Performance

FAA Handbook Aeronautics
Chap 10
Aircraft Performance

- Landing distance
- Takeoff distance
- Rate of Climb
- Ceiling
- Payload
- Range
- Speed maneuverability
- Stability
- Fuel economy
Factors

• **Aerodynamic Characteristics** → Power and Thrust at various conditions of flight

• **Powerplant** → power and thrust available at various flight conditions
Straight and Level Flight

• Steady, level flight:
  – Lift = Weight
  – Thrust = Drag

• Remember Drag = induced (from lifting) + parasite
  – Parasite drag from high speed
  – Induced drag from low speed
Effect of Speed on Drag

- Accelerating from 100 knots to 200 knots:
  - Parasite drag increases 4 X
    - Power required to overcome drag is 8 X
  - Induced drag is ¼
    - Power to overcome is ½
Min and Maximum Level-flight Speed

• Maximum speed for level flight when:
  – Max thrust is applied

• Minimum speed for level flight when:
  – Stall speed
  – “Stability” speed
Climb Performance

• Energy provided by:
  – Excess thrust required for level flight
    • Excess thrust = Max Thrust – Thrust for level flight (e.g. 70 = 200 – 130)
  – Trading off kinetic energy (i.e. speed) for potential energy (i.e. altitude)
Maximum Angle of Climb (degrees)

• Greatest difference between Thrust Available and Thrust required
  – Propeller driven aircraft, maximum excess thrust and angle of climb will occur at speed approx stall speed

• Important for obstacle clearance
Maximum Rate of Climb (ft/min)

- Greatest difference between Power Available and Power Required (i.e. Excess Power)
- Rate of Climb $\rightarrow$ Excess Power
- Angle of Climb $\rightarrow$ Excess Thrust
Impact of Speed on Climb Performance

- As speed increases → Excess power/Thrust decreases
Impact of Weight On Climb Performance

• Change in weight:
  – Changes the drag and power required
  – Increase in weight reduces the rate-of-climb
Impact of Altitude on Climb Performance

- Increase in altitude increases power required (and decreases power available)
- Climb performance diminishes with altitude
- Absolute ceiling of the aircraft is where min and max speeds converge
  - = Zero rate of climb
  - = Coffin corner
- Service ceiling = Rate-of climb = 100 ft/min
Terminology

• **Powerloading** (pounds per horsepower)
  – Total weight/Rated Horsepower of engine
  – Determines takeoff and climb performance

• **Wing loading** (pounds per square foot)
  – Total weight/Wing area
  – Determines landing speed
Range Performance

• Range performance:
  – Extract maximum flying distance from a given fuel load
  – Fly a specified distance with minimum expenditure of fuel

• Ability to convert fuel energy into flying distance
Range vs Endurance

**Endurance**

Specific Endurance = flight hours/pounds of fuel

OR

flight hours/hour / pounds of fuel/hour

OR

1/fuel flow (pounds or gallons)

• Maximum Endurance = minimum fuel flow

**Range**

Specific Range = nm/ pounds of fuel

OR

nm/hour / pounds of fuel/hr

OR

knots/fuel flow

• Maximum Range = maximum of speed per fuel flow
Range Vs Endurance

Diagram showing the relationship between fuel flow/power required and speed, highlighting points for maximum endurance and maximum range at altitude and L/D max.
Specific Range

• Affected by:
  – Aircraft Gross Weight
  – Altitude
  – Aerodynamic configuration of the aircraft
Region of Reversed Command

• Normal command = higher airspeed requires higher thrust (at level flight)

• Reversed command = higher airspeed requires lower power (and lower airspeed requires higher thrust)
  – Low speed region of flight