DOCUMENT
GSM-G-CPL.022

DOCUMENT TITLE

GENERAL OPERATIONS, FLIGHT PLANNING AND PERFORMANCE

CHAPTER 3 – BALANCE, STABILITY AND CENTRE OF GRAVITY

Version 1.0
January 2013

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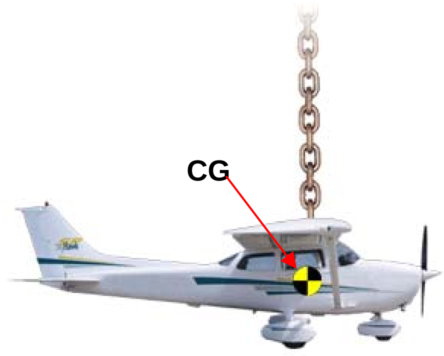
BALANCE, STABILITY AND CENTRE OF GRAVITY

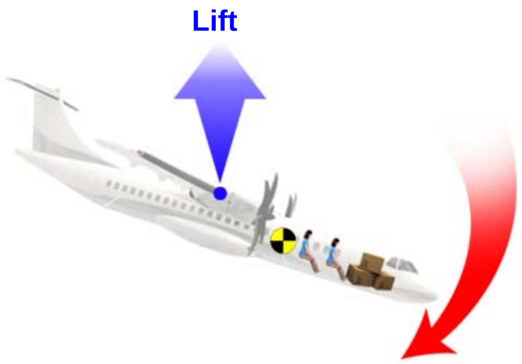
STABILITY AND BALANCE CONTROL

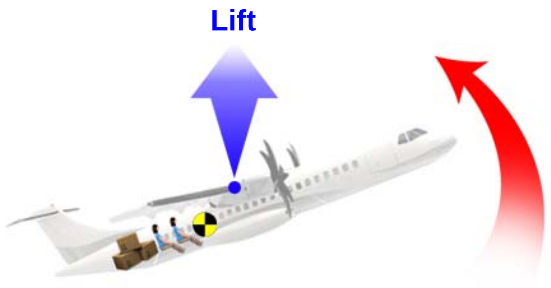


Balance control refers to the location of the centre of gravity (CG) of an aircraft, and is important to aircraft stability and safety in flight. The centre of gravity is a point at which an aircraft would balance if it were suspended at that point.

The prime concern of aircraft balancing is the fore and aft location of the CG along the longitudinal axis. The centre of gravity is not necessarily a fixed point; its location depends on the distribution of weight in the aircraft. As variable load items are shifted or expended, there is a resultant shift in CG location.

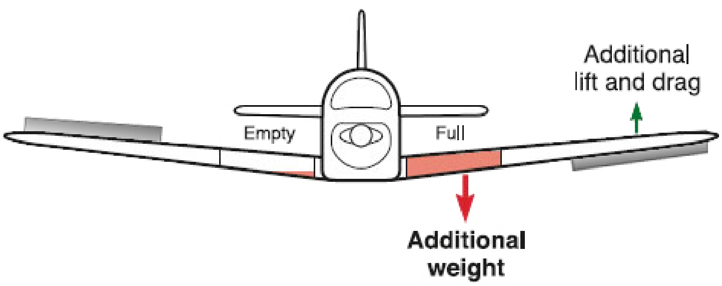
The pilot should realise that if the CG of an aircraft is displaced too far forward on the longitudinal axis, a nose-heavy condition will result.





Conversely, if the CG is displaced too far aft on the longitudinal axis, a tail-heavy condition will result. It is possible that an unfavourable location of the CG could produce such an unstable condition that the pilot could not control the aircraft.

Location of the CG with reference to the lateral axis is also important. For each item of weight existing to the left of the fuselage centreline, there is an equal weight existing at a corresponding location on the right. This may be upset, however, by unbalanced lateral loading.



Lateral imbalance causes wing heaviness, which may be correct by deflecting the aileron. The additional lift causes additional drag and the aircraft flies inefficiently.

