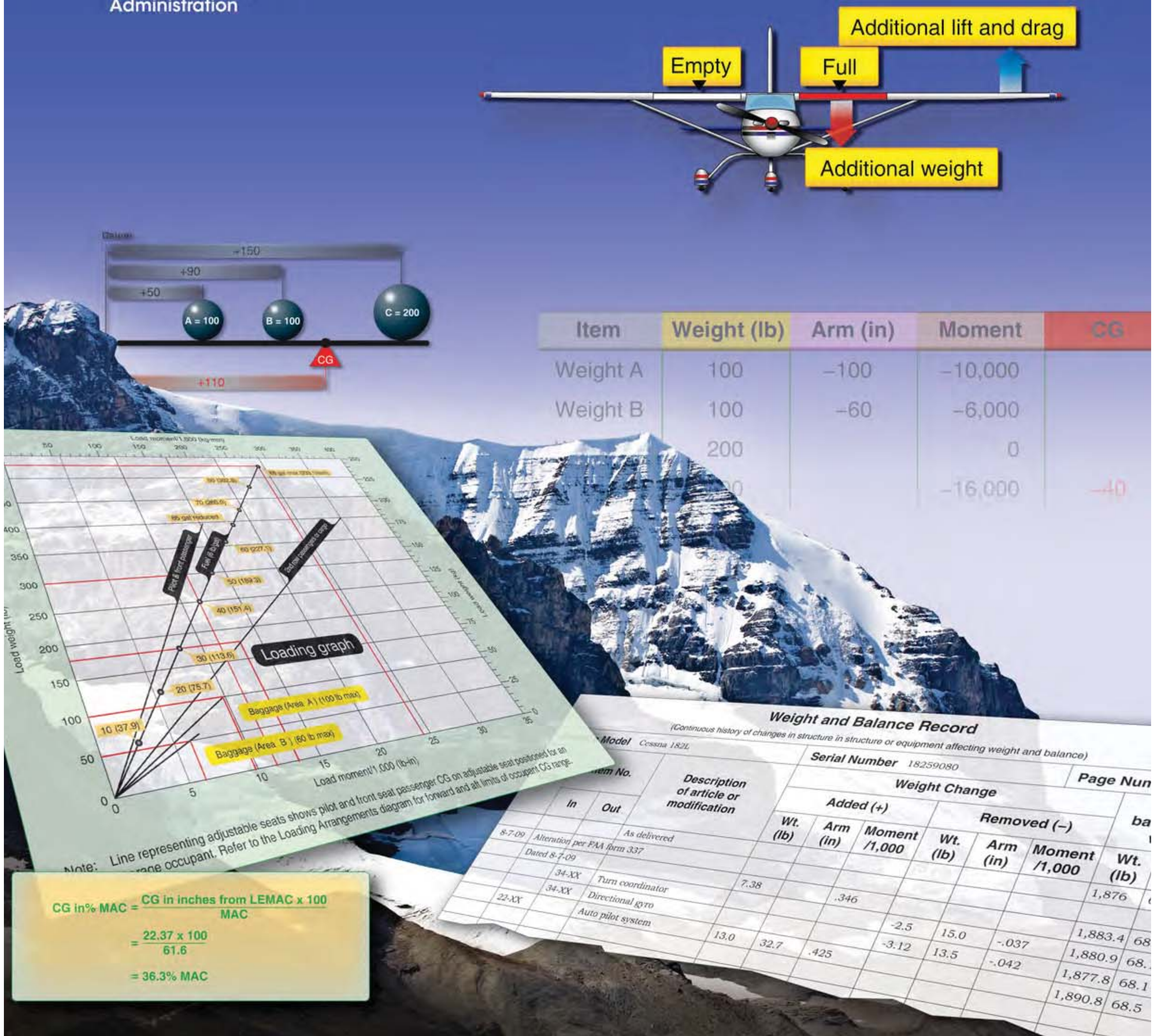
FAA-H-8083-1B

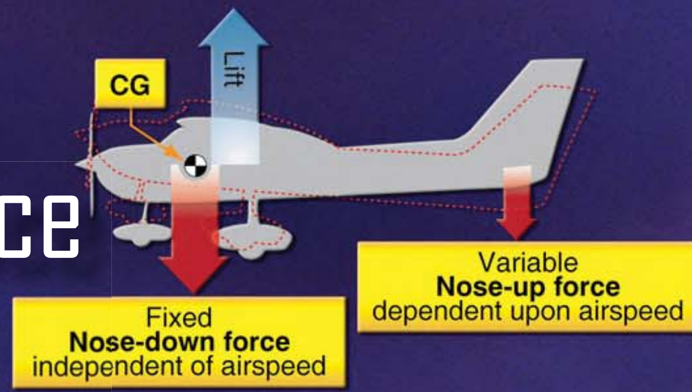
Weight and Balance Handbook

U.S. Department
of Transportation
Federal Aviation
Administration



Chapter 1

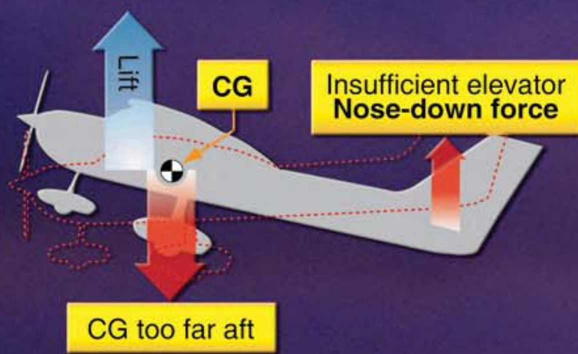
Weight and Balance Control

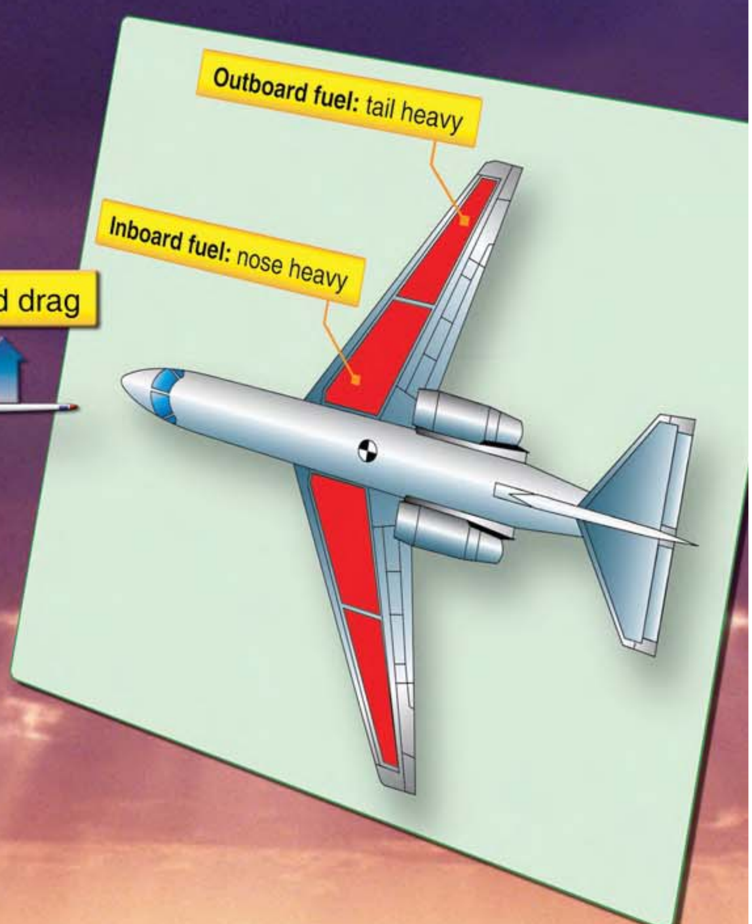


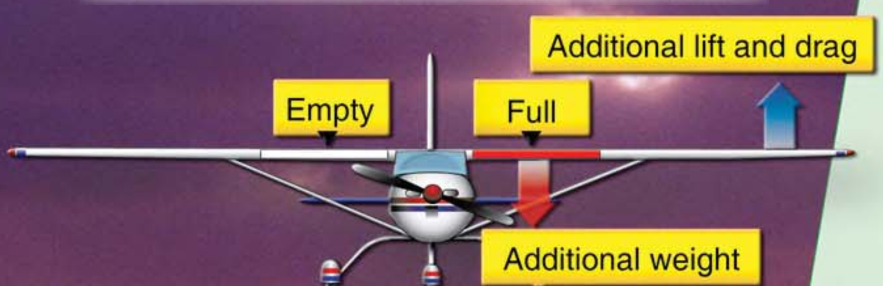
Introduction

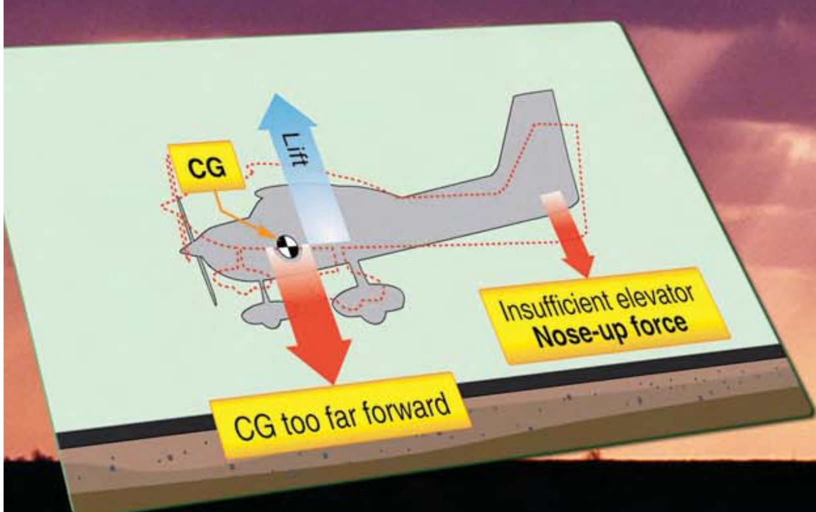
There are many factors in the safe and efficient operation of aircraft, including proper weight and balance control. The weight and balance system commonly employed among aircraft consists of three equally important elements: the weighing of the aircraft, the maintaining of the weight and balance records, and the proper loading of the aircraft. An inaccuracy in any one of these elements defeats the purpose of the system. The final loading calculations are meaningless if either the aircraft has been improperly weighed or the records contain an error.

Improper loading decreases the effic ency and performance of an aircraft from the standpoint of altitude, maneuverability, rate of climb, and speed. It may even be the cause of failure to complete the flight or, for that matter, failure to start the flight. Because of abnormal stresses placed upon the structure of an improperly loaded aircraft, or because of changed fly ng characteristics of the aircraft, loss of life and destruction of valuable equipment may result.









the aircraft must be reconfigured or placarded to prevent the pilot from loading the aircraft improperly. It is sometimes possible to install a fixed ballast in order for the aircraft to operate again within the normal CG range.

The FAA-certificated mechanic or repairman conducting an annual or condition inspection must ensure the weight and balance data in the aircraft records is current and accurate. It is the responsibility of the PIC to use the most current weight and balance data when operating the aircraft.

Stability and Balance Control

Balance control refers to the location of the CG of an aircraft. This is of primary importance to aircraft stability, which is a factor in flight safety. The CG is the point at which the total weight of the aircraft is assumed to be concentrated, and the CG must be located within specific limits for safe flight. Both lateral and longitudinal balance are important, but the prime concern is longitudinal balance; that is, the location of the CG along the longitudinal or lengthwise axis.

