Performance Aide Memoire

Take-Off(T/O) Class B

No Stopway or Clearway	TOD x 1.25 ≤ TORA
If Stopway or Clearway	TOD ≤ TORA
	TOD x 1.15 ≤ TODA
	TOD x 1.3 ≤ ASDA

Note: clearway length limited to 50% of TORA.

Surface Corrections

Grass	Dry	1.2
	Wet	1.3
Paved	Wet	1.0

Slope

Upslope up to 2%*	5% per 1% upslope
Downslope up to 2%	Nothing

*Upslope greater than 2 % requires Authority approval.

Wind (factored in CAP graphs)

Headwind	Max 50% of reported
Tailwind	Max 150% of reported

Class B Twin

V_R	Is the faster of 1.05 V_{MC} or 1.1 V_{S1}
V_2 (V_{TOSS})	Is the faster of 1.1 V_{MC} or 1.2 V_{S1}

Contaminated Runways – T/O inadvisable; delay take off.

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Climb

MEP

Both Engine Operating	
Gradient	After T/O ≥ 4%
Speed	≥ 1.2 V_{S1} and 1.1 V_{MC}
One Eng Inop	(assumes no fail prior to 300ft)
Gradient	400ft above measurably positive
	At 1500ft ≥ 0.75%
Speed	≥ 1.2 V_{S1}

Obstacle Clearance

Must clear obstacles by 50ft or miss horizontally.

Departure Sectors	= 60m+½ WS + (0.125 x D) (until specified Domain Width)
Turn Limits	Above 50ft and 15° max AOB

Lateral Distances

	≤ 15° Track Change	> 15° Track Change
VMC/Good Navigation	300m	600m
IMC/ Other Conditions	600m	900m

NTOFP (Assumes failure of critical engine when visual reference expected to be lost)

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Twin Engine Gradient	From 50ft twin engine gross factored by 0.77
One Engine Gradient	Use single engine gross gradient
Wind correction	For obstacle clearance use 50% for headwind and 150% for tailwind

EN-Route

SEP – Glide to a suitable safe forced landing area (assumes 1000ft above).

MEP – Must be able to maintain above the minimum safe altitude to a point 1000ft above aerodrome. Planned gradients following an engine failure are: climb reduced by 0.5% and descent increased by 0.5%.

SEP and MEP – Maximum planned altitude when climb rate 300fpm.

Landing

Full stop landing from 50ft* above threshold ≤ 70% of LDA. (Divide by 0.7 or times by 1.43)

*Authority may approve less that 50ft but no lower than 35ft.

Important that a/c achieves reference speed and height; impact of being fast at barrier height is the square of the error i.e if 10% fast then distance > by 21% (1.1x1.1=1.21).

Surface Corrections (compounded if required)

Grass	1.15
Wet	1.15

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Slope

Downslope up to 2%	5% per 1% upslope
Upslope up to 2%	Nothing

Wind (factored in CAP graphs)

Headwind	Max 50% of reported
Tailwind	Max 150% of reported

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Class A

V Speeds Relationships

$V_{EF} < V_1 \leq V_R < V_{LOF} < V_2$ $V_{LOF} < V_{TYRES} < V_2$

$V_{MCG} \leq V_{EF} \leq V_1 \leq V_{MBE}$ and V_R

V_1, V_R and V_2 increase with increased T/O weight (assuming R/W not limiting).

V_1 and V_{MBE} reduce with downslope and tailwind.

Requirement	V_R	V_{2MIN}	V_{REF}
V_{MC}	General Rule 5% 1.05 V_{MC}	General Rule 10% 1.1 V_{MC}	Class B (twin) 5% Class A 0%
Stall	General Rule 10% Class B (twin) 1.1 V_{S1} Class A (all engine) 1.1V_{MU} at V_{LOF} (aero limit) 8. V_{MU} at V_{LOF} (geom limit) 1 Eng Fail 1.05V_{MU} at V_{LOF} (aero limit) 1.04 V_{MU} at V_{LOF} (geom limit)	General Rule 20% Class B (twin) 1.2 V_{S1} Class A 1.13 V_{SR1} Class A (4 eng turboprops and some 4 eng turbojets) 1.08 V_{SR1}	General Rule 30% Class B (twin) 1.3 V_{S0} Class A 1.23 V_{SR0}

Note: Class B (twin) figures included for ease of reference only.