The position of the lateral CG is not computed, but the pilot must be aware that adverse effects will certainly arise as a result of a laterally unbalanced condition. Lateral unbalance will occur if the fuel load is mismanaged by supplying the engine(s) unevenly from tanks on one side of the aircraft. The pilot can compensate for the resulting wing-heavy condition by adjusting the aileron trim tab or by holding a constant aileron control pressure. However, this places the aircraft controls in an out-of-streamline condition, increases drag, and results in decreased operating efficiency.

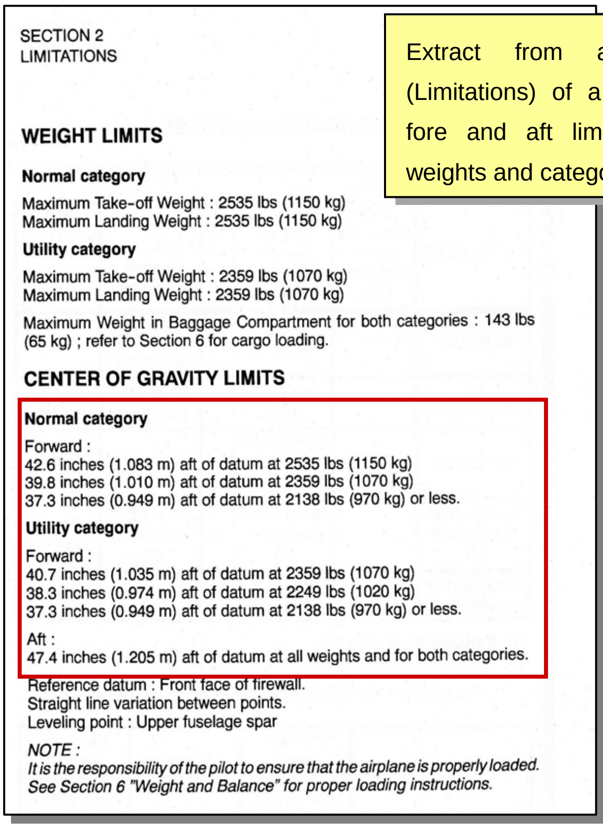
Important! Since lateral balance is relatively easy to control and longitudinal balance is more critical, further reference to balance in this learning object will mean longitudinal location of the centre of gravity.

In any event, flying an aircraft that is out of balance can produce increased pilot fatigue with obvious effects on the safety and efficiency of flight. The pilot's natural correction for longitudinal unbalance is a change of trim to remove the excessive control pressure. Excessive trim, however, has the effect of not only reducing aerodynamic efficiency but also reducing primary control travel distance in the direction the trim is applied.

EFFECTS OF ADVERSE BALANCE

Adverse balance conditions affect aircraft flight characteristics in much the same manner as those mentioned for an excess weight condition. In addition, there are two essential aircraft characteristics that may be seriously affected by improper balance; these are stability and control. Loading in a nose-heavy condition causes problems in controlling and raising the nose, especially during take-off and landing. Loading in a tail-heavy condition has a most serious effect upon longitudinal stability, and can reduce the aircraft's capability to recover from stalls and spins. Another undesirable characteristic produced from tail-heavy loading is that it produces very light control forces. This makes it easy for the pilot to inadvertently overstress the aircraft.

Limits for the location of the aircraft's centre of gravity are established by the manufacturer. These are the fore and aft limits beyond which the CG should not be located for flight. These limits are published for each aircraft in Section 2 and/or Section 6 of the Aircraft Flight Manual or Pilot's Operating Handbook (AFM/POH). If, after loading, the CG is not within the allowable limits, it will be necessary to relocate some items within the aircraft before flight is attempted.



SECTION 2
LIMITATIONS

WEIGHT LIMITS

Normal category

Maximum Take-off Weight : 2535 lbs (1150 kg)
Maximum Landing Weight : 2535 lbs (1150 kg)

Utility category

Maximum Take-off Weight : 2359 lbs (1070 kg)
Maximum Landing Weight : 2359 lbs (1070 kg)

Maximum Weight in Baggage Compartment for both categories : 143 lbs (65 kg) ; refer to Section 6 for cargo loading.

