National Transportation Safety Board
Office of Research and Engineering
Washington, D.C. 20594

Airplane Performance Study

Specialist Report

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A. ACCIDENT

Location: Mokuleia, Hawaii
Date: June 21, 2019
Time: 0422 GMT (1822 HST)
Airplane: Beechcraft 65-A90, King Air, N256TA
NTSB Number: WPR19MA177

B. GROUP

No vehicle performance group was formed.

C. SUMMARY

On June 21, 2019, at 1822 Hawaii-Aleutian standard time (HST), a Beechcraft 65-A90, N256TA, collided with terrain after takeoff from Dillingham Airfield (HDH[1]), Mokuleia, Hawaii. The commercial pilot and ten passengers sustained fatal injuries, and the airplane was destroyed. The airplane was owned by N80896 LLC and was being operated by Oahu Parachute Center (OPC) under the provisions of Title 14 Code of Federal Regulations Part 91 as a local sky-diving flight. Visual meteorological conditions (VMC) prevailed, and no flight plan had been filed.

(Note: Times in the study are quoted in HST. HST = Greenwich Mean Time – 10 hr.)

D. THE AIRPLANE

A picture of the accident airplane, a Beechcraft 65-A90, King Air, is shown in Figure 1. The airplane was manufactured by Beechcraft in1967.

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[1] The International Civil Aviation Organization four-letter airport codes for the American North Pacific region begin with the letter "P". The "P" has been dropped from the airport codes in this study.

E. WEATHER SUMMARY

Dillingham Airfield does not have weather reporting capability. The closest reporting station is 14 miles southeast at Wheeler Airfield (HHI), Wahiawa, HI, at an elevation of 843 ft.

METAR PHHI 220456Z 18004KT 10SM FEW050 BKN070 24/20 A2994

On June 21st, at 1856 HST, the automated weather at HHI was reporting wind 180˚ at 4 knots (kt); 10 statute miles visibility, a few clouds at 5,000 feet (ft) above the ground (agl); broken clouds at 7,000 ft agl, temperature 24˚ Celsius (C); dew point 20˚C; altimeter 29.94" mercury.

F. PERFORMANCE STUDY

Take-off Distance

A runway diagram for Dillingham's runway 8/26 from the Federal Aviation Administration (FAA) Chart Supplement is shown in Figure 2. There were no radar or Automatic Dependent Surveillance – Broadcast (ADS-B) data recovered for the accident. The lack of radar data was likely because the airplane remained below coverage after take-off from runway 8, and the airplane was not equipped with ADS-B equipment. As such, take-off performance data provided by the airplane manufacturer were used to assess the accident flight.

HDH runway 8 has 9,007 ft of runway available for take-off, including a 2,000 ft displaced threshold on both ends. However, it is unknown where N256TA initiated its take-off preceding the accident. Figure 3 highlights three locations where N256TA may have initiated the take-off roll: location A provides the full 9,007 ft available, location B provides 7,007 ft of runway, and location C provides approximately 4,500 ft for take-off. Based on video analysis of the previous flight documented in the video study, it is believed that N256TA initiated the accident take-off from location C. Locations A, B and C are at positions where the taxiway south of the runway connects to the runway. As indicated by the dotted lines in Figure 3, the airplane would have taxied from the OPC location at the east end of the runway, and then turned right onto the runway to take off to the east.

Beechcraft's estimated take-off distance over a 50 ft obstacle at conditions similar to the accident is shown in Figures 4 and 5. The normal take-off distance chart in the A90 Pilot's Operating Handbook (POH) indicates that approximately 1,750 ft are necessary to clear a 50 ft obstacle. This assumes light winds, sea level airport altitude, and a take-off gross weight of approximately 7,900 lb.

In addition to POH data, Beechcraft provided an average airplane acceleration during take-off of 5 kt/sec based on flight test data (both engines operating). It represents a take-off from a complete stop to a climb altitude of approximately 80 feet agl[2]. This results in a take-off

[2] It is unknown how high the airplane climbed before impact. Assuming 5 kt/sec, the airplane would have climbed to approximately 100 ft agl before reaching the displaced threshold for runway 26.

distance of approximately 2,052 ft over a 45 sec time period[3]. The climb to 80 ft is shown in the context of runway 8 in Figure 6. The flight test and POH data produce similar take-off results.

The wreckage was located approximately 3,030 ft upwind of location C and 460 ft to the left of the runway centerline. In addition to the impact location shown in Figures 5 and 6, Figures 7 and 8 show security video stills just before and after impact. The impact location is consistent with the take-off distance calculations from point C.

Aft Center of Gravity

The accident airplane was operating close to the aft center of gravity (CG) limit of 160.4" (aft of the weight and balance datum). The exact location of all passengers and their gear are unknown. However, the likely loading scenarios that were considered all put the accident CG either slightly forward or just aft of the aft CG limit. See Figures 9-11.

An aft CG reduces the static longitudinal stability of the airplane[4]. Static longitudinal stability is a measure of the airplane's tendency to return to its equilibrium or "trim" point once disturbed. For example, static longitudinal stability affects how the airplane responds to an atmospheric disturbance. In addition, an aft CG results in lighter pilot stick forces. In the extreme case, an aft CG can lead to the pilot overcontrolling the airplane and loss of control. The CG of the accident airplane was of particular interest because the video shows the airplane impacting the ground in an unusual pitch attitude consistent with a loss of control.

While an aft CG reduces static longitudinal stability and pilot control forces, flight test data provided by Beechcraft[5] indicate that the 65-A90 has acceptable column forces at conditions similar to the accident. The flight test data were compared to Civil Air Regulations (CAR), Part 3, the certification basis for the airplane.

CAR Part 3 states that "the stable slope of stick force versus speed curve be such that any substantial change in speed is clearly perceptible to the pilot through a resulting change in stick force". The King Air flight test data show a stable 1.3 lb of stick force change for a 6 kt change in speed, even at the aft CG position and at speeds 22 kt below the trim speed[6].

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[3] $V_f^2 = V_0^2 + 2AS$ where V_f is the final speed, V_0 is the initial speed, A is the constant acceleration, and S is the take-off distance. In addition, $V_f = V_0 + At$ where t is time.

[4] The wing contribution to static longitudinal stability is $(dC_m/dC_L)_{wing} = x_{cg}-x_{ac}$, where x_{cg} and x_{ac} are the locations of the airplane center of gravity and the wing aerodynamic center as a percentage of the wing mean aerodynamic chord, respectively. Since the location of the aerodynamic center is relatively constant, static longitudinal stability is largely a function of the airplane CG. Moving the airplane CG further aft is destabilizing.

[5] Beechcraft Report FTR 20, page 147.

[6] Title 14 Code of Federal Regulations Part 25 for the Certification of Transport Category aircraft specifies that the average gradient of stick force versus speed curve may not be less than 1 pound for each 6 knots.

Aileron Trim

The aileron trim[7] was found in the full left-wing-down (LWD) position in the wreckage. Prior photographs confirmed that this was required for take-off in N256TA, possibly due to an earlier accident in which the airplane was substantially damaged[8].

