



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

May 8, 2019

Aircraft Performance Study

Aircraft Performance

CEN18FA063

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A. ACCIDENT

Location: Corozalito, Costa Rica
Date: December 31, 2017
Time: 1156 central standard time (1756 UTC)¹
Airplane: Cessna 208B-0900; TI-BEI

B. GROUP

No aircraft performance group was formed

C. SUMMARY

On December 31, 2017, about 1756 hours universal coordinated time, a Cessna 208B airplane bearing Costa Rican registration TI-BEI, was destroyed when it impacted terrain while maneuvering after takeoff from runway 3, at the Islita Airport (MRIA), near Corozalito, Costa Rica. The 2 flight crewmembers and 10 passengers were fatally injured. The airplane was destroyed by impact forces and post impact explosion and fire. The aircraft was registered to and operated by Nature Air, San Jose, Costa Rica, as a commercial charter flight operating under Costa Rican flight regulations. Visual meteorological conditions prevailed for the flight. The flight was originating at the time of the accident and the intended destination was the Juan Santamaria International Airport (MROC), San Jose, Costa Rica.

The accident airplane was the second of a flight of two airplanes transporting hotel guests from MRJA to MROC, where most of the passengers had international airline flights out of Costa Rica. Both airplanes were Cessna 208 airplanes. The first airplane departed MRJA using runway 3 and after liftoff made a right turn through a pass in the hills that led southeast to the Pacific Ocean. The first airplane reached MROC successfully. The accident airplane remained on the ground for about 15 minutes longer. According to the hotel worker that was at the airport during the departure, when the accident airplane took off, it did not make the same right turn as the prior airplane but continued on runway heading. The terrain in the direction of the runway orientation consisted of a valley with rising terrain on either side. The valley continues and turns left with the floor of the valley rising until reaching a mountain. When heading in a northerly direction there was no exit from the valley. The airplane impacted terrain on the northwest side of the valley about 0.5 miles from the departure end of runway 3 at MRJA.

The purpose of the Aircraft Performance Study is to determine the after-takeoff climb performance of the airplane and to compare the performance to local terrain features to determine if the airplane had enough performance to clear terrain obstacles after takeoff.

D. DETAILS OF THE INVESTIGATION

1.0 Performance Parameters

Several parameters needed to perform the performance calculations were required. Some of these parameters were obtained from the airplane records, while others had to be estimated based on witness accounts and other flight parameters. The parameters used for the calculations were as follows:

- Aircraft empty weight obtained from maintenance records.
- 12 occupants total occupying the forward 12 seats.
- Standard 170 lb. occupant weight used.
- 4 suit cases at 50 lbs. each based on a witness account.
- Baggage loaded into the forward 2 cargo pod locations
- A calm wind condition was used due to the unpredictability of wind conditions in mountainous terrain.

2.0 Weight and Balance Calculations

The takeoff fuel load of the airplane could not be determined, calculations were based on:

1. The minimum fuel required for the accident flight.
2. The maximum fuel allowable to remain within the manufacturer's weight and balance parameters.
3. The previously discussed passenger and baggage load.

The empty weight and balance was obtained from maintenance records dated 10-16-2017, shown in Figure 1. The records indicated an empty weight of 5,422.5 lbs., at 194.06 inches aft of datum, yielding an empty moment of 1,052,355.536 in lbs. The airplane was equipped with a 14-seat arrangement consisting of 12 seats in addition to the flight crew seats. The moment arms for the 12 passenger seats from the maintenance record did not exactly match the moment arms listed in the international seating supplement from the manufacturer and the moment arms from the maintenance records were used.

			
Weight & Balance			
N181GC Cessna 208B0900 October 16, 2017			
Removed	Weight	Arm	Moment
Seat, 1ea. Row 2	-29.4	175.3	-5153.82
Seat, 1ea. Row 3	-29.4	211.3	-6212.22
Seat, 1ea. Row 4	-29.4	247.3	-7270.62
Seat, 1ea. Row 5	-29.4	283.3	-8329.02
Totals	-117.6		-26,965.68
Installed	Weight	Arm	Moment
Bench Seat Row 2	52.6	178.04	9364.904
Bench Seat Row 3	52.6	214.04	11258.504
Bench Seat Row 4	52.6	250.04	13152.104
Bench Seat Row 5	52.6	286.04	15045.704
Totals	210.4		48,821.216
Previous BEW weight	5329.7	Amended BEWCG	1,030,500
Remove seats	-117.6		-26965.68
Install seats	210.4		48821.216
Totals	5422.5	194.06	1,052,355.536

