V_s new = V_s old x √ (New weight ÷ old weight)

Higher TOM:
V_{mu} = Min unstick speed increase
Stalling speed higher
Gliding speed increase, gliding range unaffected
Fuel flow increase
Stick force increase
AOA increase
Drag increase
Landing distance increased
Manoeuvrability decrease
Range decrease
Rate of climb decrease
Safety margin reduced

CG:
Elevator & tailplane effectiveness in all flight conditions most likely to affect range & CG position

CG neutral:
CG aft located at CP

CG forward:
Stability increase
Stall speed increase
Stick force increase
Range decrease
Absolute ceiling decrease
Rate of climb decrease
Lower mileage
Moment arm longer = fuel consumption increase
Too fwd:

- Difficulty/inability to flare, nose wheel touch-down
- Require nose trim which increases fuel consumption
- Insufficient aft pitch control

CG aft:
Reduction in power for a given speed
Longitudinal static stability decrease
Less drag
Increased cruise range
Fuel consumption decreased
Determines minimum control speed V_{MCG}
Too aft:

- Difficulty/inability to recover from a spin
- Degradation/loss of nose wheel steering (weight on nose wheel decreased = reduced efficiency)

Extending landing gears:
Extend/retract forwards: CG moves **fwd**
Extend/retract rearwards: CG is **aft**

Contingency & reserve fuel: Used in "**unforeseen circumstances"**
Fly regulated TOM with both full traffic & fuel load: **Some** aircraft in **some** cases
Traffic load: Can be limited by the desired range (Short or long flight)
Fuel volume conversion: Done using standard fuel density values in **operations manual**

Useful load:

- TL + useable fuel
- TOM – DOM
- **Light aircraft:** Pilots, operating items, passengers, baggage, cargo & usable fuel

BEM:

- Determined by manufacturer & includes no additional equipment
- Is a component of DOM
- BEM = OM – crew – fuel load
- **Already includes unusable fuel & full operating fluids**

DOM:

- No TL & useable fuel
- TOM – TL
- BEM + operating items
- **INCLUDES CREW & THEIR BAGGAGE**

ZFM:

- TL, no fuel
- TOM – take off fuel

OM:

- No TL, with fuel
- DOM + fuel

TOM:

- Everything
- DOM + TL + TOF

LM: TOM – trip fuel

Mass Definition	Airframe, Engines	Removable Equipment (all roles) [1]	Unusable Fuel, Oil, Hydraulic Fluid	Variable Load (crew /crew baggage, catering, optional equipment)	Payload / Trafic Load	Fuel
Basic Empty Mass (**BEM**)	✓	✓	✓			
Dry Operating Mass (**DOM**)	✓	✓	✓	✓		
Zero Fuel Mass (**ZFM**)	✓	✓	✓	✓	✓	
Operating Mass (**OM**)	✓	✓	✓	✓		✓ (takeoff fuel)
Takeoff Mass (**TOM**)	✓	✓	✓	✓	✓	✓ (takeoff fuel)
Landing Mass (**LM**)	✓	✓	✓	✓	✓	✓ (fuel remaining)

TOF:

- Block fuel – taxi fuel
- Total fuel – unusable fuel

Ramp fuel = Trip + taxi + alternative + extra fuel

USG x 6 = lb
USG x 3.7852 = litres
lb x 0.454 = kg
Kg x 2.205 = lb
Inch x 2.54 = cm
Ft x 12 = inches
SG AVGAS = 0.71
SG JET A1 = 0.8
Lb/ft^2 = x 0.454 ÷ (1 ÷ 3.28)^2

MFZM:

- Is a **structural limitation,** listed in the **flight manual**
- A regulatory limitation, based on maximum bending moment at root , **inner wing** tanks fuel consumed first
- Max load factor +2.5G
- Bending moment/strength of wing root
- Maximum mass an aircraft can be loaded to **without usable fuel**
- **DOM + traffic load**
- Limits traffic load on **short flights**

Max certified mass: **Structural limitation**
Max **regulated** mass: Lower of **structural & performance limitation**
Max taxi ramp mass:

- Governed by structural considerations, fixed value in flight manual
- Max mass aeroplane may be loaded prior to engine start

Max landing mass: Restricted by structural & performance limits, & strength of runway
Max structural landing mass: Total aircraft mass upon landing under normal circumstances
Max take-off mass:

- Limited by **altitude & temperature** of departure airfield
- Limits traffic load on **long flights**

Max floor load: Max load per unit area
Above performance limited landing mass:

- Not enough sufficient runway length to stop safely
- Tyre temperature limits exceeded
- Physical damage might be suffered as a result of the extra mass
- Go around might not be achievable

Jettison: Reduce mass to a safe level at or below the regulated landing mass

Baggage:

- Intercontinental: 15kg
- Europe & all others: 13kg
- Domestic: 11kg
- Exceeded baggage mass: Must determine actual mass of such baggage by weighing or adding additional mass increments
- Standard masses for baggage only for aircraft with **20 seats** or more
- No baggage (For aircraft <19 seats) = Deduct 6kg

Person mass:
Flight crew 84kg (Baggage included)
Cabin crew 75kg (Baggage included)
Child 35kg regardless