While the nature of the lateral anomaly is unknown, the result was the need for aileron input during take-off to maintain wings level in N256TA. This required the pilot to input a wheel force. However, instead of carrying a wheel force during take-off, the pilot could use LWD aileron trim to balance the wheel force. The effects of this lateral anomaly may have included one or more of the following:

1. The control wheel biased or "cocked" (although not apparent in previous videos).
2. Reduced aileron deflection available for maneuvering. This would also affect the engine-out minimum control speed.
3. Higher drag and fuel burn.
4. Higher stall speeds.

Turn Performance

The conditions associated with a steady, coordinated turn[9] shortly after lift-off until the final impact were considered in the accident. The purpose was to approximate the airplane state during the accident sequence. While the accident airplane was climbing, the calculations provide an approximation.

The forces acting on the airplane in the turn are shown in Figure 13. Summing forces in the vertical direction:

$\Sigma F_z = 0$, or

$L\cos\phi - W = 0$ where,

L is the total lift
W is the weight or product of mass (m) and gravity (g)
ϕ is the bank angle

$$L\cos\phi = mg \qquad [1]$$

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[7] Only the left aileron tab on the Beechcraft 65-A90 is adjustable from the cockpit. The right aileron has an anti-servo tab that is driven by aileron movement. The role of the anti-servo tab is to increase the control wheel force. See Figure 12.

[8] N256TA was substantially damaged on July 23, 2016 in Byron, California, when the right horizontal stabilizer and elevator separated from the airplane during recovery from a spin (WPR16LA150). That accident also involved a skydiving flight, but all of the skydivers were able to exit the airplane, and the pilot was able to recover and land. There were no injuries. (The pilot in the Mokuleia accident was not the same pilot that was involved in the Byron accident.) The NTSB determined the probable cause to be the pilot's failure to maintain an adequate airspeed and his exceedance of the airplane's critical angle of attack, which resulted in an aerodynamic stall and subsequent spin. Also causal to the accident was the pilot's failure to follow prescribed spin recovery procedures, which resulted in increased airspeed and airflow and the subsequent overstress separation of the right horizontal stabilizer. Contributing to the accident was the pilot's inadequate preflight weight and balance calculations, which resulted in the center of gravity being aft of the limit.

[9] Constant altitude and zero sideslip.

Summing forces in the horizontal direction:

$\Sigma F_y = m(V^2/R)$, or

$L\sin\phi = m(V^2/R)$, where, [2]

V is the tangential velocity

R is the turn radius

Dividing equation [1] into [2] yields:

$\tan\phi = V^2/Rg$, or

$R = V^2/(g \tan\phi)$ [3]

$= [(105\text{ kt})(1.688\text{ ft/s/kt})]^2/[(32.174\text{ ft/s}^2)\tan(20^\circ)]$

$= 2{,}680$ ft

Note: A 20˚ left-banked turn was found to provide the appropriate radius to the crash site. The turn radius of 2,680 ft that results from calculations from the 50 ft obstacle point to the crash site is depicted in Figure 14. This suggests that little bank angle, i.e., 20˚, was required to reach the accident site and does not indicate a turning/accelerated stall. However, if the turn is initiated at the end of runway 8 (as marked by the two trees in Figure 15 and discussed in the video study), a tighter turn is necessary. With a left-banked turn of approximately 66˚, an accelerated stall would result. The calculation is shown below.

The V-G diagram[10] shows the load factor that an airplane can sustain at various speeds. A generic diagram with select Beechcraft 65-A90 airspeeds is shown in Figure 15. Note that the curved line of maximum positive lift capability is highlighted by the solid red line. Any load factor above this line is unavailable aerodynamically because the airplane will stall. Stalls at load factors above "1g" are called accelerated stalls and occur at speeds greater than the 1g stall speed. The power on, 1g, stall speed for the Beechcraft 65-A90 at the accident conditions is approximately 67 kt.

The stall speed at load factors above 1g can be computed from the 1g stall speed as follows:

$V_s = \sqrt{n}\, V_{s_{1g}}$ where, V_s is the accelerated stall speed

n is load factor

$V_{s_{1g}}$ is the 1g stall speed or 67 kt (power on, 7,900 lb)

or, $n = \left(\frac{V_s}{V_{s_{1g}}}\right)^2$

Assuming the accident airplane entered an accelerated stall during the climb[11] :

$n = \left(\frac{105\ kt}{67\ kt}\right)^2 = 2.5\text{g}$

The bank angle associated with this load factor is:

$n = \frac{1}{\cos\phi}$

[10] The FAA Pilot's Handbook of Aeronautical Knowledge defines the V-G diagram as a chart that relates velocity to load factor. It is valid only for a specific weight, configuration and altitude and shows the maximum amount of positive or negative lift the airplane can generate at a given speed.

[11] The speed of 105 KIAS was chosen because it is approximately halfway between the rotation speed of 97 KIAS and the climb out speed of 110 KIAS. The winds are neglected such that ground speed and airspeed are the same in the turn radius calculations.

or, $\phi = cos^{-1}\left(\frac{1}{n}\right) = cos^{-1}\left(\frac{1}{2.5}\right)$

$\phi = 66^\circ$

The turn radius from equation [3] above is:

$R = V^2/(g \tan\phi)$

$= [(105 \text{ kt})(1.688 \text{ ft/s/kt})]^2/[(32.174 \text{ ft/s}^2)\tan(66^\circ)]$

$= 435 \text{ ft}$

The turn radius of 435 ft that results from calculations from the end of the runway to the crash site is depicted in Figure 16.

G. SUMMARY AND CONCLUSIONS

The accident flight lasted less than a minute and occurred approximately 3,030 ft from the likely starting point of N256TA's take-off roll from runway 8 (the connection with the taxiway at point C in Figure 3). The wreckage was found about 460 ft to the left of the runway centerline.

The estimated take-off distance from both flight test and POH data put the airplane at approximately 100 ft agl over the displaced threshold for the opposite runway 26. While a take-off from point C in Figure 3 at the connection with the taxiway may or may not have been standard practice for the accident pilot, it left approximately half the available runway, or 4,507 ft, unused.

The airplane was operating at an aft CG where pilot column forces are lighter. Light column forces can lead to the pilot overcontrolling the airplane and loss of control. It could not be determined if the aft CG was a factor in the accident.

Like the take-off leaving half the runway unused, the requirement for full left-wing-down aileron trim during take-off reduced the margin of safety.