CENTER OF GRAVITY LIMITS

Normal category

Forward :
42.6 inches (1.083 m) aft of datum at 2535 lbs (1150 kg)
39.8 inches (1.010 m) aft of datum at 2359 lbs (1070 kg)
37.3 inches (0.949 m) aft of datum at 2138 lbs (970 kg) or less.

Utility category

Forward :
40.7 inches (1.035 m) aft of datum at 2359 lbs (1070 kg)
38.3 inches (0.974 m) aft of datum at 2249 lbs (1020 kg)
37.3 inches (0.949 m) aft of datum at 2138 lbs (970 kg) or less.

Aft :
47.4 inches (1.205 m) aft of datum at all weights and for both categories.

Reference datum : Front face of firewall.
Straight line variation between points.
Leveling point : Upper fuselage spar

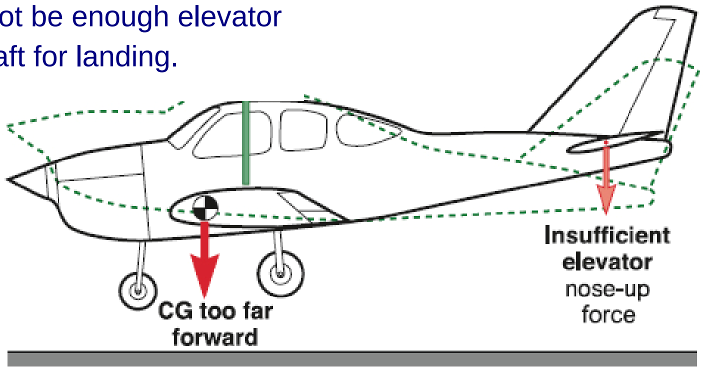
NOTE :
It is the responsibility of the pilot to ensure that the airplane is properly loaded. See Section 6 "Weight and Balance" for proper loading instructions.

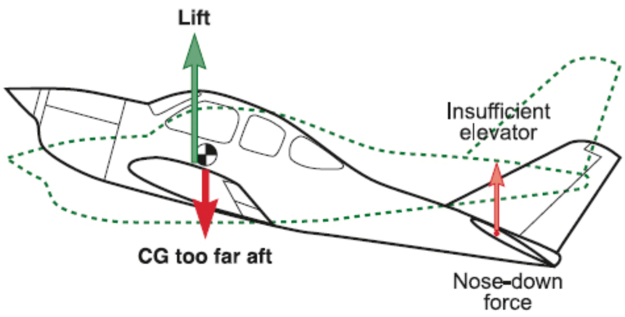
Extract from a Section 2 (Limitations) of a POH showing fore and aft limits at different weights and categories

The forward centre-of-gravity limit is often established at a location that is determined by the landing characteristics of the aircraft. During landing, which is one of the most critical phases of flight, exceeding the forward CG limit may result in excessive loads on the nose wheel; a tendency to nose over on tail wheel type aircrafts; decreased performance; higher stalling speeds; and higher control forces.

In extreme cases, a CG location that is forward of the forward limit may result in nose heaviness to the extent that it may be difficult or impossible to flare for landing. Manufacturers purposely place the forward CG limit as far rearward as possible to aid pilots in avoiding damage to the aircraft when landing. In addition to decreased static and dynamic longitudinal stability, other undesirable effects caused by a CG location aft of the allowable range may include extreme control difficulty, violent stall characteristics, and very light stick forces that make it easy to overstress the aircraft inadvertently.

