Memo 8: Flight Planning

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Contents

1. The Pilots Operating Handbook

- Each aircraft has a dedicated POH
- Contains operating procedures, aircraft data and performance
- Supplements may be issued by the manufacturer, in which case they MUST be incorporated into the POH
- The state of registration may also issue supplements, which override the manufacturer
- Terms used:
  MAUW maximum all up weight
  CofG limits centre of gravity
- Beware, POH units may not be consistent throughout
- POH performance figures are generally unfactored and have no safety margin
  - Figures for dry, level, hard runway in ISA
  - Variations must therefore be accounted for

2. Mass and Balance

- Definitions:
  MTOM maximum take-off mass
  MLM maximum landing mass
  MZFM maximum zero fuel mass
  BEM/BEW basic empty mass
  UF usable fuel
  TL traffic load
  DOM dry operating mass
  Payload the spare mass for pax and luggage
- An aircraft has a designed maximum weight, MAUW or MAUM
  - Might be different for take-off and landing
- Mass includes:
  - Actual weight of the empty aircraft
    - equipment
    - engine oil
    - unusable fuel
  - pilot
  - crew
  - pax
    - actual weight is best
    - commercial flights use a standard weight from PART-OPS 1
  - baggage
  - fuel
- Aircraft empty mass is measured by a weighing report
  - Must be legally reweighed if equipment is instaled or removed, or a paint respray

- Mass and CofG must be within certain limits
- Different CofG values affect handling
- An empty a/c will have a predetermined CofG
- CofG is given in reference to a datum, e.g. the firewall
- After calculations, mass and balance figures must fall within the area specified in the POH
  - Must be checked for loaded weight and ZFM/ZFW to ensure stays within acceptable area

3. Factors affecting Performance

- Many factors, can be split into three areas:
  - Aerodynamic
  - Thrust
  - Generic
- Aerodynamic factors
  - Air density (effect on lift)
  - Airframe age and condition
    - Weight gain through corrosion, polish layers, dust and dirt, etc.
    - Cleanliness
- Thrust factors
  - Air density (effect on engine)
  - Engine age and condition
  - Propellor age and condition
- Generic factors
  - Pilot skill and experience on type
  - Groundspeed/TAS relationship
- Application of factors
  - Generic numbers are available, but use manufacturer numbers if possible
  - Since every a/c is different, an additional safety factor must be applied at the end of the calculations
  - All factors must be multipled together and applied to take-off distance and landing distance
- The generic safety factors are:

	TAKE-OFF		LANDING	
CONDITION	INCREASE IN TAKE -OFF DISTANCE TO HEIGHT 50 FEET	FACTOR	INCREASE IN LANDING DISTANCE FROM 50 FEET	FACTOR
A 10% increase in aeroplane weight, e.g. another passenger	20%	1.20	10%	1.10
An increase of 1,000 ft in aerodrome elevation	10%	1.10	5%	1.05
An increase of 10°C in ambient temperature	10%	1.10	5%	1.05
Dry grass* - Up to 20 cm (8 in) (on firm soil)	20%	1.20	15%+	1.15
Wet grass* - Up to 20 cm (8 in) (on firm soil)	30%	1.3	35%+ Very short grass may be slippery, distances may increase by up to 60%	1.35
Wet paved surface	-	-	15%	1.15
A 2% slope*	Uphill 10%	1.10	Downhill 10%	1.10
A tailwind component of 10% of lift-off speed	20%	1.20	20%	1.20
Soft ground or snow*	25% or more	1.25 +	25%+ or more	1.25 +
NOW USE ADDITIONAL SAFETY FACTORS (if data is unfactored)		**1.33**		**1.43**

4. Density Altitude

- Air density affects lift and engine parameters
- Air density is affected by atmospheric pressure, air temperature and humidity
- As you climb:
  - Pressure decreases ∴ density decreases
  - Temperature decreases ∴ density increases
  - All factors must be considered
- To calculate:
  - Get pressure altitude
    - Remember! This is the altitude with SPS set on subscale!
  - Perform temperature correction
  - Easiest with a flight computer

5. Take-off Performance

- Definitions:
  TODA Take-off distance to 50ft obstacle
  EDA/ASDA Distance to accelerate and stop on the runway and stopway
  $\boldsymbol{V_y}$ best rate of climb (maximise y)
  $\boldsymbol{V_x}$ best angle of climb (minimise x)

- Factors affecting take-off performance
  - Headwind
    - POH will contain the factor for headwind, otherwise assume no headwind
  - Tailwind
    - Use factor
  - Flap
    - Decreases ground run
    - Decreases rate of climb
  - Mass
  - Runway surface
  - Runway gradient
    - As a rule of thumb, the a/c must be able to climb at twice the angle of the runway
  - Density altitude

- Linear interpolation may be required to read from tables in the POH

- If TODA isn't published for a runway, your calculated take-off distance figure must fit within available runway length.