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H. FIGURES

Figure 1: Accident Airplane, N256TA, a Beechcraft 65-A90

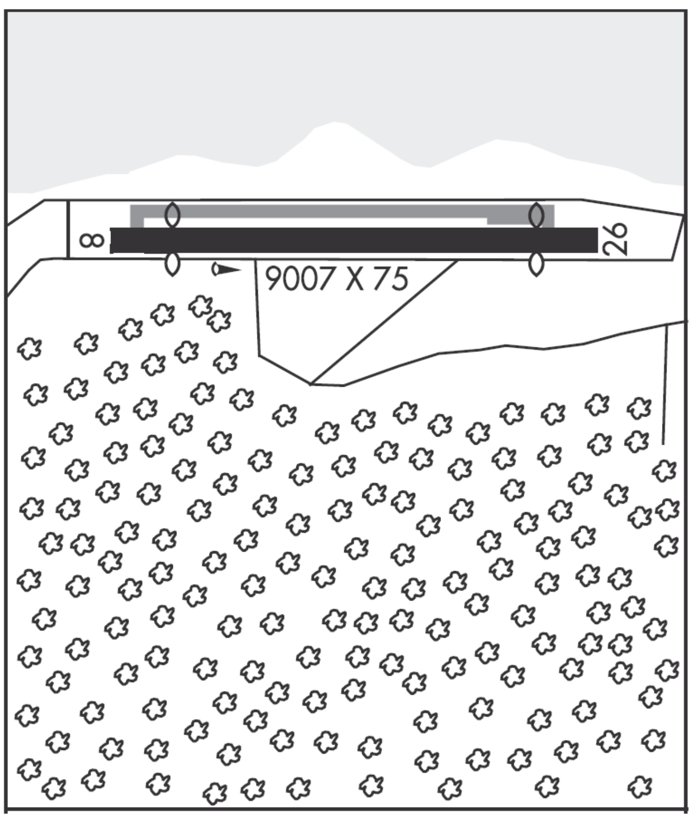


Figure 2: Dillingham Airfield Runway Diagram

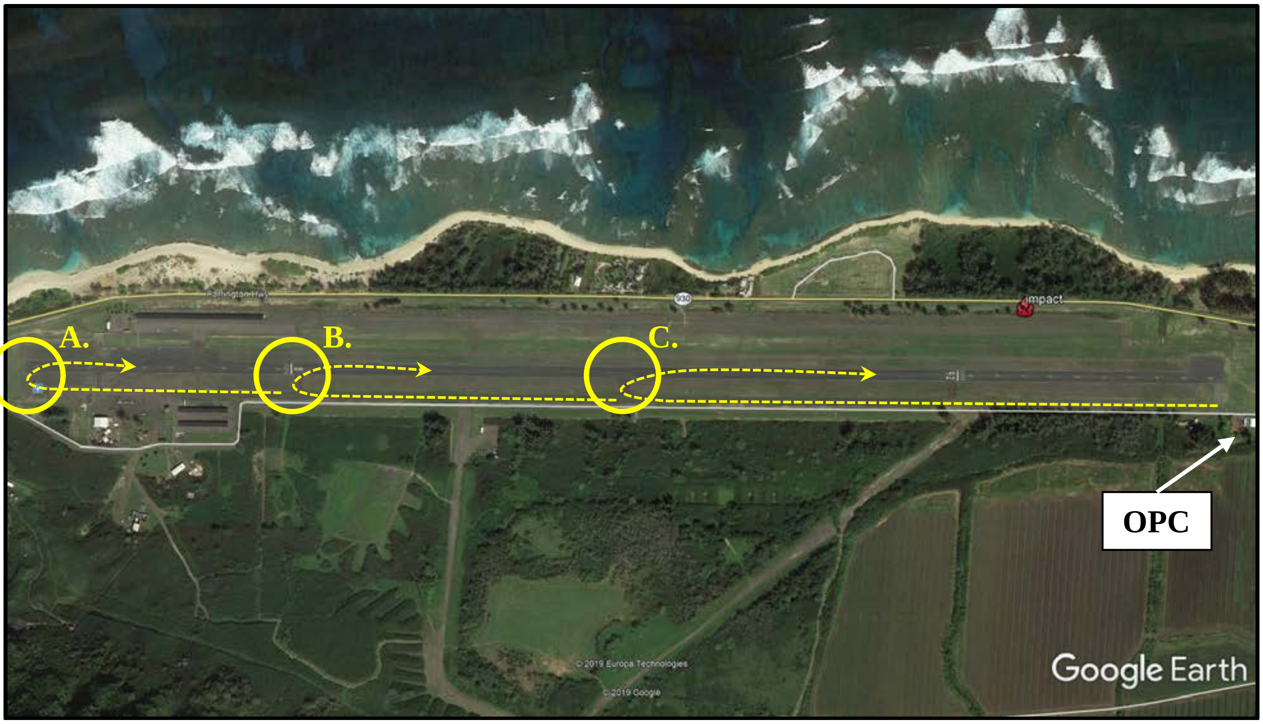
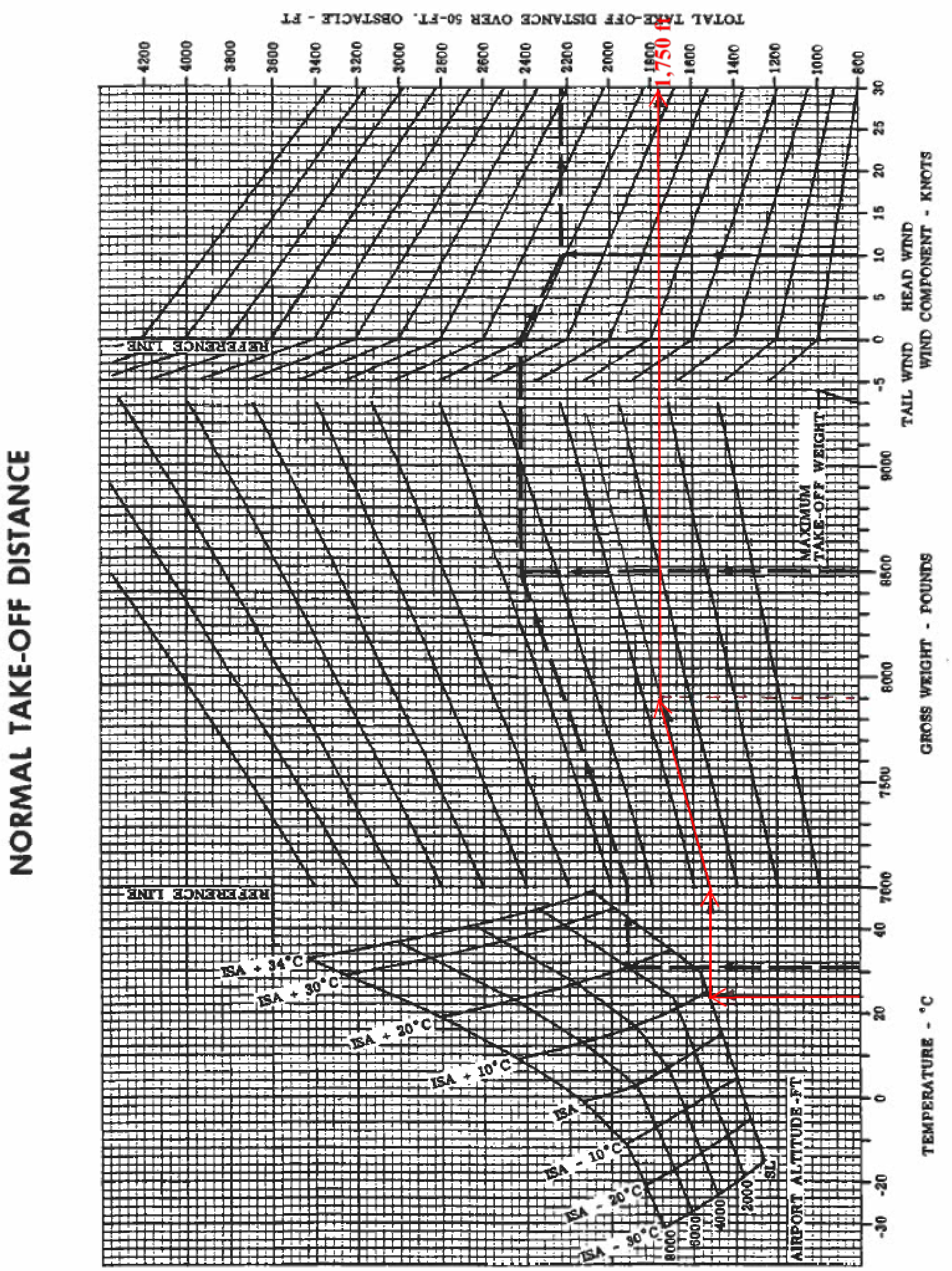