Figure 1-Weight and Balance from maintenance records

Since the takeoff fuel load could not be determined, two sets of calculations were performed. First were calculations assuming the airplane had the minimum required fuel to complete the flight (500 lbs). This yielded a loaded weight of 8,163 pounds and the airplane would have been within the weight and balance envelope. Second was a calculation assuming that the airplane had the maximum fuel load that remained within the manufacturer established weight and balance envelope. This yielded a fuel load of 931 lbs, a loaded weight of 8,594 pounds, and the airplane would have been within the weight

and balance envelope but at the aft end of the envelope. The maximum ramp weight of the airplane was specified as 8,785 pounds and the maximum takeoff weight was specified as 8,750 pounds.

SECTION 5
PERFORMANCE

CESSNA
MODEL 208B (675 SHP)

**CARGO POD INSTALLED
FUEL AND TIME REQUIRED**

MAXIMUM CRUISE POWER (40-200 Nautical Miles)

CONDITIONS:

8750 Pounds
1900 RPM

Standard Temperature
Inertial Separator-Normal

1. Fuel required includes the fuel used for engine start, taxi, takeoff, maximum climb from sea level, descent to sea level and 45 minutes reserve. Time required includes the time during a maximum climb and descent.
2. With inertial separator in BYPASS, increase time by 4% and fuel by 2% or with cabin heat ON, increase time by 3% and fuel by 2%.

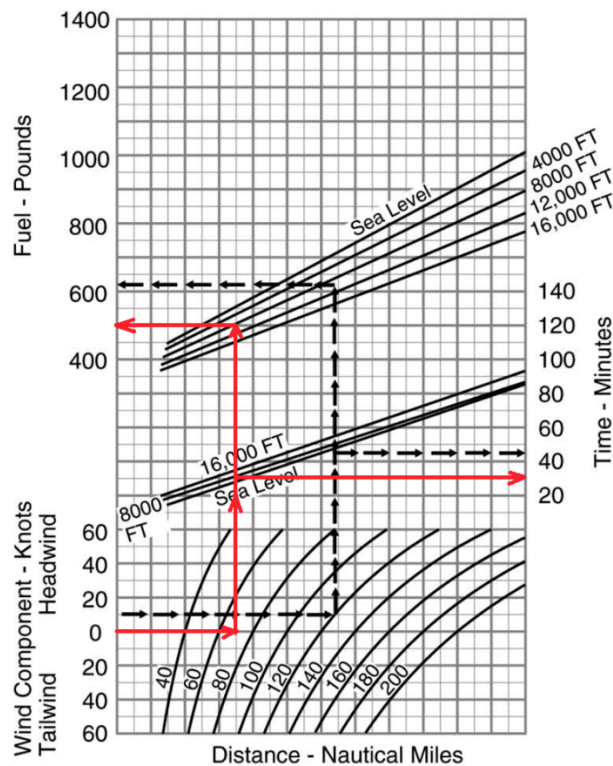


Figure 5-18. Fuel and Time Required - Maximum Cruise Power
40-200 Nautical Miles (Sheet 1 of 2)

5-52

U.S.

Revision 23

Figure 2-Minimum fuel load chart

2001 208B; 208B0900; TI-BEI					
Punta Islita, Costa Rica; 12-31-17					
Accident aircraft weight and balance data					
			Weight	Arm	Mom/1000
Empty Weight			5422.5	194.0683	1052335
Fuel - Main	gal.	74.7	500.49	269.2	134732
Seat 1			170	135.5	23035
Seat 2			170	135.5	23035
Seat 3			170	178.04	30267
Seat 4			170	178.04	30267
Seat 5			170	178.04	30267
Seat 6			170	214.04	36387
Seat 7			170	214.04	36387
Seat 8			170	214.04	36387
Seat 9			170	250.04	42507
Seat 10			170	250.04	42507
Seat 11			170	250.04	42507
Seat 12			170	286.04	48627
Pod Zone A			100	127.38	12738
Pod Zone B			100	182.05	18205
Pod Zone C			0	233.35	0
Pod Zone D			0	294.68	0
Total			8162.99	200.93	1640188
				C/G	

