11.2 Landing Gear Arrangements

Longitudinal Tipup Margin

The procedure for calculating the longitudinal tipup margin appears to be straightforward. However, it is important to take account of the location of the butt line of the MAC relative to the butt line of the main landing gear.

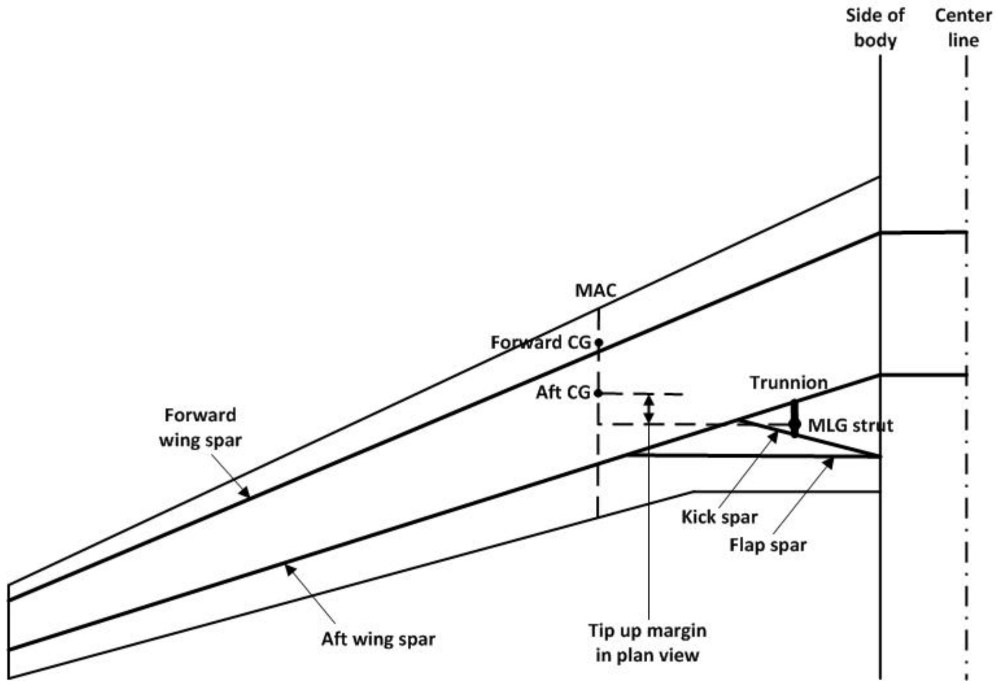


Fig. 11.2.1 Relative Location of Aft C.g. and MLG Strut

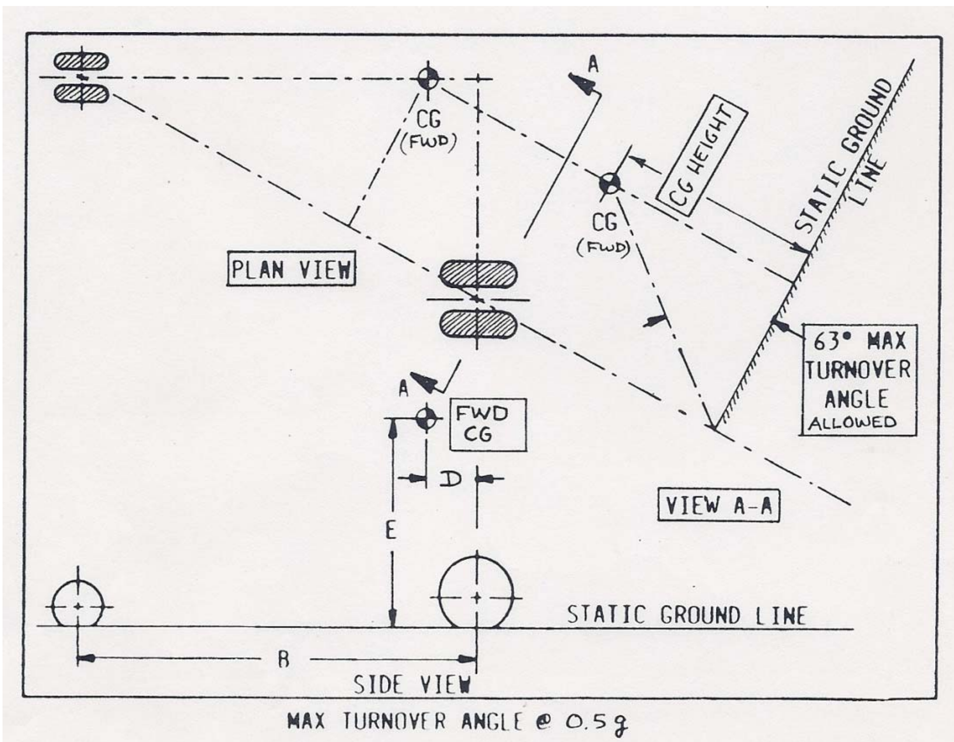
The location of the MAC is determined by the geometry of the wing planform. At this point in the design process it may be assumed that for a commercial aircraft with engines on the wing the forward c.g. is at 15% of the MAC and aft c.g. is at 35%. For fuselage-mounted engines the travel limits may be somewhat more (see the following subsection on Center of Gravity Location). The center of the main landing gear (MLG) bogie must be 15^0 - 20^0 (in the side elevation view) aft of the aft location of the c.g. This angle is based on the requirement that the fuselage should return to the horizontal position if it is tipped up so that the rear of the fuselage is touching the ground. The landing gear must also be long enough that the aircraft can rotate to the angle necessary to meet the minimum unstick speed (V_{MU}). V_{MU} is the minimum speed at which an aircraft certificated to FAR 25 can lift off the ground.

If the wing has moderate sweep and aspect ratio, the required tipup angle can normally be achieved without much difficulty. However, as sweep or aspect ratio increase, the location of the MAC moves aft relative to the MLG. For a high aspect ratio wing (as on the Boeing 787), it may be necessary to cant the MLG strut aft in order to meet the required tipup margin as shown in this picture (forward is to the right).

For a commercial airplane with wing-mounted engines, assume that the c.g. is at the height of the cabin floor. The fuselage can be moved forward or aft relative to the wing to ensure that the c.g. travel matches the required limits on the m.a.c .

