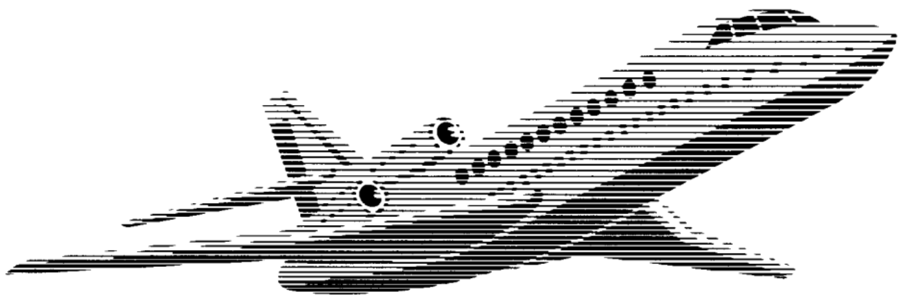
DASSAULT AVIATION

FALCON 50



OPERATING MANUAL

BOOK 1 SUPPLEMENT

PROCEDURES

PERFORMANCE

ORIGINAL: APRIL 16, 2021

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GENERAL INSTRUCTIONS

This supplement offers general performance information for landing.

This supplement is the whole section 6 of the Operating Manual. It can be used as a separate document or be manually inserted in the OM, at user's convenience.

The technical content of this document is approved under the authority of the DOA ref. EASA.21J.051

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LANDING - TABLE OF CONTENT

INTRODUCTION

This chapter describes the recommended method for computing the landing performances for Falcon 50 and 50EX based on Airplane Flight Manual (AFM).

The information presented in this chapter does not replace or supersede any AFM data.

This chapter is divided into the following points:

- Definition of landing speeds, distances and field length,
- Pre-flight or in-flight calculation process,
- Influence of operational conditions,
- Various examples of landing distance, field length calculations

The examples given in this document are based on Falcon 50EX data.

This sub-section, introduces definitions and parameters for computing landing performance:

- Definitions & runway characteristics
- Operational conditions

DEFINITIONS

LANDING SPEEDS

V_{MCL}: Minimum Control Speed during approach and landing

According to CS 25.149: *"V_{MCL}, the minimum control speed during approach and landing with all engines operating, is the calibrated airspeed at which, when the critical engine suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative, and maintain straight flight with an angle of bank of no more than 5 degrees"* .

V_{MCL} is the minimum calibrated airspeed at which the airplane is controllable in landing configuration, with a maximum bank angle of 5°, when one engine becomes suddenly inoperative and the other is operating at maximum take-off thrust.

V_S: Calibrated Stall Speed

V_S is the Calibrated Airspeed determined during the stall maneuver in the specific configuration.

V_S is determined by Dassault Aviation in the following configurations:

- CLEAN: Air brakes 2,
- CLEAN: Air brakes 0,
- SLATS,
- S+FLAPS 20°: Landing gear down,
- S+FLAPS 20°: Landing gear up,
- S+FLAPS 48°: Landing gear down.

V_{REF}: Reference Speed

V_{REF} is the minimum speed at which the airplane over flies the runway threshold at a screen height of 50 ft during a normal landing.

V_{REF} should not be less than:

- 1.23 V_S in S+FLAPS 48° landing configuration, AND
- V_{MCL}.

V_{RF}*: Reference Speed in case of failure

V_{RF*} is the minimum speed at which the airplane over flies the runway threshold at a screen height of 50 ft during a normal landing in the event of failure.

V_{APP}: Approach Speed

The Final Approach Speed (V_{APP}) is a trade-off between the handling qualities (stall margin, controllability / maneuverability) and the landing distance.

$$V_{APP} = V_{REF} + \underbrace{(1/2\ V_{HEADWIND} + V_{GUST})}_{\text{Wind correction}}$$

Wind correction must not exceed 20 kt

V_{GUST} = Gust - Wind velocity

NOTE
No recommended "Wind correction" for tail winds.

Flying the approach or a part of the approach at V_{REF} instead of V_{APP} is at PIC discretion.

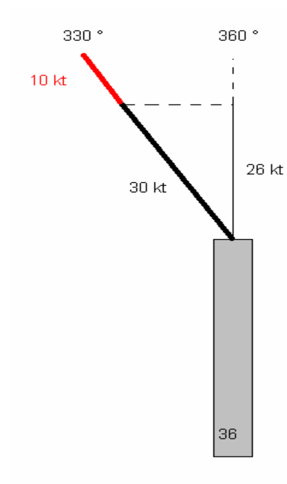
The wind correction or any add-on to V_{REF} (at PIC discretion) is called "Extra speed" or "Overspeed".

<u>Example</u>

- Runway 36 in use,
- ATC broadcasts Wind 330/30G40,

⇨ Steady state headwind component is 26 kt.
⇨ Gust factor is 10 kt.

⇨ Wind correction = 26 / 2 + 10 = 23 kt,
⇨ 23 kt > 20 kt (maximum Wind correction),
⇨ **$V_{APP} = V_{REF} + 20$ kt**.



Average Wind and Gust

ATC gives the two-minute average wind velocity and reports the gust if it exceeds the 2-min average by 10 kt.

The variation of the instantaneous wind during those two minutes commonly reaches half of the average value: for example for an average wind of 10 kt, the actual instantaneous wind can vary from 5 kt to 15 kt.

Approach speed in Emergency or Abnormal situations

When an emergency or abnormal procedure requires a "configuration correction" to V_{REF} the final approach speed becomes:

$$V_{APP} = \underbrace{(V_{REF} + \text{Configuration correction})}_{V_{RF}*} + \underbrace{(1/2\ V_{HEADWIND} + V_{GUST})}_{\text{Wind correction}}$$

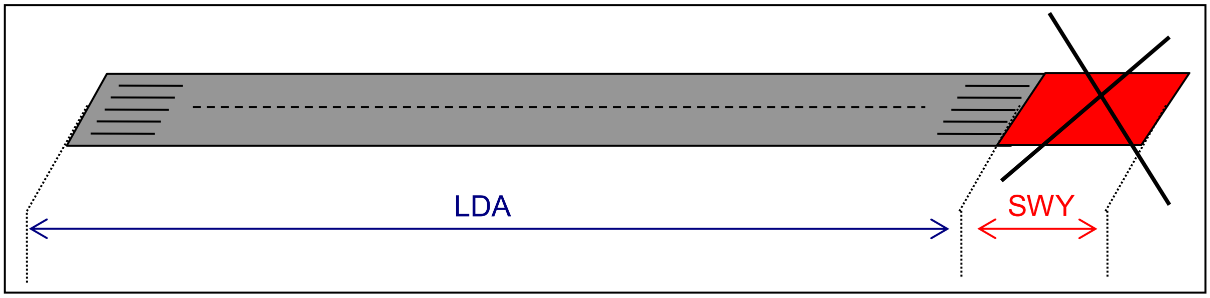
The "configuration correction" is usually stated in the abnormal / emergency procedure (refer to AFM / OM).
Flying the approach or a part of the approach at V_{RF*} instead of V_{APP} is at PIC discretion.

LANDING DISTANCES

Landing Distance Available (LDA)

Landing Distance Available (LDA) equals the available length from runway threshold to the end of the runway. Sometimes, the threshold may be displaced due to the presence of obstacle(s) below the final approach segment.

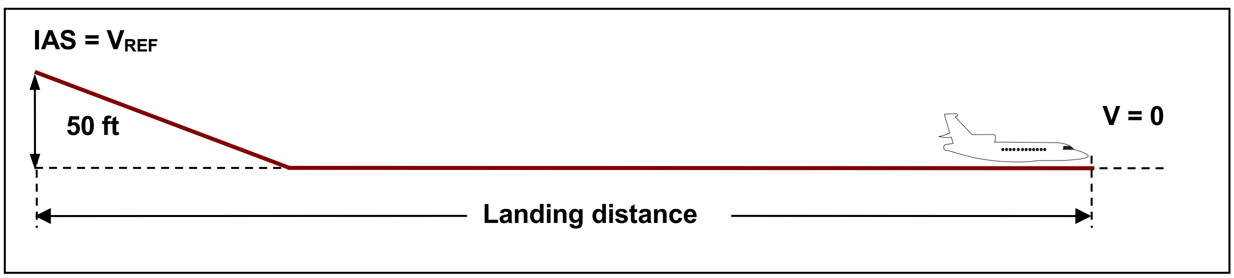
> **NOTE**
> The LDA does not include the stopway (SWY).