Aircraft data for charts			
Weight	C/G	Mom/1000	
8163.0	200.93	1640	a Loaded a/c
7662.5	196.5	1505.5	b empty fuel

Note: You need to manually move the "a" and "b" on each chart

Weight and balance envelope from TCDS for charts		
Normal category		
Weight	Arm	Mom/1000
4000	179.6	718.4
5500	179.6	987.8
8000	193.37	1546.96
8750	199.15	1742.5625
8750	204.35	1788.0625
4000	204.35	817.4

Figure 3-Minimum fuel weight and balance calculation

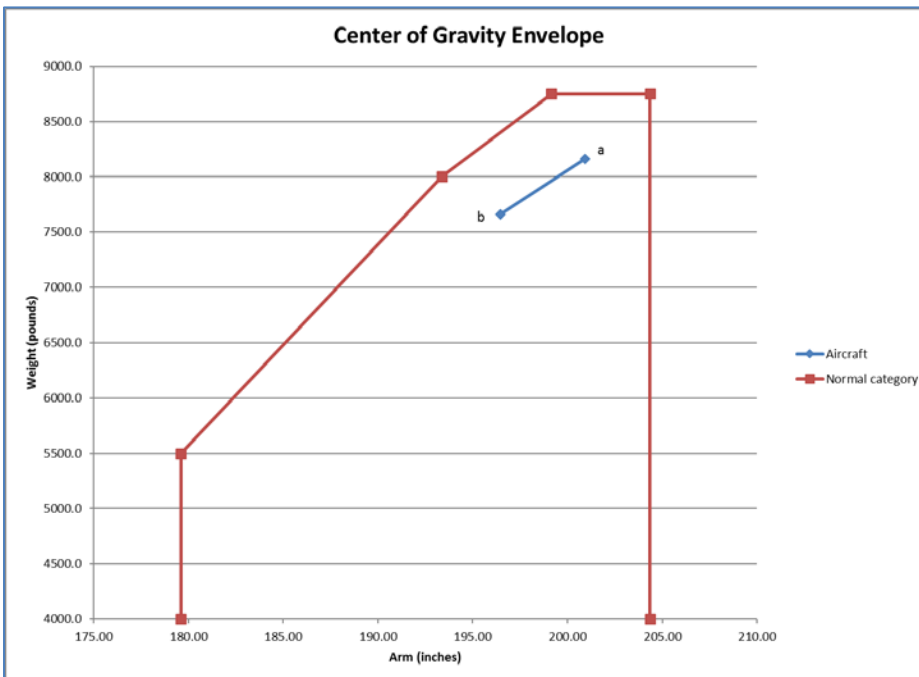


Figure 4-Minimum fuel center of gravity envelope

2001 208B; 208B0900; TI-BEI					
Punta Islita, Costa Rica; 12-31-17					
Accident aircraft weight and balance data					
			Weight	Arm	Mom/1000
Empty Weight			5422.5	194.0683	1052335
Fuel - Main	gal.	139	931.3	269.2	250706
Seat 1			170	135.5	23035
Seat 2			170	135.5	23035
Seat 3			170	178.04	30267
Seat 4			170	178.04	30267
Seat 5			170	178.04	30267
Seat 6			170	214.04	36387
Seat 7			170	214.04	36387
Seat 8			170	214.04	36387
Seat 9			170	250.04	42507
Seat 10			170	250.04	42507
Seat 11			170	250.04	42507
Seat 12			170	286.04	48627
Pod Zone A			100	127.38	12738
Pod Zone B			100	182.05	18205
Pod Zone C			0	233.35	0
Pod Zone D			0	294.68	0
Total			8593.8	204.35	1756162
				C/G	

Aircraft data for charts			
Weight	C/G	Mom/1000	
8593.8	204.35	1756	a Loaded a/c
7662.5	196.5	1505.5	b empty fuel

Note: You need to manually move the "a" and "b" on each chart

Weight and balance envelope from TCDS for charts		
Normal category		
Weight	Arm	Mom/1000
4000	179.6	718.4
5500	179.6	987.8
8000	193.37	1546.96
8750	199.15	1742.5625
8750	204.35	1788.0625
4000	204.35	817.4

