Mass and Balance

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01 Purpose of Mass and Balance Considerations

Mass limitations

- increase mass → increase stall speed

$$V_{s_{new}} = V_{s_{old}} \cdot \sqrt{\frac{m_{new}}{m_{old}}}$$

Centre-of-gravity (CG) limitations

- operator can add own limitation to be more restrictive
- Range of CG → determined by elevator

CG forward

- Rate of climb decrease
- elevator control are heavy → more difficult to manoeuvre
- excessively stable
- ceiling reduction
- determine stall speed

CG Aft

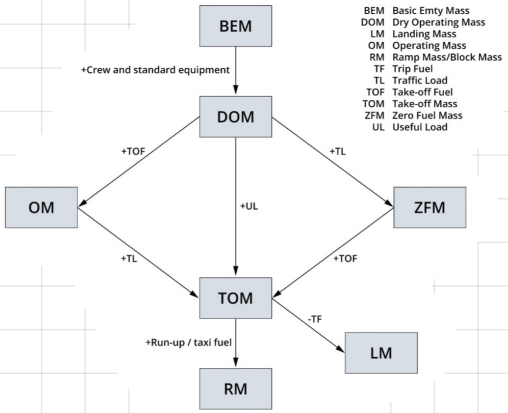
- Determine min control speed
- low stability
- controllability increases

02 Loading

Terminology

1 Kg = 2.2 lbs

1 USG = 3.785 l



BEM Basic Emty Mass
DOM Dry Operating Mass
LM Landing Mass
OM Operating Mass
RM Ramp Mass/Block Mass
TF Trip Fuel
TL Traffic Load
TOF Take-off Fuel
TOM Take-off Mass
ZFM Zero Fuel Mass
UL Useful Load

Mass limits

MZFM: bending moment / strength at wing root
↳ calculated at +2.5 g

floor loading: $\frac{mass}{m^2}$

mass calculation

Baggage

- Standard masses only if > 20 seats
- Hand bagages included in PAX calculation

Passengers

- verbal statement if aircraft seats < 10
- Crew not included in TL calculation
- Ages: infant < 2, child > 2-12, adult > 12

Person mass

- Children 35 kg

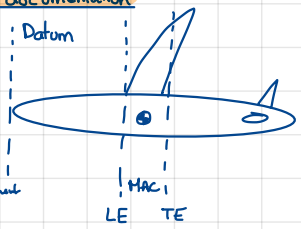
Maximum Take-off mass

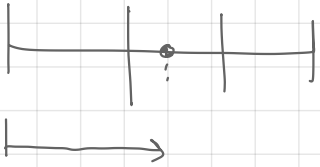
Lowest of:
- MTOM
- MLM + trip fuel
- MZFM + TO fuel (everything except taxi fuel)

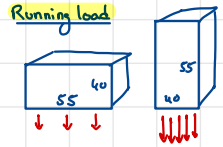
04 Mass and Balance Details of Aircraft

Contents of mass-and-balance documentation

- CG limits are found in the AFM (limitation section)
- Tailplane has no impact on CG
- Station: location identified by a number (distance from datum)
- Datum: fixed vertical plane → arm measurement
- $\frac{L - LEMAC}{MAC} \cdot 100$







Determination of aircraft empty mass and CG by weighing

- Weigh every 4 years or every 9 years if fleet
- Weighing in enclosed building
- Weigh when change to DOM > ±0.5 % of max landing mass
- BEM and CG noted in Weighing report
- BEM recorded in weighing schedule + amended to take account of changes

05 Determination of CG Position

Methods

Index

- Simplifies calculation of moments (reduces dimension)
- ex: $\frac{moment}{100}$
- DOI: position of CG at DOM

$$DOI = \frac{DOM \cdot GG}{Constant} = \frac{\sum M_{DOM}}{12'000}$$

Load and trim sheet

Repositioning of CG

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

m: mass to move
M: total mass
d: distance CG moves
D: distance mass moves

New total moment = old total moment ± load shift [m]

06 Cargo Handling

- Containers lock to restraint + have own manifest
- palletized cargo consists of multiple cargo boxes on pallets stored in cargo hold
- large cargo (irregular shape) is best loaded in pallets / palletised