots)	

TAKEOFF PERFORMANCE

Procedure

- Perform a normal takeoff. When the plane lifts off, note the location on the runway. Either using the POH, or a map of the airport, or Google Earth (with the Ruler tool), estimate the ground roll before takeoff.

Line	Description	Your Information
11	Estimated Ground Roll (ft)	

CLIMB PERFORMANCE

Procedure

- After a normal takeoff, go to a practice area and climb to at least 1,000 feet AGL.
- Face the plane relative to fields below to make it easy to maintain the same heading during the climb.
- Lean the engine as you would a normal climb.
- Apply full power and start the climb. Establish the speed that you would set during a normal takeoff (between Vx and Vy). **Record the speed.**
- Once the speed has stabilized, start the stopwatch and **record the altitude every 30 seconds** for 3 minutes. Or at least 3,000 feet altitude gain. You should hold the same speed within 3 knots or mph during the climb.
- After the first trial, descend to your base altitude and repeat the test.
- After the flight, calculate the climb rate (feet/sec) for each 30 seconds interval and look for consistency. If the values are reasonably consistent, calculate the overall average across the two reciprocal flights.
- Calculate the overall feet/min average climb rate by multiplying the feet/sec by 60. **Report this number**.

Line	Description	Your Information
12	Speed during climb (KIAS)	
13	Approximate Average Altitude (MSL) during tests	

Line	Trial	Elapsed Time (mm:ss)	Altitude	Calculated Climb Rate (ft/sec): Difference between adjacent rows / 30
14	1	0:00		
15		0:30		
16		1:00		
17		1:30		
18		2:00		
19		2:30		
20		3:00		
21	2	0:00		
22		0:30		
23		1:00		
24		1:30		
25		2:00		
26		2:30		
27		3:00		
28			Average (ft/sec)	
29			Average (ft/min): Above value x 60	

CLIMB RATE LOST PER 1000 FT DENSITY ALTITUDE

See procedure for calculating this from your POH (page 10).

GLIDE PERFORMANCE

Procedure

- After a normal takeoff, go to a practice area and climb to at least 4,000 feet AGL.
- Face the plane relative to fields below to make it easy to maintain the same heading during the glide.
- Apply carburetor heat as applicable, pull the power to idle, and trim the plane for the best-glide airspeed (POH).
- Once the speed has stabilized, start the stopwatch and **record the altitude every 30 seconds** until you reach an altitude of 2,000 feet AGL.
- After the first trial, ascend back up to your base altitude and repeat the test.
- After the flight, calculate the descent rate (feet/sec) for each 30 seconds interval and look for consistency. If the values are reasonably consistent, calculate the overall average across the two reciprocal flights.
- Calculate the overall feet/min average descent rate by multiplying the feet/sec by 60. **Report this number**.

Line	Description	Your Information
30	Speed during glide (KIAS)	
31	Approximate Average Altitude (MSL) during tests	

Line	Trial	Elapsed Time (mm:ss)	Altitude	Calculated Climb Rate (ft/sec): Difference between adjacent rows / 30
32	1	0:00		
33		0:30		
34		1:00		
35		1:30		
36		2:00		
37		2:30		
38		3:00		
39	2	0:00		
40		0:30		
41		1:00		
42		1:30		
43		2:00		
44		2:30		
45		3:00		
46			Average (ft/sec)	
47			Average (ft/min): Above value x 60	

ALTITUDE LOST DURING TURNBACK

Procedure

- After a normal takeoff, go to a practice area and climb to a safe altitude.
- Face the plane relative to fields below so that you will be able to easily tell when the plane has turned 180 degrees.
- Climb as you would during takeoff (full power, no flaps, velocity between Vx and Vy).
- Climb to a safe pre-established altitude. Look for other planes in the area. Pull the throttle to idle. **Record the altitude**.
- Hold the same climb pitch for five seconds, being careful not to stall.
- Roll into a 45-degree bank turn. Be aware that stall speeds increase in steep turns.
- Pitch for best glide speed.
- Turn 180 degrees. *Note: In a real turnback, you will turn more than 180 degrees. The turnback-model will use the 180 degree turn to calculate whatever is needed to perform the turnback towards the runway.*
- Roll wings level. **Record the altitude**.
- Repeat several trials and calculate the average altitude lost during the power out and 180-degree turn.