Figure 3: Possible Take-off Initiation Points for Runway 8



FAA Approved
Reissued: September 25, 1968

MODEL 65-A90 FAA Flight Manual 7-9

Figure 4: Estimated Take-off Distance over 50 ft Obstacle from POH: 1,750 ft

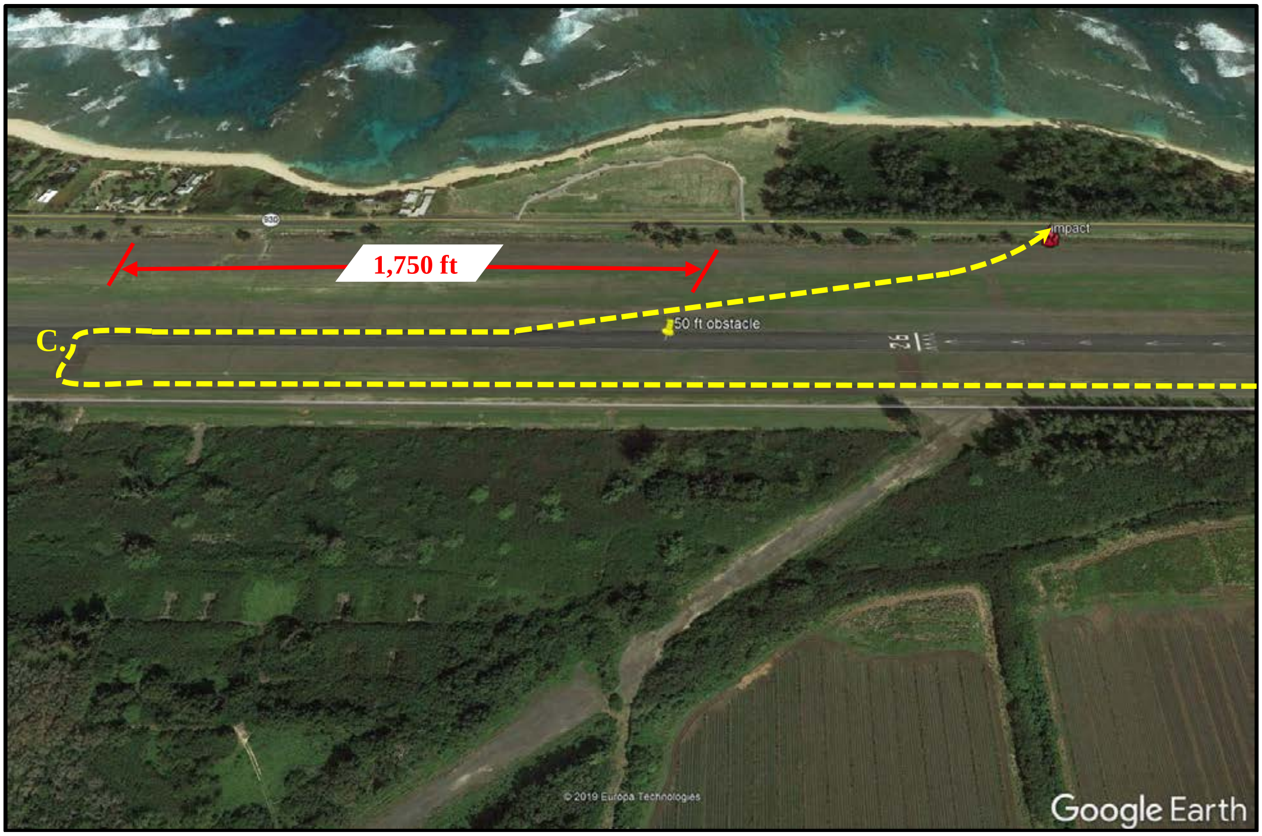


Figure 5: Estimated Take-off Distance Over 50 ft Obstacle from POH: 1,750 ft

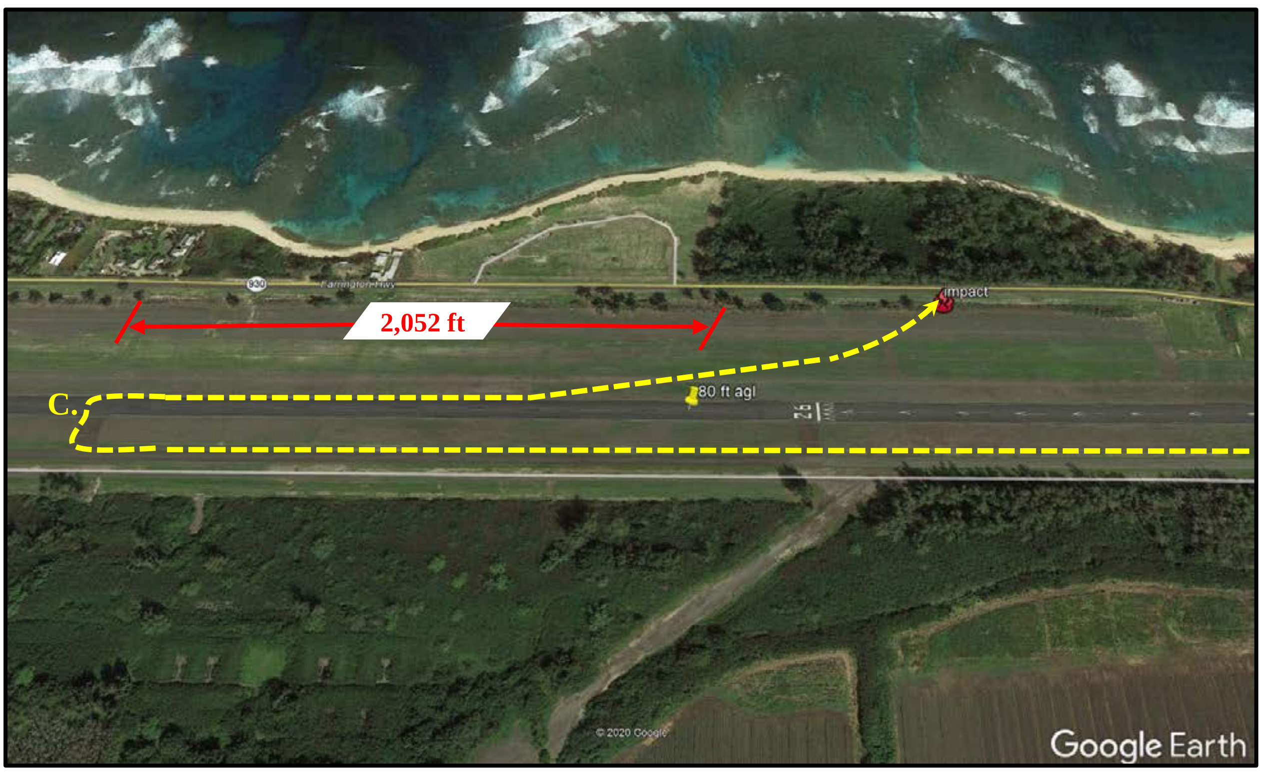


