Masses – Components of Take-Off Mass

[B] **Basic Empty Mass** (BEM): The mass of an aeroplane plus standard items such as: unusable fuel and other unusable fluids; lubricating oil in engine and auxiliary units; fire extinguishers; pyrotechnics; emergency oxygen equipment; supplementary electronic equipment.

+ [V] **Variable Load** (VL): Mass of operational items for a specific type of operation. Includes items such as, crew and crew baggage; catering and removable passenger service equipment; potable water and lavatory chemicals; food and beverages.

+ [T] **Traffic Load** (TL): Also known as payload. The total mass of passengers, baggage and cargo, including any 'non-revenue' load.

+ [F] **Take-Off Fuel**: The total mass of usable fuel loaded for a flight excluding taxi fuel.

= [TOM] Take-Off Mass

[D] **Dry Operating Mass** (DOM): Basic Empty Mass + Variable Load. The total mass of the aeroplane ready for a specific type of operation excluding usable fuel and traffic load. The DOM is determined by the operator as the selection of equipment and composition of crew may vary.

+ [U] **Useful Load** (UL): Traffic load + Fuel. *the total mass of the passengers, baggage and cargo, including any non-revenue load and usable fuel*

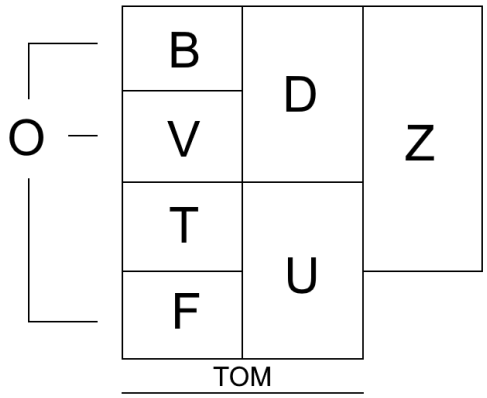
= [TOM] Take-Off Mass

- Traffic Load = [O] **Operating Mass** (OM): *DOM plus fuel but without traffic load*

- Fuel = [Z] **Zero Fuel Mass** (ZFM): *DOM plus traffic load but excluding fuel*

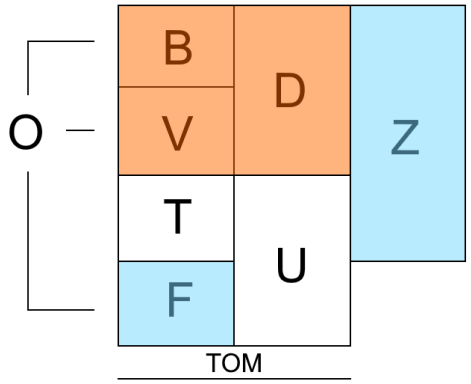
Mass Mnemonic

To remember the components of the take-off mass (i.e. the all up mass at take-off). Memorise **"B**ig **V**ans **T**ravel **F**ast **D**own **U**nder in **OZ"** and draw a sketch with the masses like the following diagram:



Examples:

- BEM + VL = DOM
- ZFM + Fuel = Take-off Mass
- BEM+VL+TL+Fuel are four components adding up to TOM
- DOM+UL are two components adding up to TOM



Limiting Masses

Maximum Zero Fuel Mass (MZFM): The maximum permissible mass of an aeroplane with no usable fuel. It ensures the maximum bending value of the wing at the wing root is not exceeded.

Maximum Structural Taxi/Ramp Mass: The structural limitation of the mass of the aeroplane at commencement of taxi.

Maximum Structural Take-off Mass (MSTOM): The maximum permissible total aeroplane mass at the start of the take-off run.

Performance Limited Take-off Mass (PLTOM): The take-off mass subject to departure aerodrome limitations.

Regulated Take-off mass (RTOM): The lowest of the 'performance limited' and 'structural limited' take-off mass.

Maximum Structural Landing Mass (MSLM): The maximum total aeroplane mass on landing in normal circumstances.

Performance Limited Landing Mass (PLLM): The landing mass subject to the landing aerodrome limitations.

Regulated Landing Mass (RLM): The lowest of the 'performance limited' landing mass and 'structural limited' landing mass.

Other Masses

Take-off Mass (TOM): The mass of the aeroplane including everything and everyone contained within it at the start of the take-off run.

Taxi Mass: The mass of the aeroplane at the start of the taxi (at departure from the gate). Sometimes referred to as Ramp Mass.

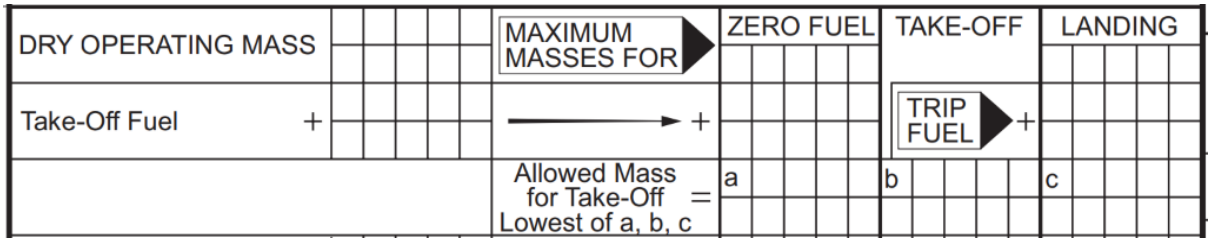
Landing Mass: The mass of the aeroplane at landing. Take off Mass – Trip Fuel = Landing Mass