6. Climb Performance

- For a climb, we want more lift than weight
  - Lift can be increased by:
    - Airspeed
    - AoA
  - Increasing lift also increases drag
  - Performance is a factor of power or thrust available to produce lift and overcome drag

- By viewing a thrust curve (speed - thrust available and req'd), you can establish the best angle of climb speed, V_x, by the global maximal difference between thrust available and thrust required (to remain airbourne)
  - Thrust is a function of power, but does not take into account the amount of work per unit time

- By viewing the power curve (speed - power available and req'd), you can establish the best rate of climb speed, V_y, by the global maximal difference between power available and power required (to remain airbourne)
  - Power takes into account the amount of work per unit time

- Rules of thumb:
  - V_x and V_y decrease by 1kt for eveny 100lb lower than the a/c MAUW
  - V_y decreases by 1kt for every 1000ft increase in density altitude
  - V_x increases by 1kt for every 1000ft increase in density altitude

- Rules of thumb for cruise climb:
  - Once we are clear of the ground, we can climb for best fuel efficiency and journey progress
  - As a rule of thumb, if not provided in the POH:
    - $V_{\text{cruise climb}} = V_y + (V_y - V_x)$
- If you are "on the back of the drag curve", you are in the region where more power is required just to stay aloft (i.e. close to a stall but not quite there)

7. Cruise Performance

- The maximum level flight speed is found where the power available meets the power required
- Best endurance speed
  - Found by the point where a tangent drawn to the power required line is horizontal on the power curve
- Best range speed
  - Range is a function of speed and power
  - Found by the point whose tangent to the power required curve meets the horizontal axis at the speed of the head-/tail-wind component
  - decreased by a tailwind
  - increased by more a/c weight
- Effect of CofG on performance
  - The tail produces a downwards force to pitch the nose up
  - If the CofG moves:
    - forwards: more downforce is required from the tail plane, adding weight to the a/c, resulting in a higher AoA and more drag
    - aftwards: performance increases
- Cruise performance varies by density altitude, via engine power and aerodynamics
  - Airspeed can be misread due to errors:
    - Insturment error
    - Position error
    - Density error
    - IAS vs CAS vs TAS
- Take advantage of tail winds!
  - Recall as well that winds veers (+) as altitude increases and backs (-) as altitude decreases
- Glide angles will be specified in the POH, but to convert to a glide distance, it is worth using the flight computer
  - Heavier aircraft need to glide faster!
    - same glide distance, rate of descent increased!
  - Headwinds and tailwinds do not affect the rate of descent in a glide, but change the effective gliding angle
  - A windmilling propellor adds significant drag
    - If airspeed is reduced to almost stall speed to stop windmilling, an extra 20% glide performance can be achieved
- Cruise performance is also affected by:

- Rain
- Ice
- Flap

8. Landing Performance

- Definitions:
  LDA Landing distance available (from a 50ft obstacle)
  V_{mc} minimum control speed (twin engine a/c only)
  V_{ref} landing reference speed, used at the 50ft obstacle height
  V_{at} approach threshold speed
    - The speed to perform the approach in landing configuration
    - dirty stall speed $+30\%$
- Factors affecting landing performance
  - Headwind
    - Decreases landing distance
    - Increases effective descent angle
  - Tailwind
    - Increases landing distance significantly
    - Decreases effective descent angle
  - Flaps
    - Increased lift
    - Increased drag
    - Lower nose attitude
  - Mass
    - An increase of mass increases landing distance
  - Runway surface
    - Anything other than dry hard paved surface will need a factor applied
  - Runway gradient
  - Density altitude
- A final safety factor of 1.43 must be applied
  - accounts for non-perfect piloting, a worn engine, dirty airframe, and unforseen circumstances

9. Performance Graph References

- In the exams:
  - CAP696, CAP697, CAP698

10. Flight Planning

- Referencing the Earth
  - Latitude

  - Longitude
  - as either decimal degrees, or degrees, minutes and seconds

- Distance is difficult, as the width between longitudes is inconsistent at different latitudes

- However, latitude is easier, 1 minute of latitude is one nautical mile

- Celestial navigation can be used to determine true North
  - Magnetic North is not quite the same as True North
  - The magnetic field can also be bent around geographic features, but this can be plotted
  - Isogonals show lines of equal magnetic variation
    - When applying magnetic variation, remember "West is best (+), East is least (-)".

- Route planning
  - Charts show obstructions >328ft AGL
  - All heights are typically AMSL
  - Altimeter setting regions are split by lines of barbells
  - Remember that flying below airspace requires you to use the QNH of that airspace, not the regional setting

- Fuel planning:
  - You must land with at least 30 minutes (day VFR) or 45 minutes (night or IFR) endurance after landing
  - Best practice, hold enough fuel for route + 5% + diversion + final reserve + 15 minutes of cruise fuel for takeoff, taxi, etc.

- Check NOTAMs
  - https://nats.aero/ais
  - Additional last minute notifications can be found by calling the AIS briefing line: 0808 535 4802 (or +441489 887 515).
  - a guide to decoding NOTAMs

- File a flight plan
  - Required if crossing an FIR boundary
  - Must be submitted at least 60 minues prior to off blocks
  - Remember to close it after the flight!

11. Flight Monitoring

- A good flight plan has:
  - Fuel planning
  - Pre-flight information
  - Flight leg spaces
  - Fuel management
  - Ordered log space
  - Reference information

- Plan Maintenance
  - Keep up-to-date
  - Monitor your track
  - Amend ETAs as you go

- Record notable in-flight events
- Keep track of how much fuel you have and have left