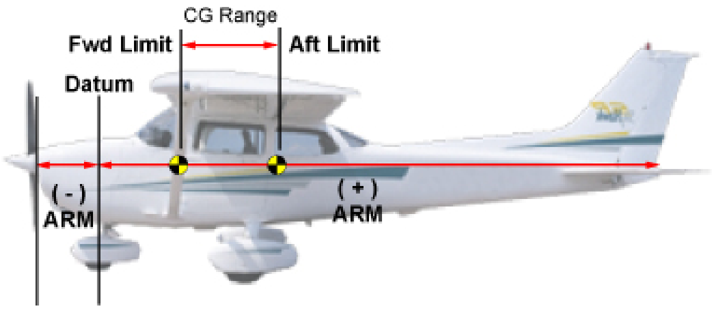
If the CG is too far forward, there will not be enough elevator nose-up force to flare the aircraft for landing.





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 recovery.

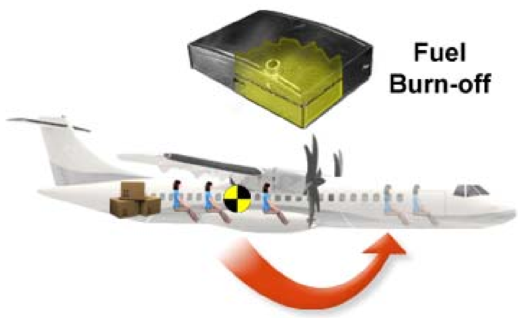
A restricted forward centre-of-gravity limit is also specified to assure that sufficient elevator deflection is available at minimum airspeed. When structural limitations or large stick forces do not limit the forward CG position, it is located at the position where full-up elevator is required to obtain a high angle of attack for landing.



The aft centre-of-gravity limit is the most rearward position at which the CG can be located for the most critical manoeuvre or operation. As the CG moves aft, a less stable condition occurs, which decreases the ability of the aircraft to right itself after manoeuvring or turbulence.

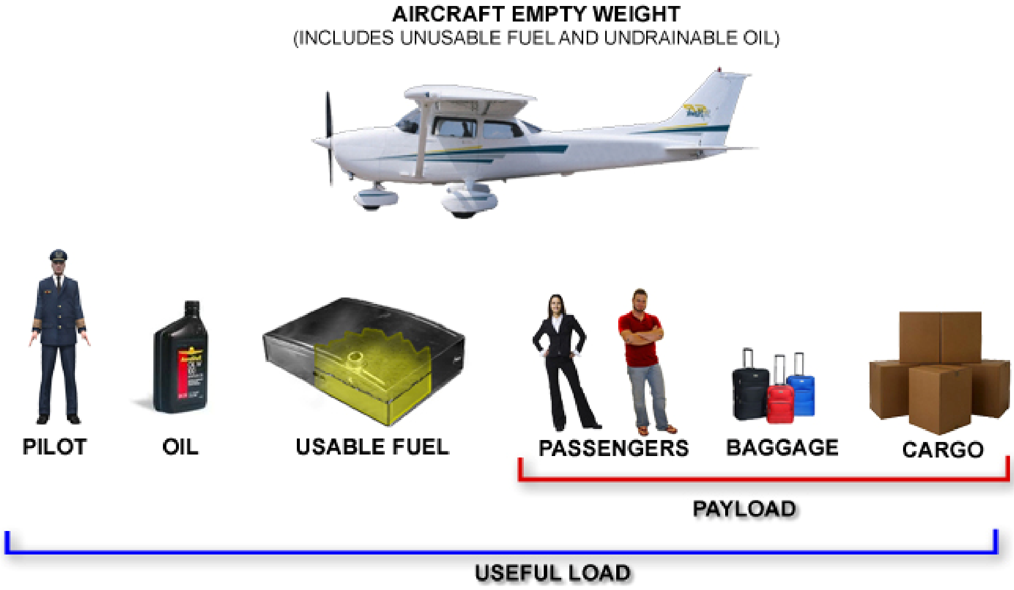
For some aircraft the CG limits, both fore and aft, may be specified to vary as gross weight changes. They may also be changed for certain operations such as acrobatic flight, retraction of the landing gear, or the installation of special loads and devices that change the flight characteristics.

The actual location of the CG can be altered by many variable factors and is usually controlled by the pilot. Placement of baggage and cargo items determines the CG location. The assignment of seats to passengers can also be used as a means of obtaining a favourable balance. If the aircraft is tail-heavy, it is only logical to place heavy passengers in forward seats. Also, fuel burn can affect the CG based on the location of the fuel tanks.