Figure 5-Maximum fuel center of gravity calculation

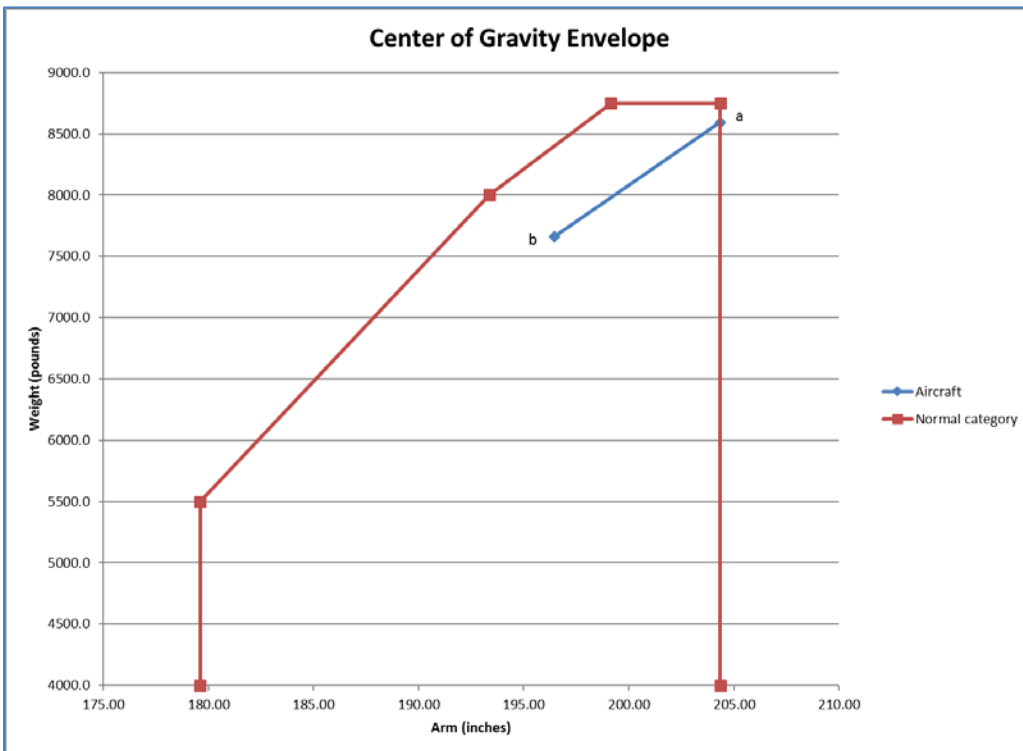


Figure 6-Maximum fuel center of gravity envelope

3.0 Takeoff Performance

Since a takeoff in the opposite direction of the accident takeoff would have eliminated the concerns for obstacles in the takeoff direction, the takeoff performance was calculated to determine if a downwind takeoff would have been feasible. Since there was no wind monitoring equipment at the accident airport, the wind used for the calculation was based on a witness who estimated the wind to be from the north at 10-15 knots. According to the POH for the airplane, downwind takeoffs were limited to 10 knots of tailwind, therefore if the wind were greater than 10 knots, a downwind takeoff was not feasible. Using POH data, the ground roll required at gross weight, 30° C air temperature, and a 10 knot tailwind (50% increase of takeoff distance), the airplane would have needed a ground roll of 2,235 feet to become airborne. The runway at MRJA was about 3,000 ft long, indicating that the airplane would have had sufficient runway length to become airborne with a 10 knot tailwind.

4.0 Climb Performance

Climb performance was determined using charts from the POH for an airplane with the cargo pod installed. Two possible airplane weights were used as previously calculated, and two possible flap position settings were used, 0° flaps, and 20° flaps. The values from the charts were interpolated to account for values different from the chart values and to convert from ft/nm to ft/mile. The resultant climb gradient ranged from 570 ft/nm (495 ft/mile) to 671 ft/nm (583 ft/mile).