Landing distance (LD)

According to CS 25.125: "*The landing distance must be determined on a level, smooth, dry, hard-surfaced runway*. LD is the horizontal distance required to land and to come to a complete stop from a point at screen height of 50 ft (15 m) above the landing surface, provide that:

- The airplane is in landing configuration,
- The approach is stabilized; airspeed is V_{REF} at 50 ft screen height."



> **NOTE**
> **Landing distances on dry runway are minimum distances based on certification procedures. Consequently, they require to be factored to take into account operational variability.**

Wind influence on the LD

Refer to chapter "Meteorological Parameters – Wind" hereafter.

Landing distance in Emergency or Abnormal situations

Emergency and abnormal procedures may provide a LD increment in percentage, which already takes into account the effect of the configuration correction due to the failure.

NOTE
In windy conditions, wind correction affects the LD. Refer to chapter “Operational conditions – Wind” hereafter.

Landing Field Length (LFL)

Operational regulations require LD to be factored. The pilots must only consider this factored distance, also called Landing Field Length (LFL).

LFL is a required distance and must be calculated according to operational regulations.

Steep Approach landing field length

When the path angle of the final approach segment is greater than 4.5° (steep approach), before glide slope interception, the landing configuration S+FLAPS 48° is set. Therefore LFL calculation is not modified:

Path angle	Up to 6.65°
V_{APP} (zero wind)	V_{REF}
LFL increment	None

The use of go-around speed of V_{REF} in S+FLAPS 20° conducts to a decrease of the climb gradient and adjustment of the maximum landing weight. Refer to AFM data.

Runway Condition Code (RWYCC)

The RWYCC is a standardized code issued by some airports to assess the actual runway condition.

A specific matrix available in annex 7 of the AFM and in the *Operational conditions section* below, correlates the RWYCC with, the runway surface condition, pilot-reported braking action and recommended maximum crosswind.

Landing Distance at Time of Arrival (LDTA)

In flight, pilots should assess the landing performance based on the real conditions at time of arrival. Depending on the type of operations, both the FAA and EASA respectively recommend or mandate performing an in-flight assessment.

Landing distances at time of arrival, provided in the annex 7 of the AFM, include an air distance consistent with those achieved during routine flights. They are established:

- for the actual runway slope.
- for the actual temperature.
- for the target approach speed at threshold V_{APP}.
- with no reverse thrust,

as per EASA AMC 25.1592 and FAA AC 25-32 recommendations.

The EASA regulation mandates that commercial operators multiply the LDTA by at least a 1.15 factor (safety margin factor, also recommended by FAA). The result is called the Factored Landing Distance at Time of Arrival (F-LDTA). Some additional information and restrictions are published in the annex 7 of the AFM

LDTA assumes a 7 seconds flare time and a speed of 98 percent of V_{APP} at touchdown. This yields a longer flare distance than the one considered by LFL during pre-flight.

Considering the RWYCC, the pilot is able to assess the landing performance based on the real conditions of the runway at the time of arrival. The braking action reported by pilots is a subjective assessment of runway slipperiness.

Data are provided only for RWYCC 6 and 5. For codes 4 to 1, refer to the relevant operating regulations. RWYCC 5 may yield a F-LDTA longer than the LFL computed with pre-flight coefficients. Therefore, Dassault strongly recommends computing the F-LDTA at pre-flight for this RWYCC.

APPROACH CLIMB GRADIENT (1 ENGINE INOP)

According to CS 25.121: For three engines airplanes, in a normal approach configuration, the steady climb gradient may not be less than 2.4 % with:

- The critical engine INOPERATIVE, the remaining engines at take-off thrust,
- Landing Gear up,
- Slats/Flaps S+FLAPS 20°,
- Climb speed = V_{REF}.

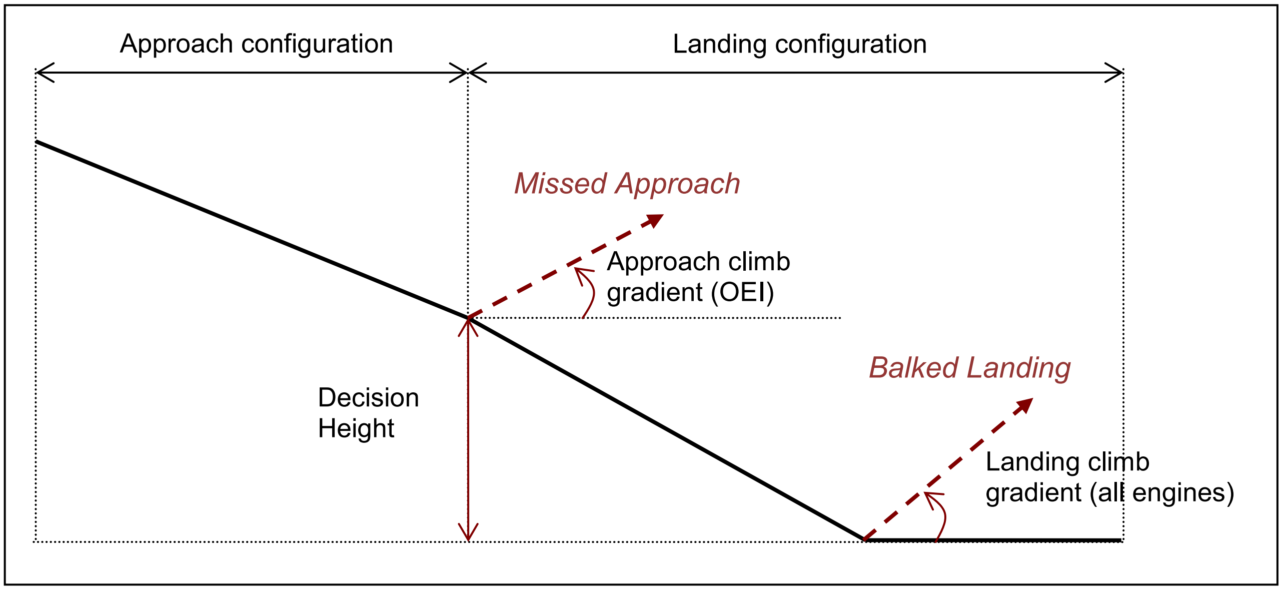
Note that the approach climb gradient is not wind corrected.

LANDING CLIMB GRADIENT (ALL ENGINES)

According to CS25.119: for three engine airplanes in landing configuration (S+FLAPS 48°), the climb gradient must be not less than 3.2 %, with:

- All engines at take-off thrust,
- Landing Gear down,
- Climb speed = V_{REF}.

Note that the landing climb gradient is not wind corrected.



MANDATORY MISSED APPROACH CLIMB GRADIENT

If the published missed approach procedure imposes a One Engine Inoperative (OEI) climb gradient for regulatory constraints, the operator must verify that at the expected landing weight, the airplane is capable of this specific OEI climb gradient.

PRE-FLIGHT CALCULATION

Operational regulations mandate that operators perform landing calculations at pre-flight.

It is mandatory to consider:

- Landing Field Length (LFL) on a dry or wet runway
- Landing Field Length (LFL) on a contaminated runway

It is strongly recommended to consider:

- Factored Landing Distance at Time of Arrival (F-LDTA). Refer to *In-flight calculation* section

The LFL and F-LDTA calculations will differ. If the F-LDTA is greater than the LFL calculation, it is the operator responsibility to define the landing distance to consider.

LANDING ON A DRY RUNWAY (LFL_{DRY})

(CAT.POL.A.230) & (FAR 135.385)

For EASA CAT and FAA Part 135 operators:

"An operator shall ensure that the landing mass of the airplane for the estimated time of landing at the destination aerodrome and at any alternate aerodrome allows a full stop landing from 50 ft (15m) above the runway threshold within 60% of the landing distance available."

$$\mathbf{LD_{DRY} \leq LDA \times 0.6 \quad OR \quad LFL_{DRY} = LD_{DRY} \times 1.67 \leq LDA}$$

(NCC.POL.135) & (FAR 91.103)

For EASA NCC and FAA Part 91 operators:

"[…] The airplane shall be able to land and stop […] within the landing distance available".

$$\mathbf{LFL_{DRY} = LD_{DRY} \times Ops\ Factor \leq LDA}$$

The Ops Factor to be used is at the operator discretion.