Passenger seats	20 and more		30 and more
	Male	Female	All adult
All flights except holiday charters	88 kg	70 kg	84 kg
Holiday charters*	83 kg	69 kg	76 kg
Children	35 kg	35 kg	35 kg

Passenger seats	1 - 5	6 - 9	10 - 19
Male	104 kg	96 kg	92 kg
Female	86 kg	78 kg	74 kg
Children	35 kg	35 kg	35 kg

Passengers:

- Weighing machine at least **150kg** graduating at **500g**
- Ages: Infant <2, child >2 – 12<, adult >12
- **Verbal statement if aircraft seats <10**

Flight crew:

- 85kg, cabin crew: 75kg, inclusive of hand baggage allowance OM: DOM + take off fuel

TOM:
Limited by whichever is lowest:

- MTOM
- MZFM + take off fuel
- MLM + trip fuel/fuel burn

If question does not say limiting, TOM = DOM + TL + take-off fuel

LM = TOM – trip fuel

Traffic load = TOM - OM
Useful load = TOM – DOM or TL + Useable fuel

Total fuel **loaded** includes **taxi fuel**

Traffic load established by **actual weighing** the mass in accordance to standard masses in EASA AIR ops

CG:

CG:

- Computed along longitudinal axis
- Weight acts parallel to gravity
- Point where mass acts vertically downwards
- CG position **NOT** affected by **stabiliser trim/horizontal stabilizer**
- CG safe range includes both limits

Datum:

- Fixed **vertical plane** from which all the arm distances are measured
- A **reference plane** chosen by manufacturer, given in **aircraft flight/loading manual**
- Datum at nose: All moments positive
- Moments ahead of datum: Negative arm & negative moment
- Located at a **convenient point** which may not be **physically** on the plane, not necessarily between nose & tail

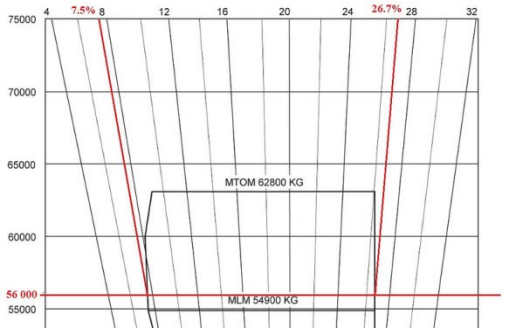
Moment/balance arm: Distance from **datum to CG**

Station: A particular point in relation with datum, identified by a number designating distance from datum

CG = Total moment ÷ total mass

Force = Mass x acceleration (m x a)

Moment (Nm) = mass x distance from datum = **force x arm (F x d)**



Load intensity is in kg/foot^2

CG can be expressed in relation to **MAC (%)**, distance from **leading edge**

MAC %= CG distance from Leading edge ÷ Mac Leading edge distance X 100%

Weighing procedures:

- Not required: Ensuring all fuel & oil tanks are full
- Not required: Drain all engine tank oil
- In an enclosed hangar, clean, complete & fluids accounted for
- Every **9 years fleet masses**
- Every **4 years individual masses**
- Interval between **two fleet mass evaluations must not exceed 48 months**
- **3** points of support
- Weighed on initial entry, records have not been adjusted for mods, every 48 months unless "fleet masses" is used, change of CG exceeds +/- 0.5% of MAC, change of DOM exceeds +/- 0.5% of MLM
- BEM: Recorded in **weighing schedule** & is amended to take account of changes **due to modifications of the aeroplane**

Aeroplanes per fleet

- 2/3 = n
- 4 – 9 = (n+3)/2
- >10 = **(n+51)/10**

Indexes:

- A figure without unit of measurement which represents a moment, simplified & scaled down
- Used to simplify calculations
- **Decrease magnitude** of the **moments**
- Reduced dimensions of the moments thus making it easier to calculate
- Divide high magnitude moments by a constant & thereby simplify calculations by decreased values
- DOI = Dry operating mass index
- **DOI = DOM x CG arm ÷ constant**
- Fuel index: **Used to calculate the correct position of the CG** due to the different locations of fuel tanks

M&B document signed, **acceptable last minute changes must be documented**

**Be aware of ZFM or TOM*

For fuel mass index not given, use the next highest index

New total moment = old total moment +/- load shift (m)
Mass to be moved ÷ Total new mass = Distance CG moves ÷ distance moved load is from CG

Distribution of mass using load sheet:
Measure CG old to new, length compare to corresponding cargo compartments
Add values divide by 4

Cargo handling:
Palletized: Individual/multiple items stored on pallets & secured with nets & straps
Passenger baggage:

- Personal belongings should be placed **as baggage in special containers**

Bulk cargo:

- Rush bags, last minute baggage & cabin crew baggage is held in **bulk cargo**
- Late arrival & crew baggage

Containers:

- Can be connected directly to aircraft & each container has its own manifest
- Standard size: Designed to fit & lock into cargo compartment for maximum space efficiency

Traffic load: Must be **fixed** during flight so that **only previously calculated movements of CG due to fuel burn can occur**
Tie downs: Prevent loads from moving & to remain within CG limits of aircraft, avoid unplanned CG movement & aircraft damage

Floor load = Load ÷ pallet size

Surface load (kg/m^2 or kg/ft^2) = load ÷ (length x width)
Running/linear load **(N/m or kg/m)** = load ÷ length