Climb gradient interpolation (Interpolated values in yellow)									
Flaps set to 20 degrees. Values represent FT/NM					Flaps set to 20 degrees. Values represent FT/SM				
Weight	0 deg C	20 deg C	40 deg C	30 deg C	Weight	0 deg C	20 deg C	40 deg C	30 deg C
8300	705	665	630	647.5	8750	612.6281	577.869	547.4549	562.662
8163	729.66	689.66	653.29	671.475	8163	634.057	599.298	567.6933	583.4957
7800	795	755	715	735	8300	690.8359	656.0769	621.3178	638.6974
Flaps set to 0 degrees. Values represent FT/NM					Flaps set to 0 degrees. Values represent FT/SM				
Weight	0 deg C	20 deg C	40 deg C	30 deg C	Weight	0 deg C	20 deg C	40 deg C	30 deg C
8750	630	595	560	577.5	8750	547.4549	517.0407	486.6266	501.8336
8594	656	619.2667	584.2667	601.7667	8594	570.0483	538.1279	507.7137	522.9208
8300	705	665	630	647.5	8300	612.6281	577.869	547.4549	562.662
Flaps set to 0 degrees. Values represent FT/NM					Flaps set to 0 degrees. Values represent FT/SM				
Weight	0 deg C	20 deg C	40 deg C	30 deg C	Weight	0 deg C	20 deg C	40 deg C	30 deg C
8300	725	690	535	612.5	8750	630.0076	599.5934	464.9022	532.2478
8163	749.66	713.29	556.92	635.105	8163	651.4365	619.8319	483.9501	551.891
7800	815	775	615	695	8300	708.2154	673.4564	534.4202	603.9383
Flaps set to 0 degrees. Values represent FT/NM					Flaps set to 0 degrees. Values represent FT/SM				
Weight	0 deg C	20 deg C	40 deg C	30 deg C	Weight	0 deg C	20 deg C	40 deg C	30 deg C
8750	655	620	475	547.5	8750	569.1793	538.7651	412.7636	475.7644
8594	679.2667	644.2667	495.8	570.0333	8594	590.2664	559.8523	430.8383	495.3453
8300	725	690	535	612.5	8300	630.0076	599.5934	464.9022	532.2478

Figure 7-Interpolated climb performance

5.0 Terrain Profiles

Elevation profiles were created using Google Earth for the successful path used by the previous airplane and two other possible paths to the north of MRJA. The minimum and maximum airplane climb gradients calculated previously were plotted on the elevation profiles and are shown below. The critical elevation point for the successful path taken by the previous airplane was about 265 ft. above

the airport elevation and 0.75 statute miles from the airport requiring a minimum climb gradient of 353 ft/mile.