(FAR 135.385) & (FAR 91.1037)

For FAA Part 135 EOD and Part 91 subpart K operators, the Ops Factor should not be less than 1.25.

"The airplane's weight on arrival […] would allow a full landing stop […] within 80 percent of the effective length of each runway…"

$$\mathbf{LFL_{DRY} = LD_{DRY} \times 1.25 \leq LDA}$$

The equivalent Runway Condition Code for a dry runway is 6.

LANDING ON A WET RUNWAY (LFL_{WET})

(CAT.POL.A.235) & (PART 135.385)
For EASA CAT and FAA part 135 operators:
"An operator shall ensure that when the appropriate weather reports or forecasts, (or a combination thereof) indicate that the runway at the estimated time of arrival may be wet; the landing distance available is at least 115% of the required landing distance".

In other words, $LFL_{WET} = LFL_{DRY} \times 1.15$ and given that $LFL_{DRY} = LD_{DRY} \times 1.67$:
On a wet runway, a commercial operator must ensure that, at least:

$$\mathbf{LFL_{WET} = LFL_{DRY} \times 1.15 = LD_{DRY} \times 1.92 \leq LDA}$$

(NCC.POL.135) & (FAR 91.103)
For EASA NCC and FAA part 91 operators:
"[…] The airplane shall be able to land and stop […] within the landing distance available".

$$\mathbf{LFL_{WET} = LD_{DRY} \times Ops\ Factor \leq LDA}$$

The Ops Factor to be used is at the operator discretion.

(FAR 135.385) & (FAR 91.1037)
"[…] *the runway length at the destination airport is at least 115 percent of the"* LFL_{DRY}.
For FAA Part 135 EOD, Part 91 subpart K and operators, the Ops Factor should not be less than 1.44.
In other words, $LFL_{WET} = LFL_{DRY} \times 1.15$ and given that $LFL_{DRY} = LD_{DRY} \times 1.25$:
On a wet runway, an operator must ensure that, at least:

$$\mathbf{LFL_{WET} = LFL_{DRY} \times 1.15 = LD_{DRY} \times 1.44 \leq LDA}$$

The equivalent Runway Condition Code for a wet runway is 5.

REDUCED REQUIRED LANDING DISTANCE (LFL_{DRY} AND LFL_{WET})

(CAT.POL.A.255)
For EASA CAT reduced required landing distance operation, LDTA must be used at preflight.

On dry runway (LDTA for RWYCC 6):

$$\mathbf{LFL_{DRY} = LDTA_{RWYCC6} \times 1.25 \leq LDA}$$

On wet runway (LDTA for RWYCC 5):

$$\mathbf{LFL_{WET} = LDTA_{RWYCC5} \times 1.25 \leq LDA}$$

NOTE

Reduced required landing operation for EASA CAT operators is subject to national authority approval.

CONTAMINATED RUNWAY (LFL_{CONTA})

Computing the landing distance on a contaminated runway consists in multiplying the LD_{DRY} by an adjustment factor, as below defined:

LANDING DISTANCE FACTORING ON CONTAMINATED RUNWAYS				
Standing water or slush				
Depth of standing water	mm	0.1 to 3.0	3.1 to 6.3	6.4 to 12.7
	in	0.01 to 0.12	0.13 to 0.25	0.26 to 0.50
Depth of slush	mm	0.1 to 3.0	3.1 to 7.5	7.6 to 15
	in	0.01 to 0.12	0.13 to 0.30	0.31 to 0.60
Adjustment factor		Refer to wet RWY	2.1	1.8
Wet snow				
Depth of wet snow	mm	0.1 to 5.0	5.1 to 12.7	12.8 to 25.0
	in	0.01 to 0.20	0.21 to 0.50	0.51 to 1.00
Adjustment factor		1.8	2.1	1.8
Dry snow				
Depth of dry snow	mm	0.1 to 20	20.1 to 31	31.1 to 62.0
	in	0.01 to 0.75	0.76 to 1.25	1.26 to 2.5
Adjustment factor		1.8	1.8	1.6
Compacted snow				
Adjustment factor		1.8		
Ice				
Adjustment factor		3.8		

Pursuant to CAT.POL.A.235 and FAR 135.385, LFL on a contaminated runway equals the equivalent LD multiplied by 1.15.
Refer to OM section 4-147 “operations on contaminated runways” for more detailed information.

PRE-FLIGHT CALCULATION TABLE

Regulation	Status	LFL_{DRY} ≤ LDA	LFL_{WET} ≤ LDA	LFL_{CONTA} ≤ LDA
EASA CAT FAR 135 FAR 121	Mandatory	1.67 x LD_{DRY}	1.92 x LD_{DRY}	Adjust. Factor x LD_{DRY} x 1.15
FAR 135 EOD FAR 91K	Mandatory	1.25 x LD_{DRY}	1.44 x LD_{DRY}	Adjust. Factor x LD_{DRY} x 1.15
EASA NCC FAR 91	Mandatory	Ops Factor x LD_{DRY}	Ops Factor x LD_{DRY}	Adjust. Factor x LD_{DRY} x 1.15
EASA CAT reduced landing distance	Ops approval required	1.25 x $LDTA_{RWYCC6}$	1.25 x $LDTA_{RWYCC5}$	Not applicable

Regulation	Status	F-LDTA ≤ LDA
EASA CAT FAR 135 FAR 121 FAR 135 EOD FAR 91K EASA NCC FAR 91	Recommended*	F- LDTA

*****_Computing LDTA is recommended at pre-flight. If F-LDTA is longer than LFL, it is the operator responsibility to define the landing distance to take into account._

IN-FLIGHT CALCULATION

Depending on the type of operation, both the FAA and EASA either recommend or mandate performing an in-flight assessment of the landing distance at the estimated time of arrival.

LANDING DISTANCE AT TIME OF ARRIVAL (LDTA)

(CAT.OP.MPA.303)
No approach to land shall be continued unless the LDA on the intended runway is at least 115% of the landing distance […] determined in accordance with the performance information […] certified by the manufacturer.

The LDTA charts are published in annex 7 of the AFM for RWYCC 6 and 5.

F-LDTA = LDTA x 1.15 ≤ LDA

NOTE
The regulations recommend applying a safety margin when LDTA are used.

The LDTA charts are not applicable to:

- Landing with a Steep Approach landing,
- In-Flight failures yielding to landing distance increment.

The dedicated AFM procedures detail the limitations and increment associated.

CONTAMINATED RUNWAY (F-LDTA$_{CONTA}$)

As no data are published for RWYCC from 4 to 1, the operator shall apply a landing distance factor (LDF) to the AFM landing distance on dry runway (LD$_{DRY}$).

(CAT.OP.MPA.303(e))
When there are no data available for the assessment of LDTA, performance information for the assessment of LDTA may be determined by applying the following method:

- *Correction factors may be applied to the certified landing distances on dry runway published in the AFM for turbojet-powered aeroplanes […].*
- *For this purpose, the landing distance factors (LDFs) […] may be used.*

Landing Distance Factor (LDF)				
Runway condition code (RWYCC)	4	3	2	1
Turbojet without reverse	2.8	3.2	4.0	5.1
Turbojet with all reversers operating	2.3	2.5	2.9	3.4

The LDFs given above include a 15 % safety margin and an air distance representative of normal operational practices. They account for variations of temperature up to international standard atmosphere (ISA) + 20 °C, runway slopes between -2 % and +2 %, and an average approach speed increment of 5 up to 20 kt. They may not be conservative for all configurations in case of unfavourable combinations of these parameters.

IN-FLIGHT CALCULATION TABLE

Regulation	Status	Normal Operations **RWYCC 6 and 5**	Normal Operations **RWYCC 4 to 1**	Abnormal or Emergency Operations	Steep Approach
EASA CAT	Mandatory	F-LDTA	F-LDTA$_{CONTA}$ = LD$_{DRY}$ x LDF	LD$_{DRY}$ x Failure Increment*	LFL$_{STEEP}$
FAR 135 FAR 121 FAR 135 EOD FAR 91K EASA NCC & FAR 91	Recommended	F-LDTA	F-LDTA$_{CONTA}$ = LD$_{DRY}$ x LDF	LD$_{DRY}$ x Failure Increment*	LFL$_{STEEP}$

**The failure increment depends on the failure encountered.*

OPERATIONAL CONDITION

TEMPERATURE

The AFM Landing Distance (LD) is always computed in ISA and is not impacted by temperature variation as sufficient margin is taken into account. On the contrary, Landing Distance at Time of Arrival (LDTA) considers the ambient temperature. At a constant pressure altitude, a jet-engine thrust being only temperature dependent, max T/O thrust decreases with the temperature increasing, so that:

Temperature ↗ ⇨ **Go-around Climb Gradient** ↘

PRESSURE ALTITUDE

Since V_{REF} is a calibrated airspeed, the corresponding TAS increases with pressure altitude. Therefore, Ground Speed increases and so does the landing distance.