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Screen Heights

Dry	35ft
Wet	15ft

T/O Distance and Run

T/O Distance Dry (TOD_{dry})	Greater of TOD_{N-1dry} or 1.15 x $TOD_{N\ dry}$
T/O Distance Wet	Greater of TOD_{N-1wet} or TOD_{dry} (result from line above)
T/O Run Dry	Greater of TOR_{N-1dry} or 1.15 x $TOR_{N\ dry}$
T/O Run Wet	Greater of TOR_{N-1wet} or 1.15 x $TOR_{N\ wet}$

Note: TOR is generally measured from start of T/O to a point equidistant between V_{LOF} and the point at which the a/c is 35ft above T/O surface; exception TOR_{N-1wet} which is between start of T/O and the point at which the a/c is 15ft above T/O surface.

Accelerate Stop Distance (ASD)

ASD must be considered for both all engine and the critical engine out case.

ASD on dry runway: greater of ASD_N and ASD_{N-1} - no account for reverse thrust can be applied.

ASD on wet runway: greater of ASD on a dry runway (as above) and the ASD_N and ASD_{N-1} for a wet runway (using the wet values for V_{EF} and V_1) - the effects of reverse thrust can be applied to the wet runway ASD_N and ASD_{N-1}.

In calculating distances, the speed at which the pilot takes the first action to reject is at V_1. In all cases, there is a distance equal to the distance covered in 2 seconds at V_1 added to the acceleration and deceleration distances.

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RLTOM increases when:

Temperature and airfield altitude decreases, the runway is longer or slopes down, there is a Headwind, with larger flap settings, air conditioning packs OFF and with engine anti-ice OFF.

CLTOM (Also known as MAT/WAT)

PLTOM is lowest of RLTOM/CLTOM/Tyre Limited Mass and Obstacle Limited Mass.

RTOM is lowest of PLTOM and MSTOM; which is greatest Mass for T/O.

<u>Obstacle Clearance</u>

- Minimum obstacle clearance 35ft

Departure Sectors	= 60m + ½ WS + (0.125 x D) (until specified Domain Width) Unless a/c WS > than 60m in which case = 90m + (0.125 x D)
Turn Limits	Above 50ft and 15° max AOB

- Turns in the NTOFP reduce climb performance and increase the stall speed, so there are additional requirements:
    - The turn must not be commenced below 50ft, or half of the wingspan of the aircraft, whichever is greater
    - The angle of bank must not exceed 15º below 400ft, and above this not exceed 25º
    - If > 15º AOB then obstacle clearance increases to 50ft.
    - Allowance must be made for effect on gradient and speed. – flight manual gives decrement for 15º AOB at V_2.
        - For 20º, use 2 x decrement and V_2 +5kts
        - For 25º, use 3 x decrement and V_2 +10kts

CAT.POL.A.210 permits greater AOB with authority approval. Max angles 20º (200-400') 30º (400-1500'); 50ft min clearance once greater than 15° AOB.

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Lateral Distances

	≤ 15° Track Change	> 15° Track Change
VMC/Good Navigation	300m	600m
IMC/ Other Conditions	600m	900m

Reduced Thrust/Flex T/O (TOGA still available)

Restrictions:

- Icy or very slippery runways (NOTAM Slippery When Wet)
- Contaminated Runway
- Anti-Skid unserviceable
- Reverse Thrust unserviceable
- Increased V_2 procedure
- PMC off
- Adverse Weather (wind shear etc)

Derate (TOGA no longer available)

Gain a commercial advantage of slower V_{MCG} and V_{MCA} speeds.

Enables slower V_1, V_R and V_2 speeds. Used when cold and low pressure alt and/or low/low medium T/O weight.

Increased V_2

Used on long runways to increase CLTOM through higher speeds (move closer to V_{MD} and therefore increase excess thrust).

Threats V_{MBE} (hot brakes/fire, burst tyres) fast V_1 (high speed reject)

Performance Aide Memoire

Contaminated runway

Impingement Drag increases to Vp then decreases

NTOFP

Safety Factors*

1 Eng	2 Eng	3 Eng
0.8%	0.9%	1.0%

* These factors equate to 8/9/10 m over each kilometre, so not much of a margin.

Segment	1st	2nd	3rd	4th
Start	35'	Gear Retracted	Min 400'	Clean a/c at final segment speed
End	Gear Retracted	Min 400'	Clean a/c at final segment speed	1500'
Twin Eng Min %	0.0%	2.4%	1.2%*	1.2%
Three Engine %	0.3%	2.7%	1.5%*	1.5%
Four Eng Min %	0.5%	3.0%	1.7%*	1.7%
Gear Position	Down or Retracting	Up	Up	Up
Flap Position	T/O Setting	T/O Setting	Reduced in stages from T/O Setting	Up
Thrust	TOGA or Reduced Thrust	TOGA or Reduced Thrust	TOGA or Reduced Thrust	Max Continuous
Speed	At least V_2	At Least V_2	Increasing from V_2 to final segment speed	Final segment speed (approx. V_{MD})

Notes: 1) Min Eng gradients are gross, therefore, for twin net is 1.6% (2.4%-0.8%).