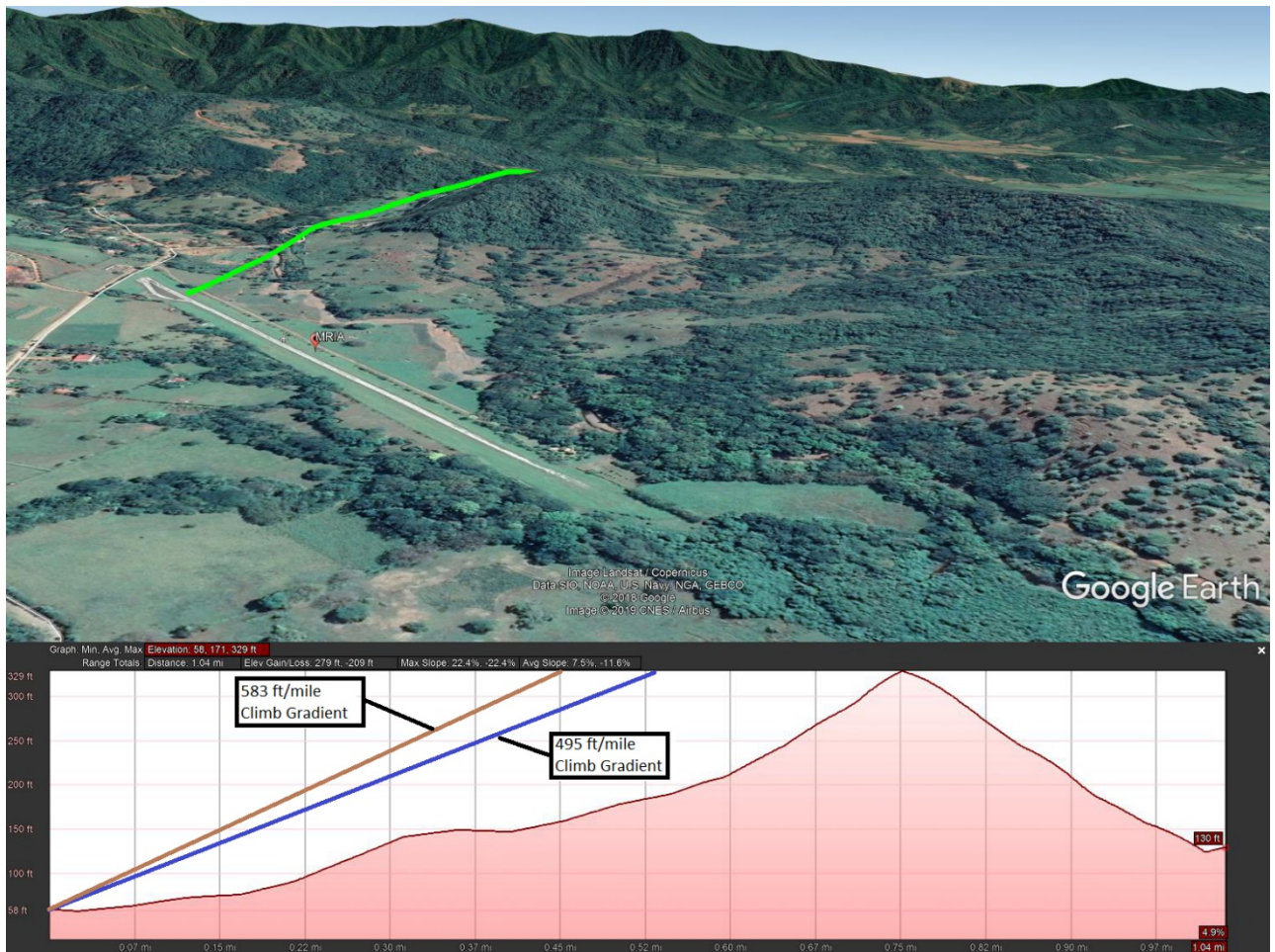


Figure 8-Successful flight path of previous airplane

The second path examined was a straight-out departure maintaining runway heading. For this path, the critical elevation was about 1,454 ft above airport elevation at 2.52 statute miles from the airport requiring a minimum climb gradient of 577 ft/mile.