Figure 6: Estimated Take-off Distance to 80 ft from Flight Test Data: 2,052 ft

Figure 7: Security Footage Just Before Impact

Figure 8: Security Footage Just After Impact

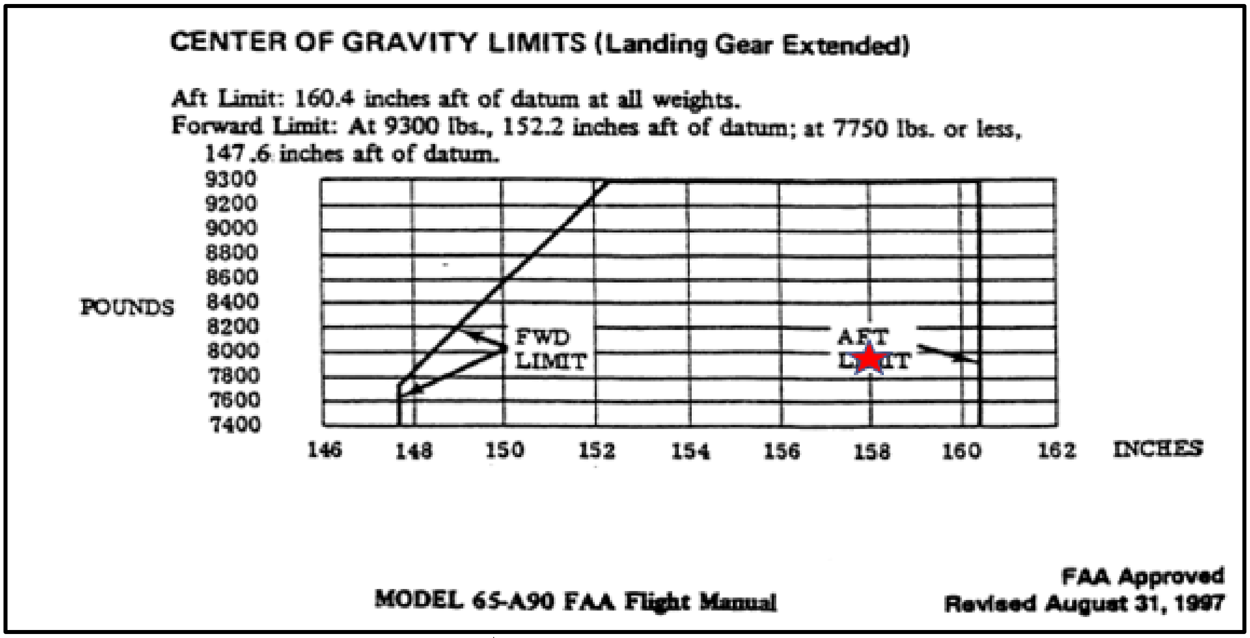


Figure 9: Center of Gravity (★) Assuming Last Two Passengers on Floor in Back

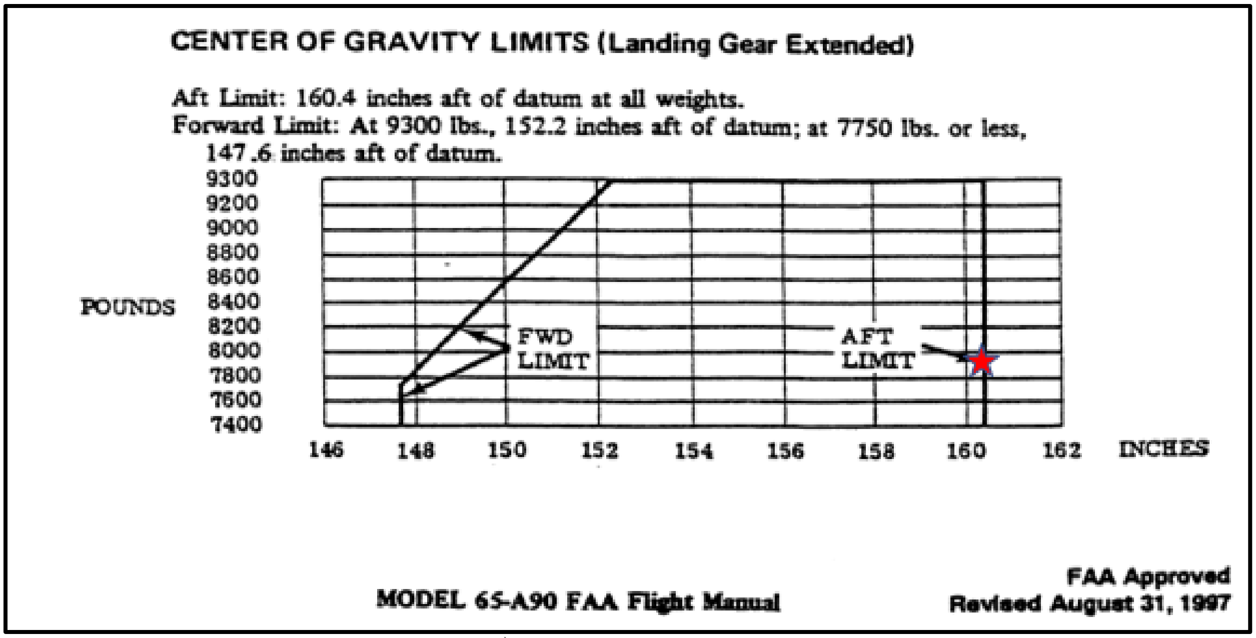


Figure 10: Center of Gravity (★) Assuming Last Two Passengers at Aft Pressure Bulkhead