MANAGEMENT OF WEIGHT AND BALANCE CONTROL

Weight and balance control should be a matter of concern to all pilots. The pilot has control over loading and fuel management (the two variable factors that can change both total weight and CG location) of a particular aircraft.



The aircraft owner or operator should make certain that up-to-date information is available in the aircraft for the pilot's use, and should ensure that appropriate entries are made in the aircraft records when repairs or modifications have been accomplished. Weight changes must be accounted for and the proper notations made in weight and balance records. The equipment list must be updated, if appropriate. Without such information, the pilot has no foundation upon which to base the necessary calculations and decisions.

WEIGHT AND BALANCE RECORD

Part A - Weight and Balance Maintenance Data (to be completed by a Weight and Balance Control Officer (WBCO))

REF OSW243	Weight and Balance Report Ref:	Flight Manual Sect 6 iss 4	Revision and Re - Issue Required 7/11/2007
	Centre of Gravity Position (CG) is LONGITUDINAL / LATERAL (delete as appropriate) measured...AFT...of datum	Configuration Four Seater	Empty Weight and Empty Weight CG (Weighing or Validation dated 7-Nov-07
	Aircraft Longitudinal / Lateral Datum Forward Face of Firewall		Max. and Min Empty weight &Empty weight CG. Revision and Reissue by WBCO is required when running totals are
P .OSMOND A162909 Approval Stamp			

	Weight:kg	Arm: mm	Index
Empty Weight and Empty Weight CG	773.8	1002.0709	775402.5
		MTOW=	1150
more than	779.55	1007.0709	
less than	768.05	997.07095	

Part B - Record of Empty Weight and Balance Changes (the person co-ordinating maintenance shall ensure that Part B is calculated and recorded in accordance with CAO100.7)

Date	Description of Alteration	Moment Arm from Datum (mm)	Weight and Balance Change Added (+) Weight:kg	Added (+) Index	Removed (-) Weight:kg	Removed (-) Index	Running Total of Empty Weight & Empty Weight CG Weight:kg	Arm: mm	Index
7-Nov-07							773.8	1002.07	775402.5
13-Jan-09	ELT Installation	3430			0.255	874.65	**773.545**	**1001.27**	**774527.9**
	Remove ELT200 Install Kannad 406								

Organisation: Flight Training Adelaide	Aircraft Type Socata TB10	VH- YTQ	PAGE 1

Before any flight, the pilot should determine the weight and balance condition of the aircraft. Simple and orderly procedures, based on sound principles, have been devised by aircraft manufacturers for the determination of loading conditions. The pilot must use these procedures and exercise good judgment. In many modern aircraft, it is not possible to fill all seats, baggage compartments, and fuel tanks, and still remain within the approved weight and balance limits. If the maximum passenger load is carried, the pilot must often reduce the fuel load or reduce the amount of baggage.

Captain: ....Bloggs......

Callsign: ....TGK........

Date: 16./11../2010

	Weight kg	Arm mm	Moment mm,kg/1000
EW	633	188	118.90
Pilot & Pax (Row1)	135	250	33.75
Baggage	10	900	9.00
ZFW	778	207.78	161.65
Fuel	66	890	58.74
TOW	844	261.13	220.39
Fuel Burn Off	33	890	29.37
LDW	811	235.54	191.02

ACFT C/S	BEW	ARM	MOMENT
TGE	643.0	195.0	125.6
TGK	633.0	188.0	118.9
TGM	654.0	215.0	140.7
TGN	627.0	200.0	125.2
TGP	646.0	220.0	142.0
TGT	635.6	189.0	120.0
TGX	644.0	216.0	139.3
TGZ	659.0	207.0	136.2

Calculations of the Grob G115 should be made with both fuel and without fuel (i.e. with thefuel tank zero)

Ensure the computed values for all weights are within the C of G envelope graph. If they are within the envelope , the loadingcondition is permissible