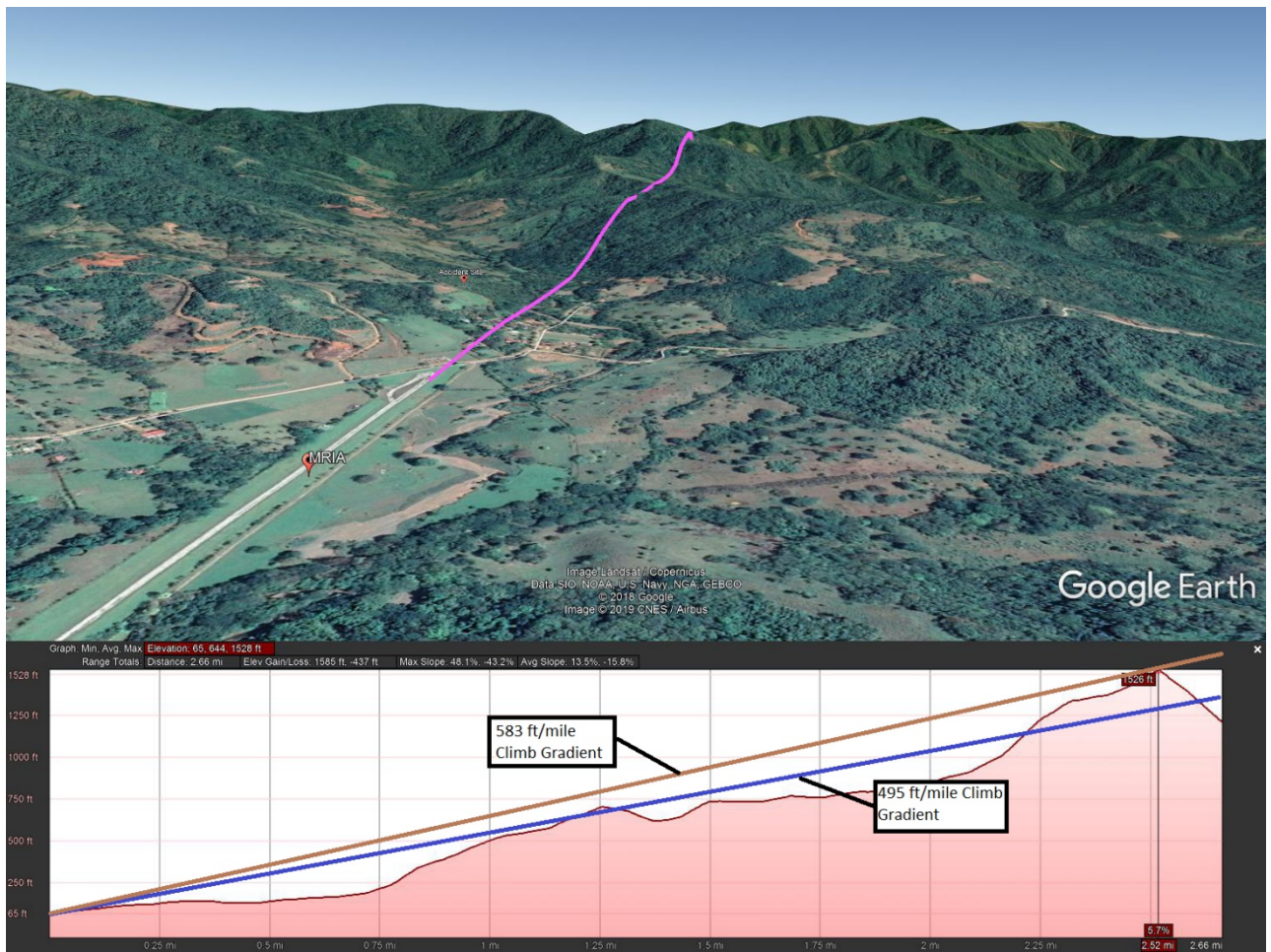


Figure 9-Straight-out departure maintaining runway heading

The final path examined was a path that turned to the left and approximately followed the valley floor. The critical elevation for this path was about 1,510 ft above the airport elevation at 2.82 statute miles from the airport requiring a minimum climb gradient of 535 ft/mile.

