SAFETY ALERT 072

NTSB National Transportation Safety Board

February 2018

AVIATION
HIGHWAY
MARINE
RAILROAD
PIPELINE

Minding Weight, Maintaining Balance

Improper or Unperformed Calculations Can be Fatal

The problem

- **Between 2008 and 2016, the probable causes of 136 general aviation (GA) accidents were related to pilots improperly conducting preflight performance calculations for weight and balance or not conducting them at all. One-third of these accidents resulted in pilot and/or passenger deaths.**
- **If pilots do not perform preflight calculations to verify that their aircraft are within allowable weight and center of gravity (CG) limits, the aircraft could be operated in exceedance of their certificated takeoff gross weight and/or outside CG limits.**
- **Overloading aircraft or operating outside of the CG limits can severely degrade an aircraft's performance characteristics and ultimately lead to an aerodynamic stall and/or loss of aircraft control, typically during takeoff or landing.**
- **Not accounting for atmospheric conditions—such as wind, high temperature, and high-density altitude— on an aircraft's performance can exacerbate the effects of operating outside of weight and CG limits. Even if an aircraft is under or near its maximum gross takeoff limit, atmospheric conditions can degrade the aircraft's performance enough to prevent it from attaining or maintaining a climb.**

Related accidents

The following examples from the National Transportation Safety Board's (NTSB) accident database show the diverse circumstances under which these types of accidents happen:

- **An airline transport pilot was conducting a flight from** a fishing lodge to a remote fishing location in a float-equipped de Havilland DHC-3T (Otter) airplane, which impacted tundra-covered terrain just after takeoff from a lake. Three passengers were killed, the pilot and four passengers sustained serious injuries, and two passengers sustained minor injuries. According to a witness, after liftoff, the airplane began to climb and then descended. The floats struck the water, then the airplane briefly became airborne again before crashing. The pilot reported that, before departure, the front and center fuel tanks were filled and that the aft fuel tank had "residual" fuel. He said that he "guesstimated" the airplane's weight and balance before departure (he did not weigh the cargo, obtain passenger weights, or document any weight and balance calculations). A postaccident weight and balance study using the passenger weights, weighed cargo, and fuel load showed that the airplane exceeded its maximum gross weight by about 508.6 lbs and that the CG was 4.08 inches aft of the aft CG limit. The pilot's failure to determine the airplane's actual preflight weight and CG led to the airplane being operated outside of its

weight and CG limits, preventing it from attaining a proper airspeed and ultimately resulting in an aerodynamic stall. (ANC15FA071)

- **A Robinson R22 Beta II helicopter sustained substantial** damage when it collided with rising terrain 10 miles west of its departure point (see figure 1). The private pilot sustained a serious injury, and the passenger sustained a minor injury. The pilot reported that, as he was flying the helicopter up a canyon and climbing in rising mountainous terrain, he noticed a substantial tailwind gust, followed by a decrease in airspeed below effective translational lift. The helicopter stopped climbing, and the pilot immediately made a left turn with the intention of reversing course and turning into the wind. However, the helicopter impacted rising terrain. The investigation determined that the helicopter was operating about 30 lbs above its maximum gross weight and that the calculated density altitude was about 9,600 ft. The pilot did not know that the helicopter's gross weight was greater than its maximum due to inadequate preflight planning. His subsequent decision to attempt to climb over rising terrain in high-density altitude conditions with a tailwind resulted in the helicopter's inability to maintain a positive climb rate and subsequent impact with terrain. (GAA15LA131)

Figure 1. Photograph of substantial damage to Robinson R22 Beta II helicopter

- **A Beech 100 ran off the departure end of the runway** during takeoff, substantially damaging the airplane (see figure 2). The airline transport pilot, copilot, and eight passengers were not injured. During the takeoff roll, the airplane did not accelerate as quickly as the pilot expected. When the airplane reached the last third of the runway, the pilot pulled back on the control yoke to lift the airplane off the runway, but the stall warning horn sounded. He lowered the nose, but the airplane subsequently departed the runway and impacted terrain and obstacles. The pilot reported that he knew that the total weight of the eight passengers, their bags, and the fuel caused the airplane to be overweight, but he did not complete a weight and balance form or determine the expected takeoff performance before the flight (figure 3 shows the unweighed luggage on board the airplane). After the accident, the pilot determined that the airplane was 623 lbs over its maximum gross weight. The pilot's decision to depart knowing that the airplane was over its maximum gross takeoff weight was unsafe. Coupling that decision with the pilot's failure to determine the expected takeoff performance resulted in the airplane not accelerating as expected and its subsequent runway excursion. (CEN17LA029)