Pressure Altitude ↗ ⇨ **Air Density** ↘ ⇨ **TAS** ↗ ⇨ **LD** ↗

On the other hand, as jet-engine thrust decreases with increasing pressure altitude, so does the go-around climb gradient.

Pressure Altitude ↗ ⇨ **Go-around climb gradient** ↘

WIND

Headwind

Headwind shortens LD, and conversely tailwind lengthens it. Headwind also decreases Ground Speed (GS) stopping distance. However:

- When V_{APP} is greater than V_{REF}, each 10 kt extra speed (refer to OM – Normal Procedures) at a screen height of 50 ft increases LD by 14 % (only applicable to LFL). Extra speed (wind correction or at PIC discretion) shall not exceed V_{REF} or V_{RF*} from 20 kt.

Tailwind

The maximum certified tailwind is 10 kt. The aircraft manufacturer never computes the landing performance data for a tailwind greater than 10kt.

RUNWAY CONDITION

In addition to the obvious influence of the runway slope, the runway condition has an influence on the landing distance.

Coefficient of friction	↘	⇨	**Landing distance**	↗
Precipitation drag	↗	⇨	**Landing distance**	↘

ANTI-ICING

Bleed air from the engines feeds the anti-icing system. As a result, when A/I is set on, the thrust decreases.

Anti-Ice ON	⇨	**Air climb gradient**	↘

RUNWAY CONDITION CODE (RWYCC) MATRIX

RWYCC	Runway Surface Condition (assessed)	Braking Action	Max recommended crosswind (including gust)
6	- Dry	------	-----
5	- Frost - Wet (includes damp and 3mm depth or less of water) **3 mm depth or less of:** - Slush - Dry snow - Wet snow	Good	20 kt
4	**-15°C and colder outside air temperature:** - Compacted snow	Good-to-Medium	20 kt
3	- 'Slippery when Wet' (wet runway) - Dry or wet snow (any depth) over compacted snow **Greater than 3 mm depth of:** - Dry snow - Wet snow **Warmer than -15°C outside air temperature :** - Compacted snow	Medium	15 kt
2	**Greater than 3 mm depth of:** - Standing water - Slush	Medium-to-Poor	10 kt
1	- Ice	Poor	5 kt
0	- Wet ice - Water over compacted snow - Dry snow or wet snow over ice	Nil	-----

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EXAMPLES

LANDING PERFORMANCE CALCULATION BEFORE DEPARTURE – DRY RUNWAY

Given:

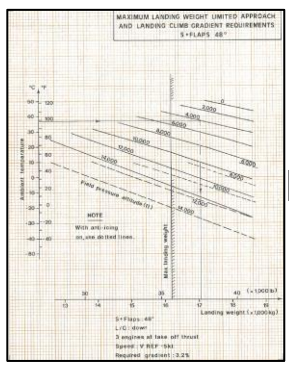
- LDA = 7,509 ft
- Runway is dry,
- Field Pressure altitude = 8,000 ft,
- QNH = 1,013.25 hPa,
- Ground Temperature = +10°C,
- Anti-icing OFF,
- Landing Weight = 28,000 lb,
- Wind is calm,
- Required missed approach climb gradient: 4.0 % up to 12,000 ft,
- Required climb gradient following a balked landing: 8 % up to 10,000 ft.

Solution:

Step 1: Verifying compliance with the regulatory 2.4 % approach and 3.2 % landing climb gradients

The "Maximum landing weight limited by approach and landing climb gradient requirements S+FLAPS 48°" chart (ref. AFM 5-650-1) gives the maximum landing compliant to both required climb gradients.

INPUT:
- Temperature 10°C,
- Field Press Alt 8,000 ft,
- A/I OFF.



OUTPUT:
Maximum LW limited by ACG/LCG requirement
> 41,000 lb

⇨ MLW limited by approach and landing climb gradient is well above actual landing weight,

⇨ Approach and landing climb gradients are not limiting

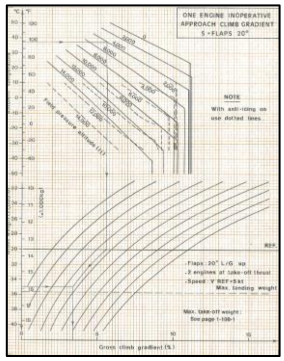
Step 2: Verifying compliance with the required missed approach climb gradient.

Refer to "One engine inoperative approach climb gradient" (ref. AFM chart 5-650-2).

“Field Pressure Altitude” and “Temperature” as read at the top of required climb segment:

- ⇨ Field pressure altitude = 8,000 ft.
- ⇨ Top of required missed approach climb gradient segment = 12,000 ft.
- ⇨ Temperature = 10 - (12,000 - 8,000) / 1,000 x 2 = 2°C.

INPUT:
- Temperature 2°C,
- MAP Alt. 12,000 ft,
- Gross Weight = 28,000 lb,
- A/I OFF.



OUTPUT:
Gross CLB gradient
= 6.6 %

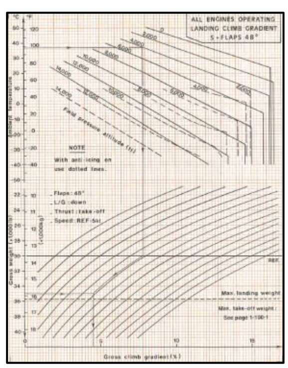
- ⇨ The OEI gross climb gradient equals 6.6 %.
- ⇨ Thus required 4.0 % climb gradient is not limiting

Step 3: Verifying compliance with the required climb gradient following a balked landing

Refer to "All Engine Operating Landing Climb Gradient" chart (ref. AFM 5-650-3). Input altitude and temperature as read at the top of required climb segment:

- ⇨ Field Pressure Altitude = 8,000 ft.
- ⇨ Top of required climb gradient segment following a balked landing = 10,000 ft.
- ⇨ Temperature = 10 - (10,000 - 8,000) / 1,000 x 2 = 6°C.

INPUT:
- Temperature 6°C,
- Balked Landing 10,000 ft,
- LW = 28,000 lb,
- A/I OFF.



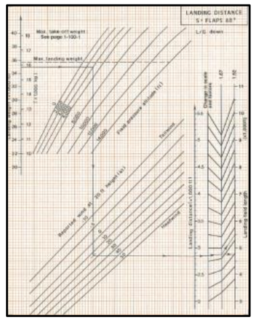
OUTPUT:
Gross CLB gradient
= 10.4 %

- ⇨ The resulting gross climb gradient equals 10.4 %, above the required 8.0 %.
- ⇨ The required balked landing climb gradient is not limiting

Step 4: LD Determination

Calculating the Landing Distance by referring to “LANDING DISTANCE S+FLAPS 48°” chart (ref. AFM 5-650-4) and regarding the wind:

INPUT:
- LW = 28,000 lb,
- Field Press Alt = 8,000 ft,
- Wind is calm.



OUTPUT:
LD = 2,900 ft

$LD_{DRY\ NO\ WIND}$ = 2,900 ft

Step 5: Approach speed

⇨ Wind is calm, $V_{APP} = V_{REF}$

Step 6: LD increment

⇨ No extra speed at threshold ⇨ No LD increment

⇨ $LD_{DRY} = LD_{DRY\ NO\ WIND}$

Step 7: LFL computation

LFL computation can be performed through 2 methods: numerical method or graphical.