An airplane is designed to have stability that allows it to be trimmed to maintain straight-and-level flight with hands off the controls. Longitudinal stability is maintained by ensuring the CG is slightly ahead of the center of lift. This produces a fixed nose-down force independent of the airspeed. This is balanced by a variable nose-up force, which is produced by a downward aerodynamic force on the horizontal tail surfaces

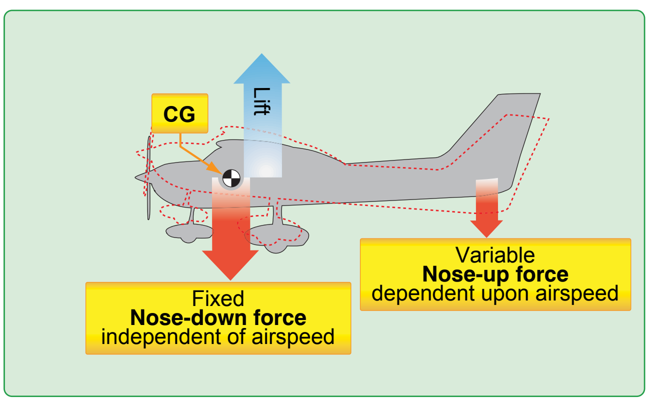


Figure 1-1. *Longitudinal forces acting on an airplane in flight.*

that varies directly with the airspeed. *[Figure 1-1]* If a rising air current should cause the nose to pitch up, the airplane slows and the downward force on the tail decreases. The weight concentrated at the CG pulls the nose back down. If the nose should drop in flight, the airspeed increases and the increased downward tail load brings the nose back up to level flight

As long as the CG is maintained within the allowable limits for its weight, the airplane has adequate longitudinal stability

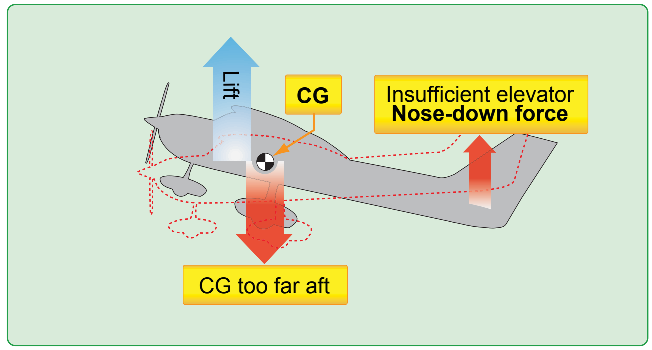


Figure 1-2. *If the CG is too far aft at the low stall airspeed, there might not be enough elevator nose-down authority to get the nose down for recovery.*

and control. If the CG is too far aft, it is too near the center of lift; the airplane is unstable and difficult to recover from a stall. *[Figure 1-2]* If the unstable airplane should enter a spin, the spin could become flat making recovery difficult or impossible. If the CG is too far forward, the downward tail load needs to be increased to maintain level flight. This increased tail load has the same effect as carrying additional weight; the aircraft must fly at a higher angle of attack and drag increases.

A more serious problem caused by the CG being too far forward is the lack of sufficient elevator authority. At low takeoff speeds, the elevator might not produce enough nose-up force to rotate; on landing there may not be enough elevator force to flare the airplane. *[Figure 1-3]* Both takeoff and landing runs are lengthened if the CG is too far forward. The basic aircraft design is such that lateral symmetry is assumed to exist. For each item of weight added to the left of the center line of the aircraft (also known as buttock line zero or BL-0), there is generally an equal weight at a corresponding location on the right.

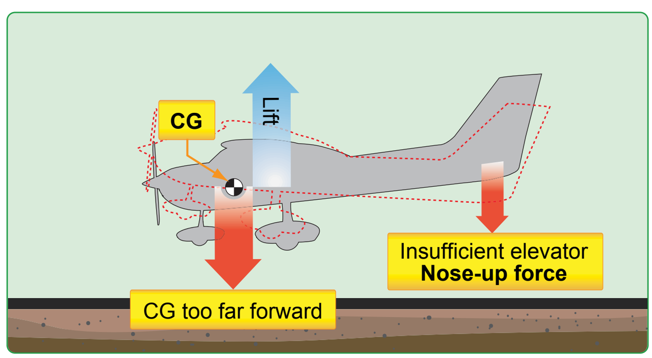


Figure 1-3. *If the CG is too far forward, there is not enough elevator nose-up force to flare the airplane for landing.*

The lateral balance can be upset by uneven fuel loading or burnoff. The position of the lateral CG is not normally computed for an airplane, but the pilot must be aware of