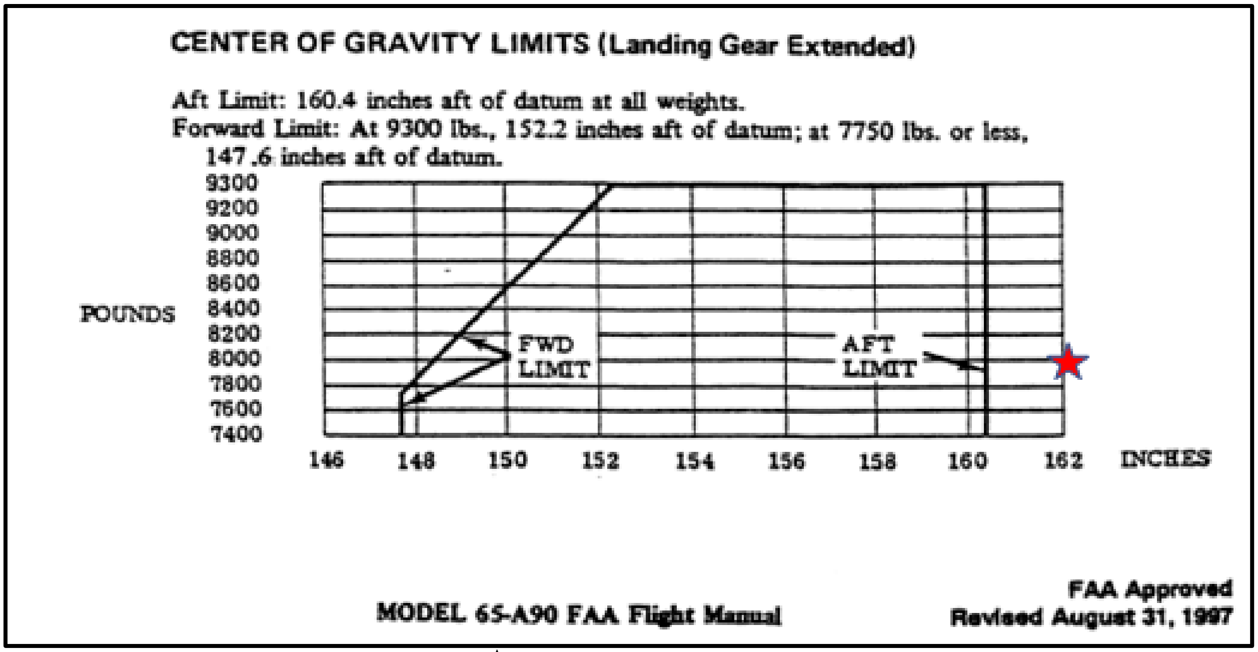


Figure 11: Center of Gravity (★) Assuming Last Three Passengers at Aft Pressure Bulkhead