Figure 2 (top). Postaccident photograph of damaged Beech 100

Figure 3 (at right). Photographs showing unweighed baggage on Beech 100

- **A flight instructor and student pilot were conducting** an instructional flight in an Aeronca 11AC airplane when it impacted trees at the departure end of the runway, resulting in minor injuries to the student. The flight instructor reported that, during the takeoff climb from a grass runway, the "climb rate became stagnant." He added that he instructed the student to "lower the nose slightly," but the airplane still could not establish a "normal climb rate." After taking over the flight controls, the flight instructor turned the airplane toward a small gap in the tree line ahead, and the airplane subsequently impacted the trees. According to the flight instructor, the airplane departed "loaded at gross weight." The student reported that the flight instructor did not discuss the airplane's weight and balance with him before the flight. Postaccident weight and balance calculations revealed that the airplane was 139 lbs over its maximum gross weight, and the calculated density altitude was about 2,648 ft. The airplane's overweight condition, in combination with the takeoff in high-density altitude conditions from a turf runway, decreased the airplane's takeoff performance and resulted in the accident. (GAA17CA347)

What can pilots do?

- **Know** your aircraft's limitations and the factors that can affect its performance.
- **Conduct** weight and balance calculations in accordance with the applicable aircraft flight manuals (AFM) to ensure that your aircraft is loaded within its weight and CG limits. The limitations section of each AFM or Pilot's Operating Handbook contains details about the maximum weight and CG limits for takeoff and landing.
- **Be prepared** and conduct takeoff and landing distance calculations as part of your preflight planning. Remember to account for fuel burn during flight, which will result in a CG shift and decrease in weight.
- **Be aware** of the atmospheric conditions that exist at the time throughout your flight and account for these factors in all your performance calculations.
- **Remember** that operating the aircraft above its maximum gross weight can result in a longer takeoff run due to the airplane's slower acceleration and the need for a higher takeoff speed; shallower climb angles and reduced climb rates; reduced cruising speed; shorter range; higher stall speeds; and longer landing rolls.
- **Be aware** that operating an aircraft outside of its CG limits can degrade its handling qualities, resulting in reduced stability and/or reduced control authority, which increases the risk of a loss of control. Be vigilant on every flight.
- **Determine** the CG even if your aircraft is under its maximum gross weight. Even if an aircraft is within its allowable gross weight, it may be loaded outside of its CG limits.
- **Do not "guesstimate"** passenger and cargo weights. The margins of error are small, and even slightly underestimating these weights could kill or seriously injure you, a friend or colleague, or a family member.
- When using automated weight and balance application calculators, **ensure** that the basic empty weight and moment match the specific values for your aircraft. Sample weight and balance data should never be used as a substitute for actual numbers in the AFM.
- If any major modifications to your aircraft change its weight or CG, such as the installation of onboard equipment, **ensure** that this information is in the updated weight and balance forms contained in the AFM.
- **Remember** that aircraft performance can only be determined after the gross weight is computed. Professional flight crews do these computations routinely. You should strive for professionalism as well when you are planning your flights.

REMEMBER — Before Every Flight, Ensure That Your Aircraft Can Operate Safely

Interested in more information?

Education and training are essential to improving GA safety. The Federal Aviation Administration (FAA) Safety Team (FAASTeam) provides access to online training courses, seminars, and webinars as part of the FAA's "WINGS—Pilot Proficiency Program." The program includes targeted flight training designed to help pilots develop the knowledge and skills needed to achieve flight proficiency and to assess and mitigate the risks associated with the most common causes of accidents, including operating outside of weight and CG limits. The courses and resources listed below (among others), as well as seminar and webinar information, can be accessed from the FAASTeam website at account or creation of a free FAASTeam account.)

- Performance Limitations
- Helicopter – Weight & Balance, Performance
- Weight and Balance P-8740-05

FAA-H-8083-1, "Weight and Balance Handbook," and FAA-H-8083-21A, "Helicopter Flying Handbook" both provide pilots with information on loading and operating aircraft and emphasize the importance of ensuring that the weight and CG are within the allowable limits. The handbooks also describe the negative effects of overloading an aircraft and operating an aircraft outside of CG limits. The handbooks provide exemplar loading computations for GA aircraft and corresponding loading graphs and tables of weight and moment indexes. Both handbooks can be accessed from the FAA's website at www.faa.gov.

A companion video to this safety alert can be accessed from the Aviation Safety Alerts link.

The reports for the accidents referenced in this safety alert are accessible by NTSB accident number from the Aviation Accident Database link, and each accident's public docket is accessible from the Accident Dockets link for the Docket Management System.

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