Lateral Tipover Margin

The critical lateral tip over condition occurs when the c.g. is at the forward limit. The 63^0 maximum turnover angle is determined by the requirements for a 1/2g turn on a taxiway.



Source: Roskam

Fig 11.2.2 Lateral Tipover Calculation

The height of the c.g. (E) is transferred to the scrap view (VIEW A-A) in order to calculate the turnover angle. The scrap view is a view as if looking parallel to a line on the ground which passes through the center of the MLG bogie and the nosewheel (this is the approximate axis about which the airplane will rotate if it were to tip over). The scrap view can be set at an arbitrary distance from the plan view so that it does not interfere with the plan view.

Landing Gear Load Distribution

From Raymer Fig. 11.6, the non-dimensional nose gear load is calculated as

$$\frac{R_n}{W} = \frac{B - N}{B} \qquad (11.2.1)$$

N is the horizontal distance of the nosewheel from the c.g. The value of this non-dimensional nose gear load should fall in the range from 0.08 to 0.15. If the load is less than 0.08 when the c.g. is at the aft limit (where $N=N_a$), then the nosewheel has insufficient traction for steering. If greater than 0.15 when the c.g. is at the forward limit (where $N=N_f$), then too much load is on unbraked wheels. If necessary, the value of N should be adjusted (i.e., the location of the nose gear) to bring the values within limits.

Center of Gravity Location

At this stage in the design process, the forward and aft locations of the center of gravity are still unknown. It may be assumed that the reference center of gravity is located at 25% MAC for a transport aircraft, and 35% for a fighter. Approximate c.g. travel is shown in the following table.

Aircraft Type	C.g. Travel (% MAC)
Personal/Utility	10%
Commuter	12%
Regional Turboprop	16%
Business Jets	18%
Jet Transports	20%*
Military Fighter/Attack	20%

*Up to 24% with aft fuselage mounted engines

Source: Schaufele