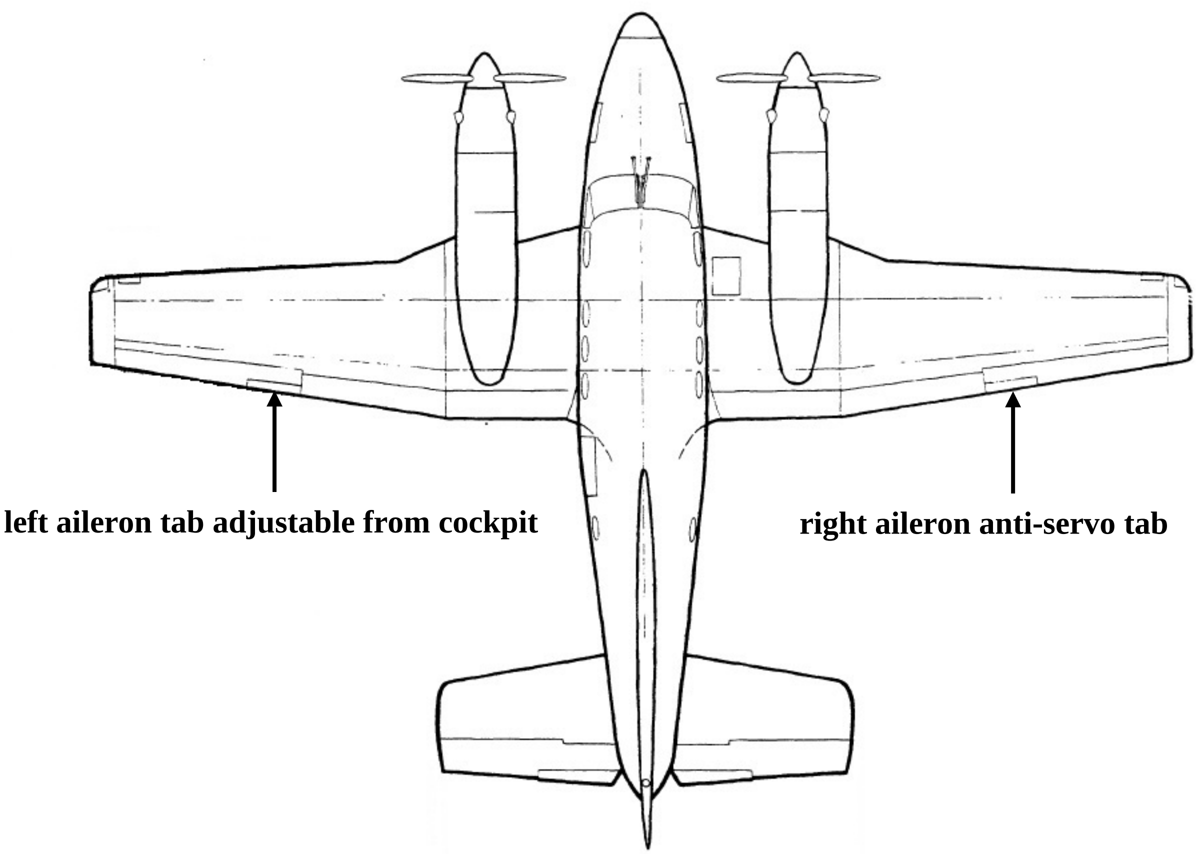


Figure 12: Plan View of Beechcraft 65-A90, King Air

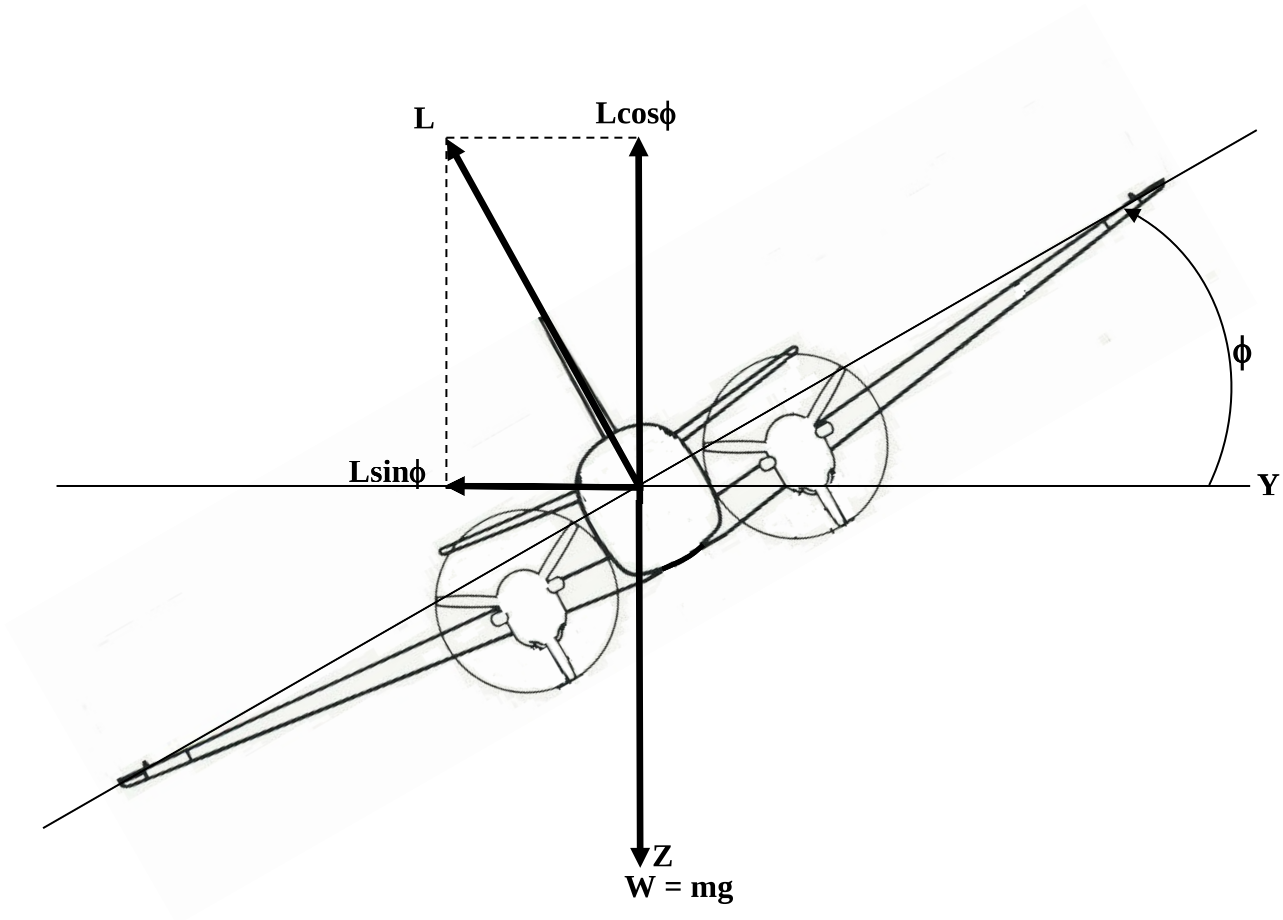


Figure 13: Forces Acting in a Steady, Coordinated Turn

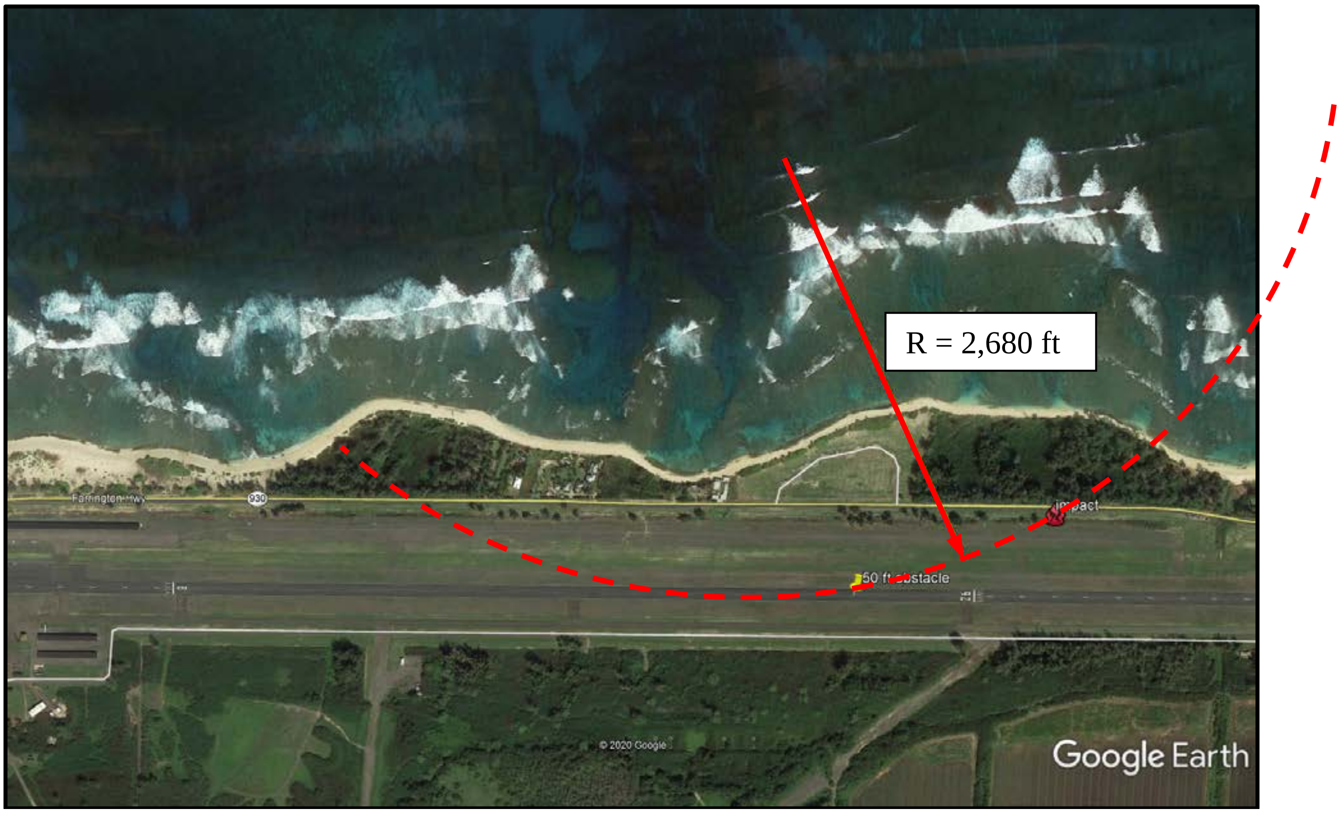


Figure 14: Steady, Coordinated Turn Shortly after Lift-off until Final Impact