Calculation of Maximum Values

To calculate the **Allowed Take-Off Mass (ATOM)**, determine the lowest of the following:

MZFM + Take-off Fuel	RTOM	RLM + Trip Fuel

As shown in figure 4.12 in CAP 696



To calculate the **Allowed Traffic Load**:

1. Calculate the ATOM, being the lowest of

MZFM + Take-off Fuel	RTOM	RLM + Trip Fuel

2. Calculate the maximum traffic load using
   Maximum Traffic Load = ATOM – DOM – T/O Fuel or ATOM-OM (or use Mass Mnemonic)

Note: Check the maximum traffic load does not exceed maximum hold capacity

To calculate the maximum **Fuel Load**:

1. Calculate the ATOM, being the lowest of: (Do not use MZFM)

~~MZFM + Take-off Fuel~~	RTOM	RLM + Trip Fuel

2. Calculate the maximum fuel load using
   Maximum Fuel Load = ATOM – DOM – Traffic Load or ATOM-ZFM (or use Mass Mnemonic)

Note: Take-off fuel does not include taxi fuel

Cargo

Tare weight: the weight of a container or object when it is empty

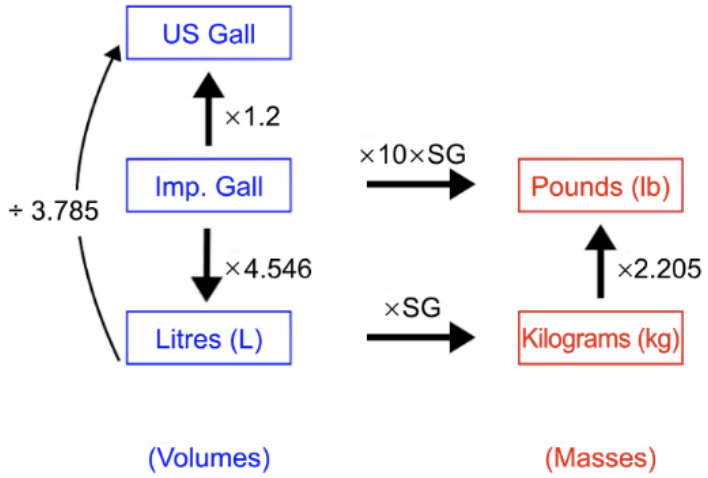
Cargo Loading Limitations:

- Maximum Floor Loading: mass per unit area
- Maximum Linear Load: mass per unit length

Conversions

Area: 1 lb/ft^2 = 4.88 kg/m^2

1 ft = 12 in



- If actual fuel density values are unknown, **standard values from Operations Manual** may be used

CG Calculations (Using Moment)

Mass * Arm = Moment

Aircraft CG = Total Moment / Total Mass

Dry Operating Index: Moment *divided with a constant*, used to simplify calculations

CG Shift Calculations (Ratio Method)

Lower case letters denotes the smaller mass and distance, upper case letters denotes the larger mass and distance.

Moving Mass:

$$\frac{m}{M} = \frac{d}{D}$$

m, mass moved
D, distance mass moved
d, CG shift
M, aeroplane mass

Adding or Removing Mass:

$$\frac{m}{M_O} = \frac{d}{D_N} \quad \text{or} \quad \frac{m}{M_N} = \frac{d}{D_O}$$

m, mass added or removed
d, CG shift

D_N, distance from mass to new CG
D_O, distance from mass to old CG

M_N, New aeroplane mass
M_O, Old aeroplane mass

Formula to be used depends on whether D_N or D_O / M_N or M_O is known. If both are known use either.

Effect of CG Position

Forward CG	**Aft CG**
Reduced manoeuvrability	Increased maneuverability
Increased longitudinal stability	Decreased longitudinal stability
Increased fuel consumption	Reduced fuel consumption
Decreased range	Increased range
Decreased rate of climb	Increased rate of climb
Insufficient aft pitch	Insufficient forward pitch

- **Failure of trim tank** may result in **reduced range,** due to fuel becoming unusable

Weighing of Aircraft

The operator should ensure an aircraft is weighed:

- Prior to **initial entry** into service.
- At intervals of **four** years if individual aircraft masses are used, or **nine** years if fleet masses are used.
- Whenever there are cumulative changes to the **dry operating mass exceed ±0.5%** of the **maximum landing mass.**
- Whenever there are cumulative change in **CG position exceeds ±0.5%** of the **mean aerodynamic chord.**
- If the effect of modifications on the mass and balance is not accurately known.

- Weighing should be accomplished in an **enclosed building**

Standard Masses (Not in CAP 696)

Flight Crew = 85kg
Cabin Crew = 75kg

Mean Aerodynamic Chord (MAC)

- Chord (length) of an imaginary rectangular wing with same longitudinal stability properties as the real wing

Limiting Values for Traffic Load

- Short flights: Maximum Zero Fuel Mass
- Long flights: Maximum Take-Off Mass