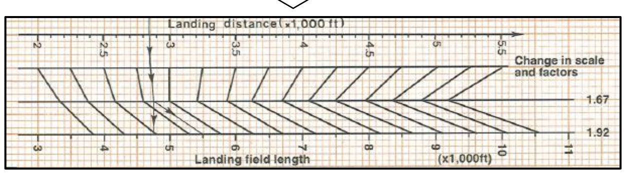
- Method 1: Numerical Method

  When the operational regulation requires to compute LFL using 1.67 ops factor (AIR OPS, FAR 135, etc.),

⇨ $LFL_{DRY} = 1.67 \times LD_{DRY} = 1.67 \times 2{,}900$ ft = 4,843 ft

- Method 2: Graphical Method

INPUT:
- LD = 2,900 ft,
- Landing Factor = 1.67.



OUTPUT:
- LFL = 4,900 ft

Step 8: LFL versus LDA

LFL_{DRY} (4,843 ft) being shorter than LDA (7,509 ft),

⇨ Landing is permitted

LANDING PERFORMANCE CALCULATION BEFORE DEPARTURE – WET RUNWAY

Given:

- LDA = 8,500 ft,
- Runway is wet,
- Landing Weight = 28,000 lb,
- Field Pressure altitude = 6,000 ft
- QNH = 1,013.25 hPa,
- Ground Temperature = 8°C,
- Anti-icing ON,
- Wind is calm.

> **NOTE**
> Assuming the airplane complies with the approach climb gradient and landing climb gradient, only the landing field length will be presented hereafter.

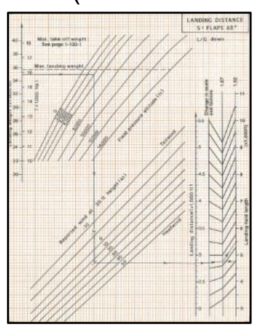
Solution:

Step 1: LD Determination

The "LANDING DISTANCE S+FLAPS 48°" chart (ref. AFM 5-650-4) gives LD on a dry runway.

INPUT:
- LW = 28,000 lb,
- Field Press Alt = 6,000 ft,
- No wind.

⇨



⇨

OUTPUT:
LD = 2,650 ft

⇨ $LD_{DRY\ NO\ WIND}$ = 2,650 ft

Step 2: Approach speed

⇨ Wind is calm, ⇨ $V_{APP} = V_{REF}$

Step 3: LD increment

⇨ No extra speed at threshold ⇨ No LD increment

⇨ $LD_{DRY} = LD_{DRY\ NO\ WIND}$

Step 4: LFL computation

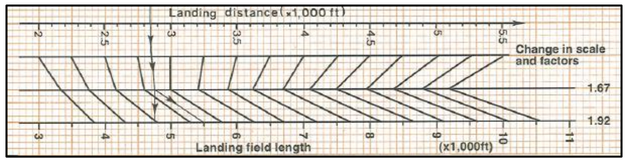
When the operational regulation requires LFL to be computed from dry runways data (AIR OPS, FAR 135, etc.), LFL must be computed from LD, using the required 1.92 wet ops factor. In that case, LFL computation can be performed through 2 methods: numerical method or graphical.

- Method 1: Numerical Method

⇨ $LFL_{WET} = 1.92 \times LD_{DRY}$ = 1.92 x 2,650 ft = 5,088 ft

- Method 2: Graphical Method

INPUT:
- LD = 2,645 ft,
- Landing Factor = 1.92.



OUTPUT:
- LFL = 5,060 ft

Step 5: LFL versus LDA

⇨ The computed LFL_{WET} (5,088 ft) being shorter than LDA (8,500 ft),

⇨ Landing is permitted

LANDING PERFORMANCE CALCULATION BEFORE DEPARTURE – WIND INFLUENCE

Wind (Headwind & Gust) correction provides an additional stall margin for airspeed excursions caused by turbulence and windshear, but it also affects the Landing Distance (LD). Consequently, a particular sequence of LD computation must be followed.

> **NOTE**
> **AFM chart gives the wind corrected LD, in assuming the pilot flies V_{REF} at 50 ft screen height. Given that the pilot actually flies V_{APP} at a screen height of 50 ft, the landing distance must be corrected according to the extra speed at threshold (= $V_{APP} – V_{REF}$).**

Given:

- LDA = 6,000 ft
- Field Pressure altitude = 0 ft,
- QNH = 1,013.25 hPa,
- Landing Weight = 28,000 lb,
- 20 kt headwind (no gust).

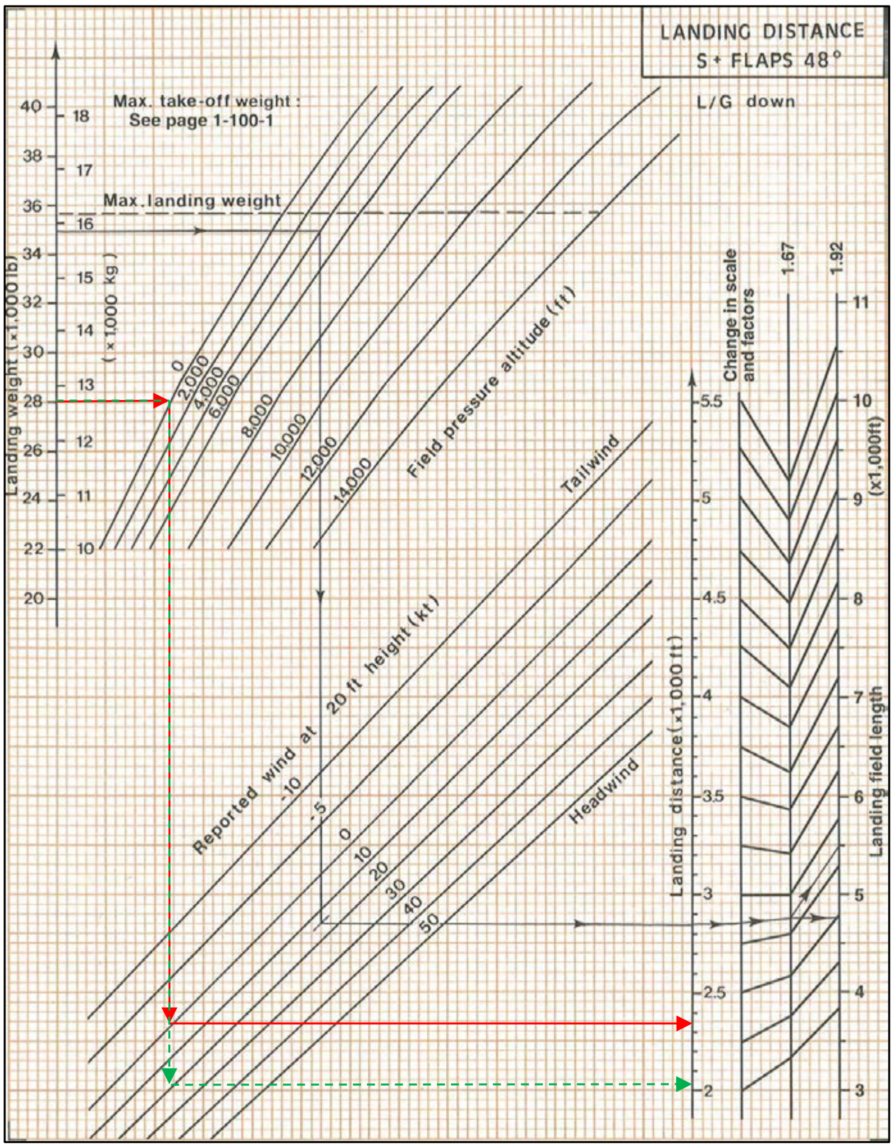
> **NOTE**
> Assuming the airplane complies with the approach climb gradient and landing climb gradient, only the landing field length will be presented hereafter.

Solution:

Step 1: LD determination

Determine LD from AFM "LANDING DISTANCE S+FLAPS 48°" chart (ref. AFM 5-650-4).

LD is computed with speed equal to V_{REF} when passing 50 ft and takes into account the effect of the wind (if any) during the flare and the landing ground roll.



- Zero wind ⇨ $LD_{DRY\ NO\ WIND}$ = 2,340 ft, and
- 20 kt headwind ⇨ $LD_{DRY\ 20\ kt\ HEADWIND\ CORRECTED}$ = 2,020 ft

> **NOTE**
> In accordance with CS/FAR25.125, AFM Take-Off and Landing charts output distances take into account:
> - Only 50 % of the headwind effect,
> - 150 % of the tailwind.
>
> i.e. If the user inputs 20 kt headwind, he then reads the LD corresponding to 10 kt headwind.