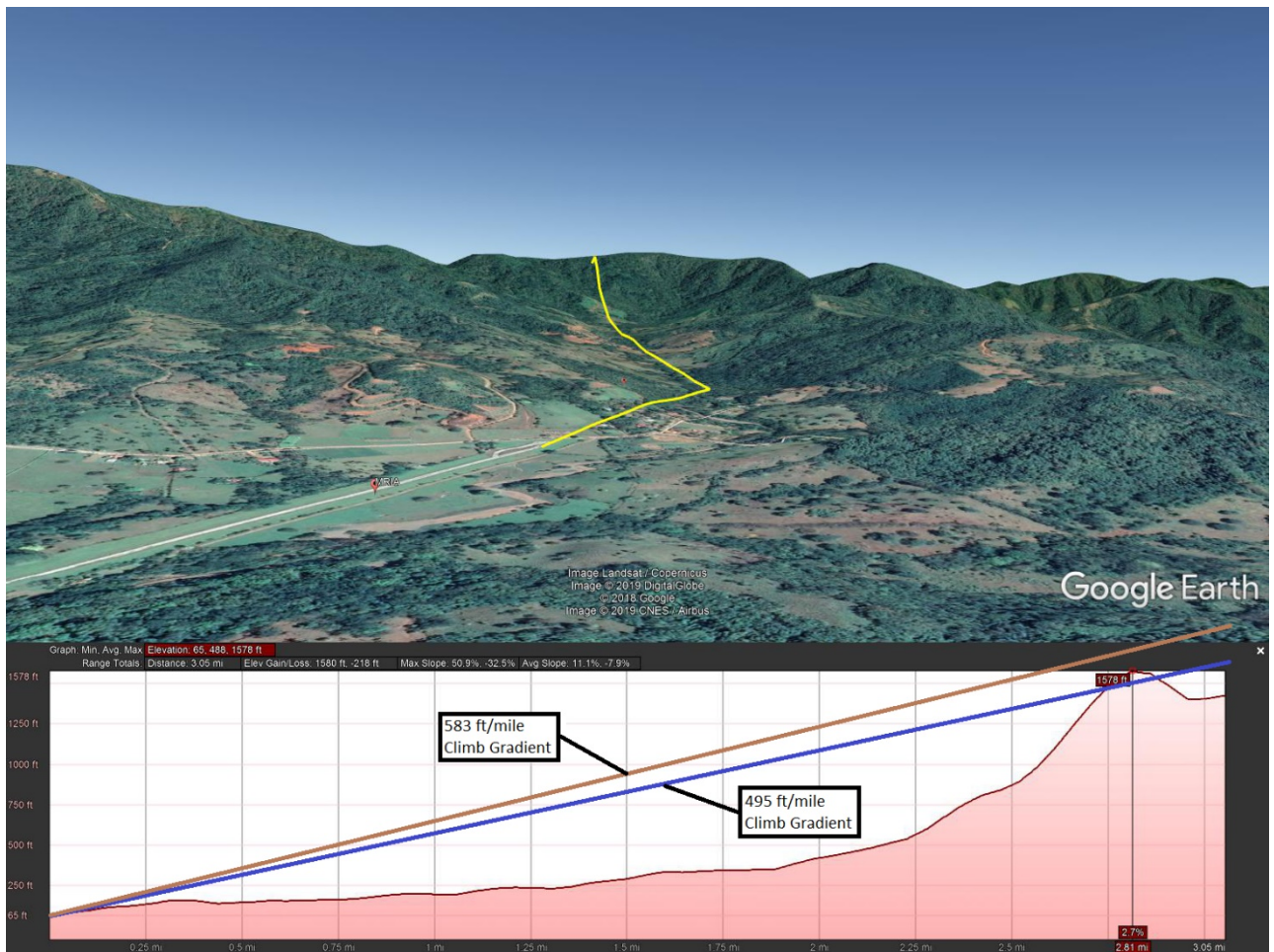


Figure 10-Path following valley floor

Minimum Climb Gradient Required					
Path used	Peak elevation ft. above airport	Distance to peak miles from airport	Required gradient to clear peak ft/mi	Margin with 495 ft/mile gradient	Margin with 583 ft/mile gradient
Successful path	265	0.75	353	40.09%	65.00%
Curved path	1510	2.82	535	-7.56%	8.88%
Straight path	1454	2.52	577	-14.21%	1.04%

Figure 11-Summary of Required Climb Gradients

In all cases the calculated climb gradient to clear the peaks was achievable if the airplane was at minimum weight and the flight crew used a 20° flap setting. The calculated climb gradient margin at minimum weight, 20° flaps, and using the straight path was less than 1%, and the margin for the path that followed the valley was about 9%, and for the path taken by the previous airplane the margin was

65%. In the case of the path used by the previous airplane, the airplane would have had a climb gradient margin of 40% even at a weight of 8,594 lbs. using 0° flap setting; however at those conditions the airplane would not have had sufficient climb performance using either the straight path or the path that followed the mountain valley.

It should be noted that the climb gradient calculations assumed no wind and did not account for the unpredictable wind conditions that would occur in mountainous terrain and could have affected the achieved climb gradient in either a positive or negative way. The calculations are also predicated on the flight crew performing the takeoff and climb as published in the POH to achieve maximum angle of climb.

6.0 Conclusions

- The airplane would have been able to make a takeoff in the south (downwind) direction provided the downwind did not exceed 10 knots; however, since there was no weather reporting at the accident airport, and no windsocks installed on the windsock frames, the pilots would have had to estimate the wind conditions based on experience. The nearest reporting station was 25 nm east and recorded wind from the east at 4 knots gusting to 12 knots, indicating that a downwind takeoff was feasible; however, according to a witness to the accident the wind velocity likely exceeded 10 knots.
- Another similarly configured Cessna 208B successfully completed a takeoff in the same direction by making a right turn immediately after takeoff to follow a terrain path that led to lower terrain, allowing the airplane to climb before crossing the mountain range. This path yielded a minimum climb gradient margin of 40%.
- The climb gradient calculations indicated that at minimum weight the airplane may have had sufficient performance to clear terrain but with little margin and without taking into account the unpredictable winds that can be encountered in mountainous terrain.

Submitted by:

John Brannen
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