Line	Trial	Altitude at Power Out (MSL)	Altitude after 180-degree Turn (MSL)	Altitude Lost in Tune (Difference)
48	1			
49	2			
50	3			
51	4			
52			Average (ft/sec)	

SUBMIT INFORMATION

Go to www.Bertha2/Aviation and enter the following information into the form:

Description	Line from Test Procedure	Line from POH Procedure	Your Information
BASIC INFO			
Make / Model of Aircraft	1		
Percent of Max Gross Weight during Test	6		
Field Elevation (MSL)	8		
TAKEOFF			
Ground Roll (ft)	11	1	
CLIMB			
Climb Speed (KIAS)	12	2	
Climb Rate (ft/min)	29	3	
Average Altitude Climb Rate was Measured at (MSL)	13	4	
Density Altitude on the Test Day (ft)	7*	5	
Climb Rate Loss Per 1000 ft Altitude (See POH)	--	6	
TURNBACK			
Altitude Lost in 180 Degree Turn (ft)	52	--	
GLIDE			
Best Glide Speed (KIAS)	30	7	
Descent Rate During Glide (ft/min)	47	9	
OR: Glide Ratio (from POH)		8	
Average Altitude Glide Rate was Measured at (MSL)	31	10	
Density Altitude on the Test Day (ft)	7*	11	
CHART			
Runway Length #1 for Report (ft) You can enter any number here that you wish to study the minimum turnback altitudes for.			
Runway Length #2 for Report (ft)			
Runway Length #3 for Report (ft)			
Name (First and Last)			
Email Address			
Comment			

** If Glide test was performed on a different day, record the density altitude for both tests.*

Within a few days, you will receive a chart showing the minimum altitudes before a turnback to the runway should be attempted along with the altitude you should be at when you cross the end of the runway on takeoff. Thank you for being part of the development of this safety tool.

APPENDIX

Procedure to Use POH Data to Determine Turnback Altitudes

If you wish to get your plane's flight characteristics from the POH instead of from a test flight, you may use the steps below.

All information should be available in your POH, except, "Altitude lost in 180-degree turn". This value is based on your plane's flight characteristics and your skill level. To measure this value, follow the steps listed in the "ALTITUDE LOST DURING TURNBACK" section on page 6.

To use your POH values, make sure your typical flying weight is at or lighter than the weights listed in the tables you are using in the POH. Also, select a field you fly from and use the altitude of that field in your calculations.

The steps listed below use tables from a **Cessna 172S POH[2] as an example** of what you might see in your POH. If the data is presented differently, many times you can still convert the numbers to what is needed. If you need any help, don't' hesitate to use the contact number in the last page.

TAKEOFF PERFORMANCE

From the Short Field Takeoff Distance Table (figure 1), you can look up the typical ground roll at your field's altitude. Since we measure this distance on a "standard day" you will determine the roll at 15° C.

Assuming, for this example, our field is at 1000 MSL:

Line	Description	Example	Your Information
1	**Ground Roll (ft)**	*roll at 15° C = Average Roll between 10° C and 20° C* = 908 ft.	

If you typically do not take off using Short Field configurations, adjust the value to something you are comfortable with that represents your typical ground roll on a standard day with light winds.

SHORT FIELD TAKEOFF DISTANCE AT 2400 POUNDS

CONDITIONS:

Flaps 10°
Full Throttle Prior to Brake Release
Paved, level, dry runway
Zero Wind
Lift Off: 48 KIAS
Speed at 50 Ft: 54 KIAS

Press Alt In Feet	0°C		10°C		20°C		30°C		40°C	
	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst
S. L.	745	1275	800	1370	860	1470	925	1570	995	1685
1000	810	1390	875	1495	940	1605	1010	1720	1085	1845
2000	885	1520	955	1635	1030	1760	1110	1890	1190	2030
3000	970	1665	1050	1795	1130	1930	1215	2080	1305	2230
4000	1065	1830	1150	1975	1240	2130	1335	2295	1430	2455
5000	1170	2015	1265	2180	1360	2355	1465	2530	1570	2715
6000	1285	2230	1390	2410	1500	2610	1610	2805	1725	3015
7000	1415	2470	1530	2685	1650	2900	1770	3125	1900	3370
8000	1560	2755	1690	3000	1815	3240	1950	3500	2095	3790

Figure 1. Takeoff Distance

CLIMB PERFORMANCE

From the Climb Table in the POH (See figure 2), select the altitude of your field (nearest 1000 feet) and read the Climb Speed (KIAS) and Rate of Climb (FPM). In this example, we select a field altitude of 1000 ft:

Line	Description	Example	Your Information
2	Climb IAS (knots)	*73*	
3	Climb Rate (FPM)	*695*	
4	Average Altitude Climb Rate Measured at (MSL)	*1,000* *Note: Enter the field's altitude as though you measured it at this altitude.*	
5	Density Altitude on the test day	*1000 (again, enter the field's altitude).*	
6	Climb Rate Loss Per 1000 ft Altitude	*Note: To calculate the climb rate loss per 1000 feet, take the difference between the climb rate at field altitude and the climb rate 2000 feet higher and divide by 2.* *Climb Rate Loss Per 1000 ft Altitude = (695 – 620)/2 = 37.5*	

TIME, FUEL AND DISTANCE TO CLIMB AT 2550 POUNDS

CONDITIONS:

Flaps Up
Full Throttle
Standard Temperature

PRESS ALT FT	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
			TIME IN MIN	FUEL USED GAL	DIST NM
S.L.	74	730	0	0.0	0
1000	73	695	1	0.4	2
2000	73	655	3	0.8	4
3000	73	620	4	1.2	6
4000	73	600	6	1.5	8
5000	73	550	8	1.9	10
6000	73	505	10	2.2	13
7000	73	455	12	2.6	16
8000	72	410	14	3.0	19
9000	72	360	17	3.4	22
10,000	72	315	20	3.9	27
11,000	72	265	24	4.4	32
12,000	72	220	28	5.0	38

Figure 2. Climb Data

Turnback Data

Unfortunately, there is no way to determine the typical altitude lost during a turnback maneuver from the POH. Instead, use the procedure in, "ALTITUDE LOST DURING TURNBACK", page 6.

GLIDE PERFORMANCE

From the Maximum Glide diagram in the POH (figure 3), we can determine:

Line	Description	Example	Your Information
7	Best Glide Speed (KIAS)	*68 KIAS (shown in chart)*	
8	Glide Ratio	Glide Ratio = 18 nautical miles per 12,000 ft. Glide Ratio = $\frac{18\ naut.\ mi. \times \mathbf{6{,}076.1155\ ft.\ per\ naut.mi.}}{12{,}000\ ft.}$ **Glide Ratio** = 9.114: 1 Note: You can enter in the Glide Ratio as 9.114 or you can calculate the Descent Rate below:	
9	Descent Rate (ft/min)	*Descent Rate* = $101.269 * \sqrt{\frac{BestGlideSpeed^2}{1+GlideRatio^2}}$ *Descent Rate* = $101.269 * \sqrt{\frac{68^2}{1+9.114^2}}$ *Descent Rate = 751 ft/min*	
10	Average Alt. Glide Rate Measured at (MSL)	*enter your field's altitude* = 1000 ft.	
11	Density Altitude on the test day	*enter your field's altitude* = 1000 ft.	

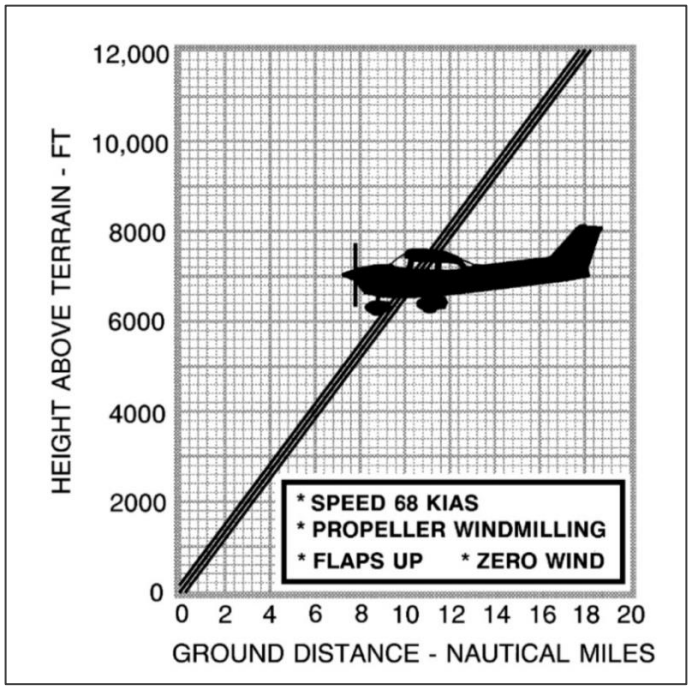

Figure 3. Maximum Glide

SUBMIT INFORMATION

Submit the information according to the instructions on page 7.

Questions?

Contact:

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References:

1. EAA Flight Test Manual - A Task-Based Approach to Phase I, Experimental Aircraft Association, Inc., October 2018.
2. Information Manual Skyhawk SP, Cessna Aircraft Co., 1998.