Step 2: Approach speed

⇨ 20 kt headwind,

⇨ $V_{APP} = V_{REF}$ + Configuration correction + (½ Headwind + Gust)

⇨ $V_{APP} = V_{REF} + 0 + (½ \times 20 + 0)$

⇨ **$V_{APP} = V_{REF} + 10$ kt**

Step 3: LD increment due to wind

⇨ 10 kt extra speed at threshold ⇨ **LFL increment of 14%**,

⇨ $LD_{DRY} = 1.14 \times LD_{DRY\ 20\ KT\ HEADWIND\ CORRECTED}$

⇨ $LD_{DRY} = 1.14 \times 2{,}020$

⇨ LD_{DRY} = 2,303 ft

> **NOTE**
> This applicable LD_{DRY} (2,303 ft) is very close to the $LD_{DRY\ NO\ WIND}$ result (2,340 ft). This example shows that increasing the approach speed (V_{APP}) for headwind component (½ Headwind) has very little impact on the LD if we compare it with a "zero wind" LD, whereas it will provide an additional safety margin against stall as shown here above.

Step 4: LFL computation

Depending on the runway condition, the LFL is calculated from the LD_{DRY} multiplied by an operation factor. The usual coefficients are 1.67 on dry runway and 1.92 on wet runway.

⇨ $LFL_{DRY} = 1.67 \times LD_{DRY} = 1.67 \times 2{,}303 \approx$ **3,846 ft**

⇨ $LFL_{WET} = 1.92 \times LD_{DRY} = 1.92 \times 2{,}303 \approx$ **4,422 ft**

Step 5: LFL versus LDA

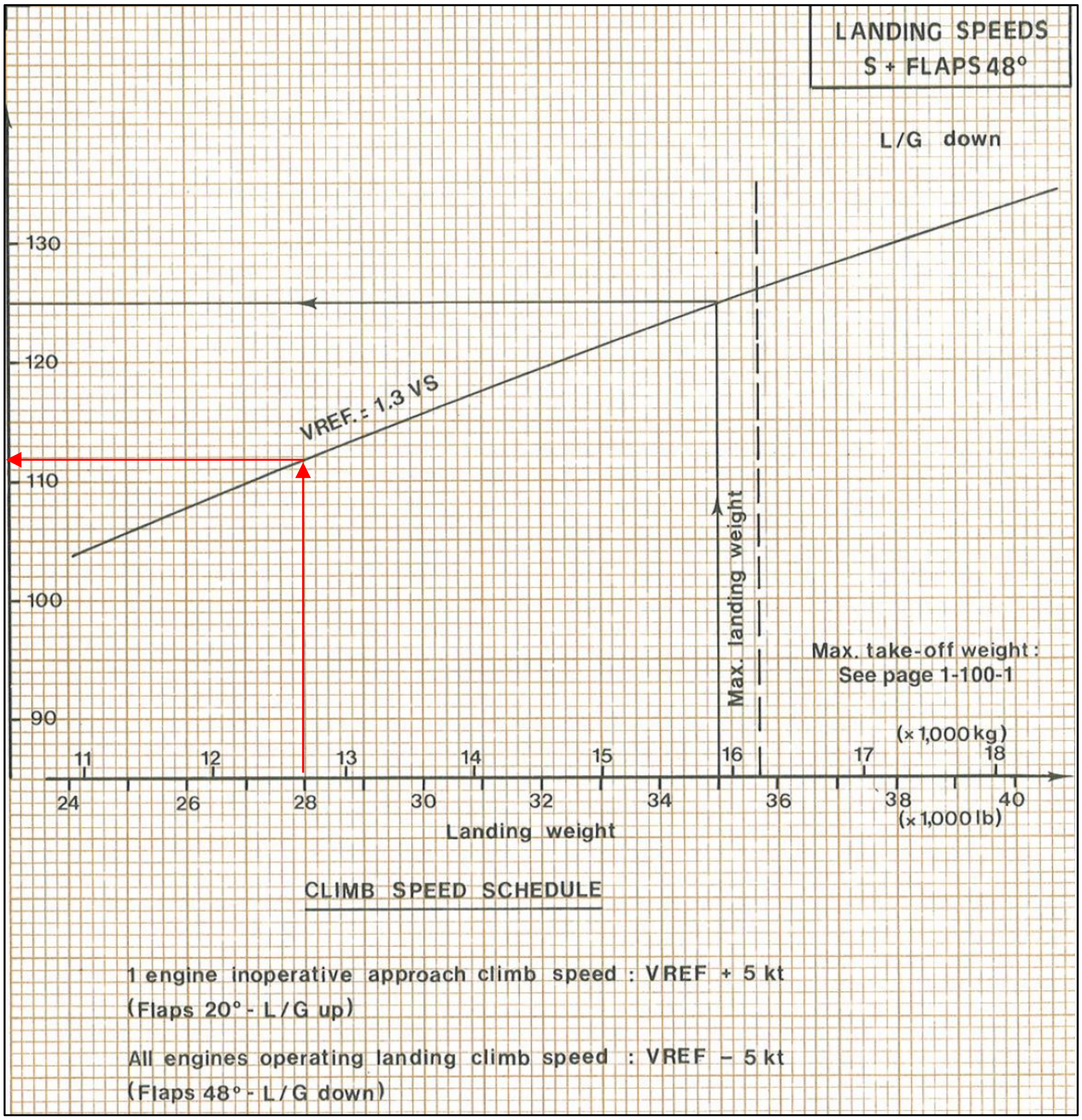
LFL must be shorter than Landing Distance Available (LDA).

⇨ The computed LFL_{DRY} (3,846 ft) and LFL_{WET} (4,422 ft) being shorter than LDA (6,000 ft),

⇨ **Landing is permitted on this runway**

<u>Step 6: V_{REF} determination</u>

Compute V_{REF} using "LANDING SPEEDS S+FLAPS 48°" chart (ref. AFM 5-650-5).



⇨ V_{REF} = 104 kt

<u>Step 7: V_{APP} determination to be maintained down to 50 ft</u>

$V_{APP} = V_{REF}$ + Configuration correction + (½ Headwind + Gust)

⇨ V_{APP} = 104 + 0 + (½ x 20 + 0)

⇨ V_{APP} = 114 kt

LANDING PERFORMANCE CALCULATION AT TIME OF ARRIVAL (RWYCC 5 AND 6)

Given:

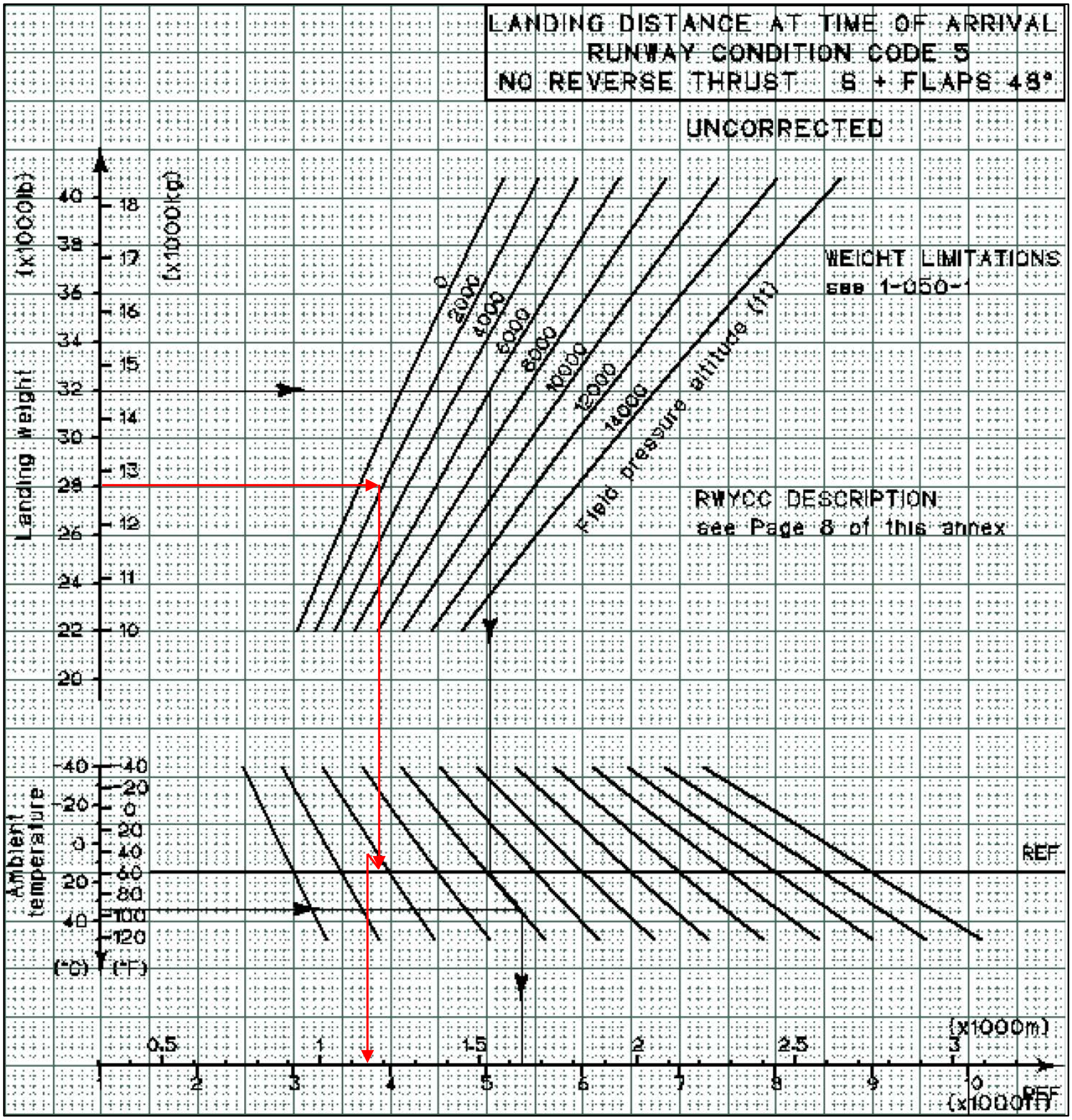
- LDA = 10,100 ft,
- RWYCC = 5,
- Field Pressure altitude = 2,000 ft,
- QNH 1,013 hPa,
- Ground Temperature = +5°C,
- A/I OFF,
- Runway slope = 1.5%,
- No thrust reversers credit,
- S+FLAPS 48°,
- Landing Weight = 28,000 lb,
- 10 kt Headwind,
- V_{REF} = 105 kt,
- V_{APP} = 110 kt
    - ⇨ Overspeed at threshold = 5 kt,
- V_{APP} down to 50 ft screen height.

NOTE

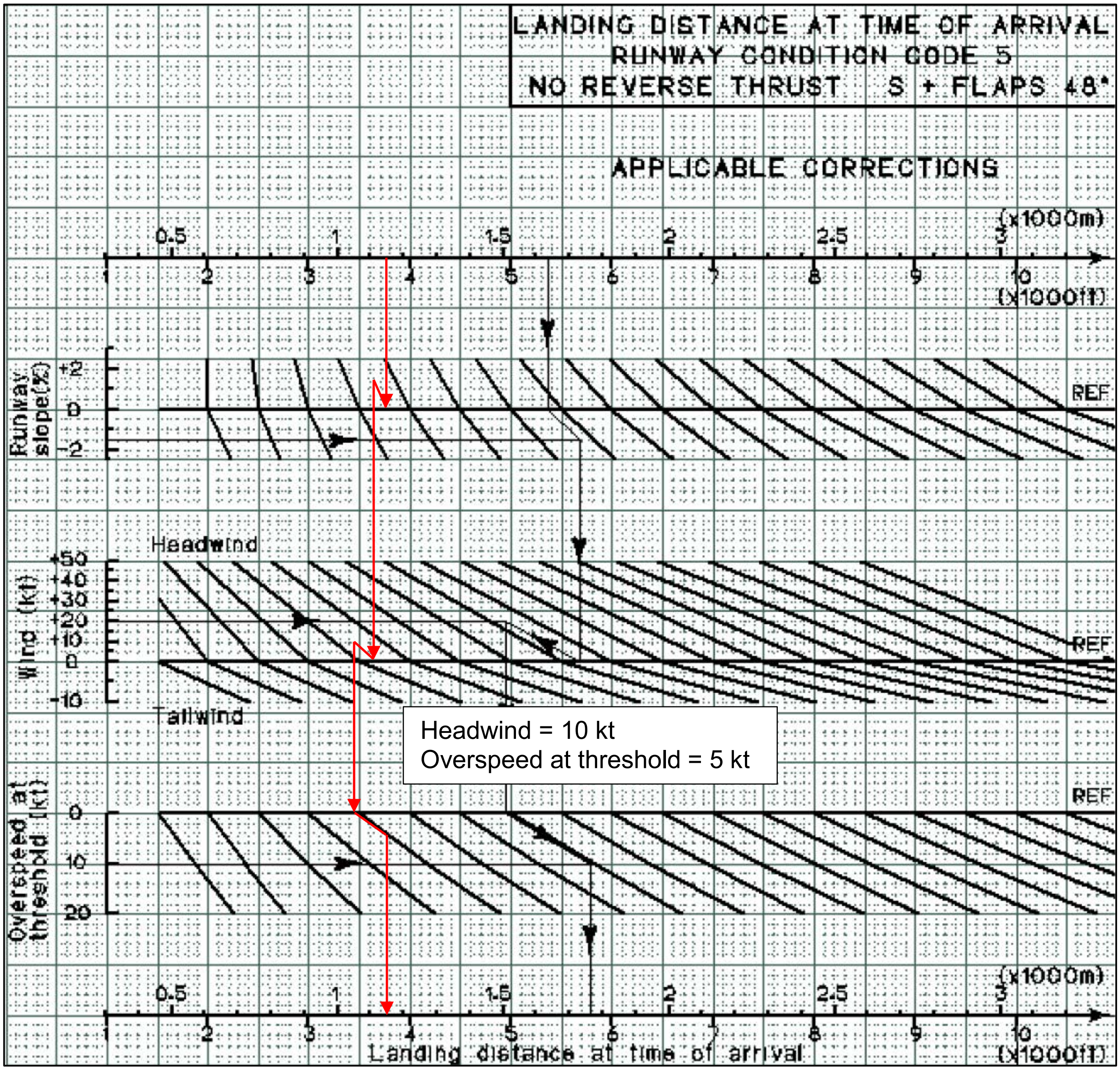
The AFM chart in annex 7 gives the wind corrected LDTA, Given that the pilot actually flies V_{APP} at a screen height of 50 ft, the landing distance must be corrected according to the extra speed at threshold (= $V_{APP} – V_{REF}$). This landing distance increment is not a regulatory requirement. The correction should be done using the correction chart on the bottom of the LDTA charts. It is a recommendation from Dassault Aviation.

Solution:

Step 1: Determine graphically the landing distance at time of arrival (LDTA)



The correction must be made using the chart below.



⇨ LDTA = 3,790 ft

<u>Step 2: Determine and verify F-LDTA against LDA</u>

In accordance with AIR OPS, the safety margin shall be applied to the LDTA:

⇨ F-LDTA = LDTA x 1.15 = 3,790 x 1.15 = 4,359 ft < LDA

The Landing Distance Available is greater than The Landing Distance at Time of Arrival. The landing is permitted.

LANDING PERFORMANCE CALCULATION AT TIME OF ARRIVAL - WIND AND FAILURE

Given:

- LDA = 8,000 ft,
- Airport elevation = 0 ft,
- QNH = 1,013.25 hPa,
- Landing Weight = 28,000 lb,
- 20 kt headwind (no gust),
- **MASTER** light + GONG possibly on with **FLAPS ASYM** light possibly on. With flaps extended up to 20°.

NOTE
Assuming the airplane complies with the approach climb gradient and landing climb gradient, only the landing field length will be presented hereafter.

Solution:

Step 1: LD determination

Determine LD with no failure from AFM LANDING DISTANCE S+FLAPS 48°" chart (ref. AFM 5-650-4) as explained here above.

⇨ $LD_{DRY\ NO\ WIND}$ = 2,340 ft,

⇨ $LD_{DRY\ 20\ kt\ HEADWIND\ CORRECTED}$ = 2,020 ft

Step 2: LD increase due to failure penalty

In this example, AFM 3-142-1, states that LD must be increased by 1,400 ft:

⇨ $LD_{FAILURE\ NOT\ CORRECTED} = LD_{NO\ FAILURE}$ + 1,400 = 2,020 + 1,400 = 3,420 ft

⇨ $LD_{FAILURE\ NOT\ CORRECTED}$ = 3,420 ft

NOTE
LD increment due to extra speed at threshold regarding the failure is already taken into account in the failure coefficient.