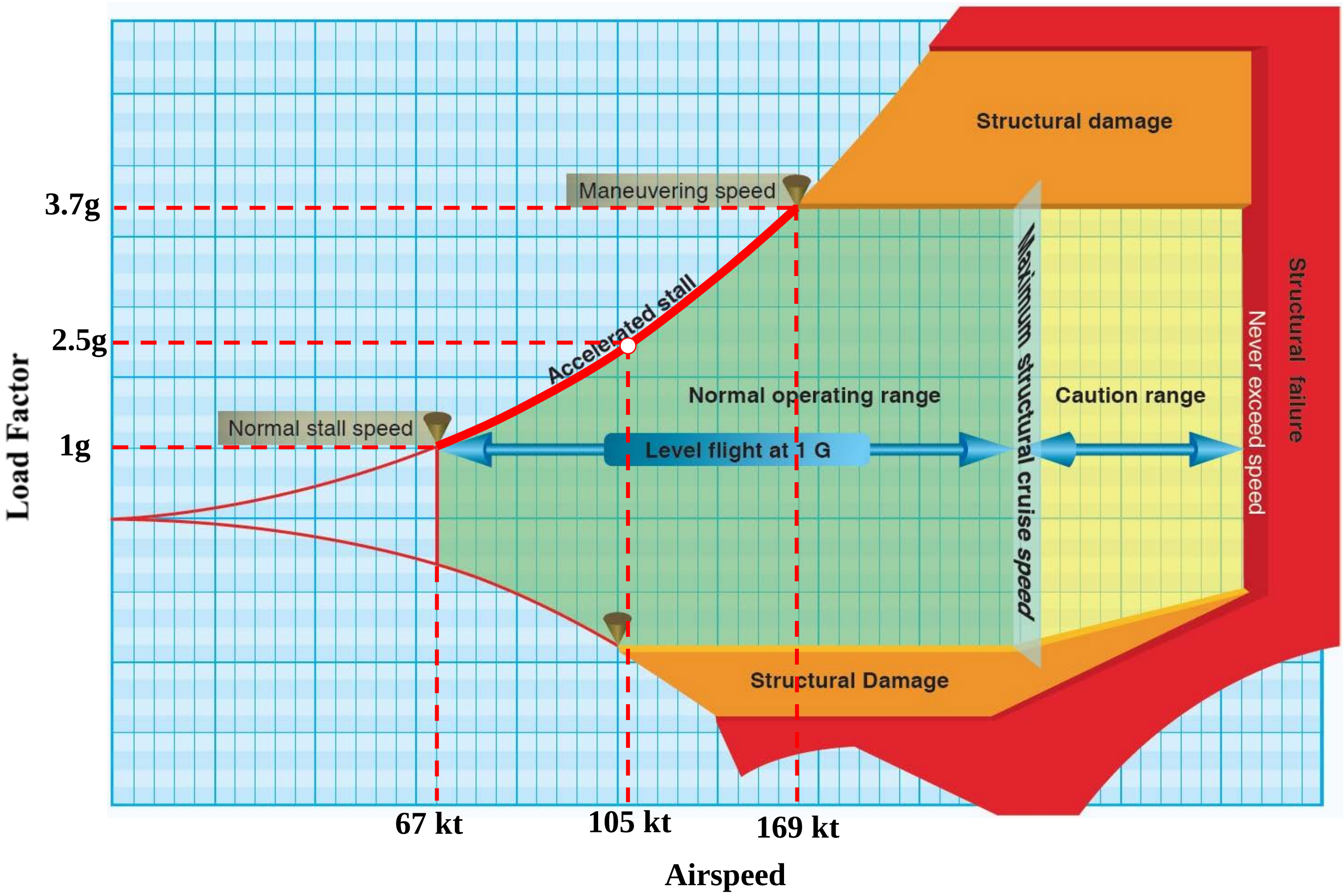


Figure 15: Typical V-G Diagram
(Source: FAA Pilot's Handbook of Aeronautical Knowledge)

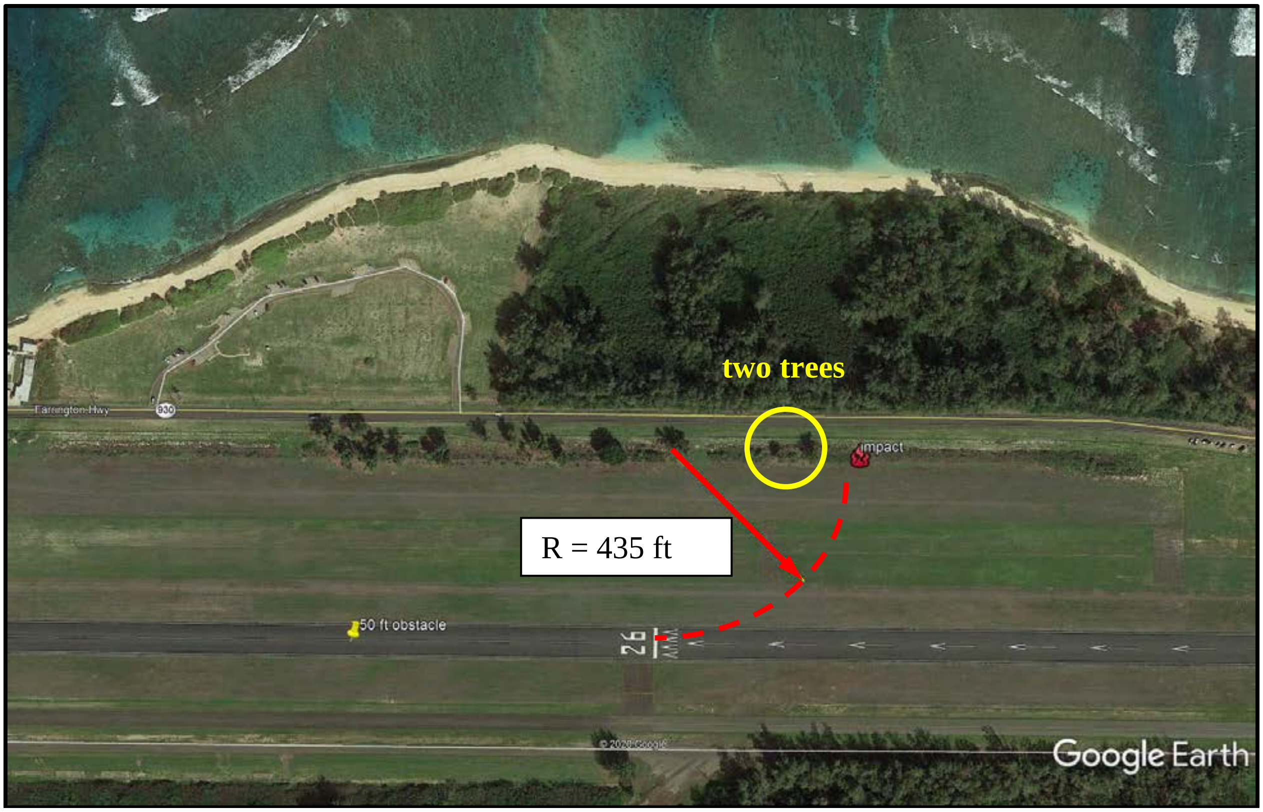


Figure 16: Steady, Coordinated Turn from End of Runway (two trees) until Final Impact (Note: this is the turn radius and not necessarily the actual ground track.)