2) Second segment ends at a minimum of 400' above the T/O surface but many operators use a higher figure such as 800'. Additionally, if there is a high obstacle in the 3rd segment the 2nd segment will be extended to achieve greater height before the level off.

3) *Gradients in the 3rd segment are 'equivalent gradients',that are used to produce a minimum acceleration during flap/slat retraction.

En-Route –One Engine Inoperative (OEI)

In assessing en-route obstacle clearance gradients are based on net performance. For one engine inoperative gross gradients are reduced by the following:

- 1.1% for 2-engine aircraft.
- 1.4% for 3-engine aircraft.
- 1.6% for 4-engine aircraft.

Obstacle Clearance:

- Have a (possible) positive net flight path gradient at least 1000ft above all terrain and obstacles along route; either in the climb or having stabilised in level flight (Net level-off altitude) following a 'drift down'.
- 'Drift Down' obstacle clearance: minimum of 2000 feet clear of all terrain and obstacles along route during the 'drift down'.

Route considerations (CAT.POL.A.215): all terrain and obstructions along the route within 9.3 km (5 NM) on either side of the intended track in accordance with the following:

- The engine is assumed to fail at most critical point;
- Account is taken of the effects of wind;
- Fuel jettisoning is permitted (subject to maintaining required fuel reserves)

- The aerodrome meets the performance and weather requirements at estimated time of landing.
- If the navigational accuracy does not meet at least navigation performance 5 (RNP5) then the route width margins are increased to 18.5 km (10 NM).

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Destination/Alternate: the net flight path shall have a positive gradient at 1500ft above the aerodrome where landing is assumed to be made in the event of engine failure.

Landing

Maximum landing mass is the lowest of: Climb Limited Landing Mass, Runway Limited Landing Mass and the Structural Maximum Landing Mass.

Baulked Climb

Maximum mass at which a 3.2% gradient can be achieved given the following conditions:

- All engines operating at the power available 8 seconds after selecting TOGA from the flight idle setting.
- Aircraft in the landing configuration.
- Expected air density for the destination aerodrome, given forecast temperature and airfield elevation at time of landing.
- Climb speed ≥ 1.13 V_{SRO} or V_{MCL}, or ≤ 1.23 V_{SRO}.

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Discontinued Approach

Maximum mass at which the following gradients can be achieved:

- Twin 2.1%.
- 3-Engine 2.4%.
- 4-Engine 2.7%.

With the following conditions:

- Critical engine inoperative and remaining engine/s at TOGA.
- Normal approach speed but ≤ 1.41 V_{SRO} .
- Gear retracted and flaps in approach configuration.
- Expected air density for the destination aerodrome, given forecast temperature and airfield elevation at time of landing.

Discontinued Instrument Approach Climb

For instrument approaches with DH below 200’ the expected approach mass that allows a missed approach climb gradient, with critical engine failed, of the greater of 2.5% or the published gradient.

Landing Distance Requirements

Full stop landing from 50’ at the estimated landing mass:

- Within 60% of the LDA for a turbojet (apply a 0.6 or 1.67 factor as required).
- Within 70% of the LDA for a turboprop (apply a 0.7 or 1.43 factor as required).

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The following conditions must be met / taken into account:

- V_{REF} must not be less than 1.23 V_{SRO}.
- Aircraft in the landing configuration.
- Corrected for the airfield altitude and temperature.

- Factored for not more than 50% of the headwind and not less than 150% of the tailwind.
- The runway slope in the direction of landing if greater than ±2%.

Note: Authority may approve the use of landing distances using a screen height of less than 50' but not below 35'.

<u>Runway Selection</u>

Landing must be considered for both the forecast wind and in still air:

- In still air, the aircraft uses the most favourable (normally longest) runway.

- Using forecast winds, planning should be based on the runway most likely to be in use; considering wind direction, approach aids, terrain etc.

<u>Wet Runways</u>

If runway is forecast to be wet then landing distances must be increased by 15% unless a lower factor is specified in the aeroplane flight manual (CAP 698 MRJT is slightly less than 15%).

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Contaminated Runways

Contaminated = >25% coverage:

1. surface water more than 3 mm (0,125 in) deep, or by slush, or loose snow, equivalent to more than 3 mm (0,125 in) of water;

2. snow which has been compressed into a solid mass which resists further compression and will hold together or break into lumps if picked up (compacted snow); or

3. ice, including wet ice, with more than 3mm of water, slush or wet snow or compacted snow or ice.

If runway is forecast to be contaminated, the LDA must be the greater of:

- 115 % of the required dry landing distance, determined in accordance with OPS 1.515, or
- 115 % of the landing distance determined in accordance with approved contaminated landing distance data or equivalent, accepted by the Authority.