Step 3: Extra speed at threshold due to wind

⇨ 20 kt headwind,

⇨ Wind correction = ½ Headwind + Gust

⇨ Wind correction = 10 kt

Step 4: LD increment due to wind according failure case

In the event of a failure, the increase of the LD due to the extra speed at threshold is:

⇨ Wind correction = 10 kt,

⇨ LD correction = 14%

⇨ $LD_{FAILURE} = LD_{FAILURE\ NOT\ CORRECTED}$ x 1.14 = 3,420 x 1.14 = 3,899 ft

Step 5: LFL computation

Compute Landing Field Length (LFL). LFL is LD multiplied by the appropriate landing factor:

- ⇨ $LFL_{DRY\ FAILURE}$ = 1.67 x $LD_{FAILURE}$ = 1.67 x 3,899 ≈ **6,511 ft**
- ⇨ $LFL_{WET\ FAILURE}$ = 1.92 x $LD_{FAILURE}$ = 1.92 x 3,899 ≈ **7,486 ft**

> **NOTE**
>
> 1.67 and 1.92 is for example only. The operator may use whatever Ops Factor providing that the National Authority approve it.

Step 6: Compare LFL to Landing Distance Available (LDA)

Check LFL must be shorter than Landing Distance Available (LDA).

- ⇨ $LFL_{DRY\ FAILURE}$ (6,511 ft) and $LFL_{WET\ FAILURE}$ (7,486 ft) being shorter than LDA (8,000 ft),
- ⇨ **The airplane can legally land on this runway**

Step 7: V_{REF} determination

Compute V_{REF} using chart "LANDING SPEEDS S+FLAPS 48°" (ref. AFM 5-650-5).

- ⇨ **V_{REF} = 112 kt**

Step 8: V_{RF*} determination

In the event of a failure, V_{REF} increases due to the extra speed linked to the aircraft configuration.

- ⇨ Configuration correction = 20 kt
- ⇨ V_{RF*} = V_{REF} + Configuration correction
- ⇨ **V_{RF*} = 132 kt**

Step 9: V_{APP} determination

AFM states that approach speed (zero wind) must be:

- ⇨ $V_{APP\ (ZERO\ WIND)}$ = V_{RF*}
- ⇨ $V_{APP\ (ZERO\ WIND)}$ = 132 kt

> **NOTE**
>
> V_{APP} = V_{RF*} + (½ Headwind + Gust)
>
> With, V_{RF*} = V_{REF} + Configuration correction

Including the wind correction from Step 3:

- ⇨ V_{APP} = 132 + (½ x 20 + 0)
- ⇨ **V_{APP} = 142 kt**

LANDING PERFORMANCE CALCULATION BEFORE DEPARTURE – CONTAMINATED RUNWAY

Given:

- LDA = 8,000 ft,
- Runway Contaminated,
- Contaminant = 0.3 inches of wet snow,
- Field Pressure altitude = 2,000 ft
- QNH = 1,013.25 hPa,
- Ground Temperature = 2°C,
- Anti-icing ON,
- Landing Weight = 28,000 lb,
- 20 kt headwind (no gust),

> **NOTE**
> Assuming the airplane complies with the approach climb gradient and landing climb gradient, only the landing field length will be presented hereafter.

Solution:

Step 1: LD determination

Determine LD with no failure from AFM LANDING DISTANCE S+FLAPS 48°" chart (ref. AFM 5-650-4) as explained here above.

⇨ $LD_{DRY\ 20\ kt\ HEADWIND\ CORRECTED}$ = 2,100 ft

Step 2: Adjustment factor determination

Determine the adjustment factor for the contaminant using the table published in "PRE-FLIGHT CALCULATION" section of this document.

Wet snow				
Depth of wet snow	mm	0.1 to 5.0	5.1 to 12.7	12.8 to 25.0
	in	0.01 to 0.20	**0.21 to 0.50**	0.51 to 1.00
Adjustment factor		1.8	**2.1**	1.8

Step 3: LD_{CONTA} determination

Using the adjustment factor selected above:

⇨ $LD_{CONTA\ NOT\ CORRECTED} = LD_{DRY\ 20\ kt\ HEADWIND\ CORRECTED} \times 2.1$

⇨ $LD_{CONTA\ NOT\ CORRECTED} = 2100 \times 2.1$

⇨ $LD_{CONTA\ NOT\ CORRECTED}$ = 4,410 ft

Step 4: Extra speed at threshold due to wind

- ⇨ 20 kt headwind,
- ⇨ Wind correction = ½ Headwind + Gust
- ⇨ Wind correction = 10 kt

Step 5: LD increment due to wind

- ⇨ 10 kt extra speed at threshold ⇨ LFL increment of 14%,
- ⇨ $LD_{CONTA} = 1.14 \times LD_{CONTA\ NOT\ CORRECTED}$
- ⇨ $LD_{CONTA} = 1.14 \times 4{,}410$
- ⇨ $LD_{CONTA} = 5{,}027$ ft

Step 6: LFL computation and AIR-OPS requirements

AIR OPS Part CAT.POL.A.235 specifies a factor of 1.15 to be applied to the landing distance data on a contaminated runway. Moreover it states that the required landing distance must not be less than that required on a wet runway.

- ⇨ $LFL_{CONTA} = 1.15 \times LD_{CONTA} = 1.15 \times 5{,}027 \approx$ 5,781 ft
- ⇨ $LFL_{WET} = 4{,}596$ ft

As a conclusion:

- ⇨ LFL_{CONTA} (5,781 ft) being shorter than LDA (8,000 ft),
- ⇨ The airplane can legally land on this runway

LANDING PERFORMANCE CALCULATION AT TIME OF ARRIVAL (RWYCC 4 TO 1)

Given:

- LDA = 8,000 ft,
- Runway Contaminated,
- RWYCC = 3,
- Field Pressure altitude = 2,000 ft
- QNH = 1,013.25 hPa,
- Thrust Reverser Operative
- Landing Weight = 28,000 lb,
- 20 kt headwind (no gust).

NOTE

Assuming the airplane complies with the approach climb gradient and landing climb gradient, only the landing field length will be presented hereafter.

Solution:

Step 1: LD determination

Determine LD with no failure from AFM LANDING DISTANCE S+FLAPS 48°" chart (ref. AFM 5-650-4) as explained here above.

⇨ $LD_{DRY\ 20\ kt\ HEADWIND\ CORRECTED}$ = 2,100 ft

Step 2: Landing Distance Factor (LDF) determination

Determine the LDF for the given RWYCC with the table published in "IN-FLIGHT CALCULATION" section of this document.

Landing Distance Factor (LDF)				
Runway condition code (RWYCC)	4	**3**	2	1
Turbojet without reverse	2.8	**3.2**	4.0	5.1
Turbojet with all reversers operating	2.3	**2.5**	2.9	3.4

Step 3: F-$LDTA_{CONTA}$ determination

Using the Landing Distance Factor (LDF) selected above:

- ⇨ F-$LDTA_{CONTA}$ = $LD_{DRY\ 20\ kt\ HEADWIND\ CORRECTED}$ x 2.5
- ⇨ F-$LDTA_{CONTA}$ = 2100 x 2.5
- ⇨ F-$LDTA_{CONTA}$ = 5,250 ft

As a conclusion:

- ⇨ F-$LDTA_{CONTA}$ (5,250 ft) being shorter than LDA (8,000 ft),
- ⇨ The airplane can land on this runway

Conclusion

With no failure, recommended computation of VAPP has little impact on landing distance when there is no gust. When there is some gust, the LD is increased but with some margin against stall.

This recommended VAPP provides the best compromise between handling qualities (stall margin or controllability / maneuverability) and landing distance. Whenever landing distance becomes an issue, the Pilot in Command (PIC) may decide, under his/her full responsibility, to tip the compromise in favor of landing distance performance by disregarding the gust correction, and to manage the approach speed to meet "$V_{APP} = V_{REF}$ + Configuration correction + 1/2 $V_{HEADWIND}$" at 50 ft.

General information can be found in the Flight Safety Foundation tool kit by following this link: http://www.flightsafety.org/current-safety-initiatives/approach-and-landing-accident-reductionalar/alar-briefing-notes-english

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