



Università degli Studi di Trieste

Dipartimento di Ingegneria e Architettura

Laurea Magistrale: Ingegneria Civile

Corso : Strade Ferrovie ed Aeroporti (401MI-2)



Lezione 09: Geometria Aeroporti

Roberto Roberti

Tel.: 040 558 3588

E-mail: roberto.roberti@dia.units.it

Anno accademico 2023/2024



Obiettivi e Sommario

Obiettivi Lezione 09:

- **Progettazione geometrica del lato aria degli aeroporti.**

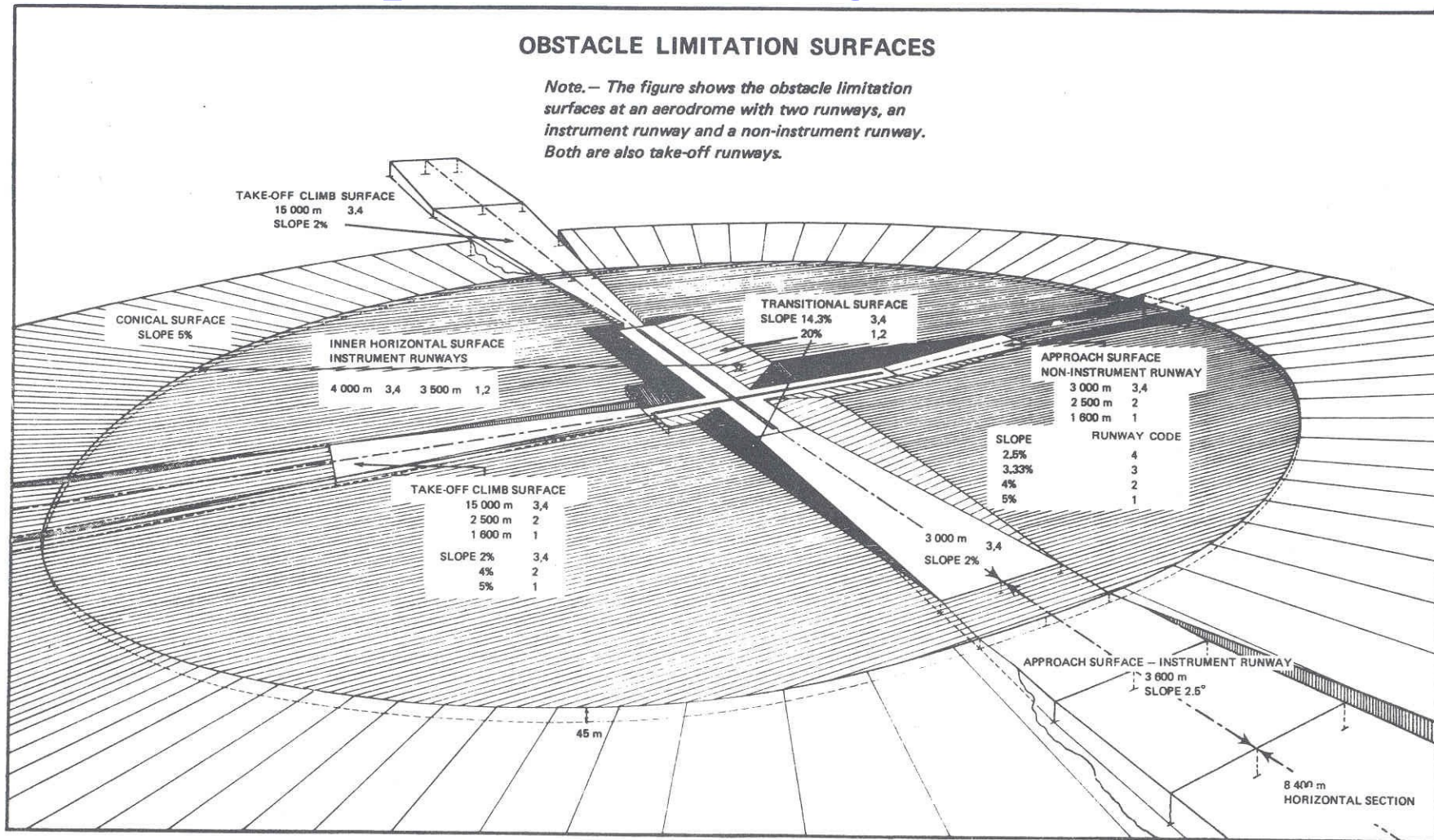
Sommario Lezione 09:

- **Le superfici di limitazione degli ostacoli;**
- **Orientamento delle piste;**
- **Dati di riferimento di un aerodromo;**
- **Manovre di decollo e atterraggio e lunghezza pista;**
- **Caratteristiche geometriche delle runway (planimetriche e altimetriche);**
- **Distanze di separazione nella circolazione a terra;**
- **Caratteristiche geometriche delle uscite dalle runway e delle holding bay;**
- **Caratteristiche geometriche delle taxiway e manovre di taxing;**
- **Area terminale**

Superfici limiti degli ostacoli

OBSTACLE LIMITATION SURFACES

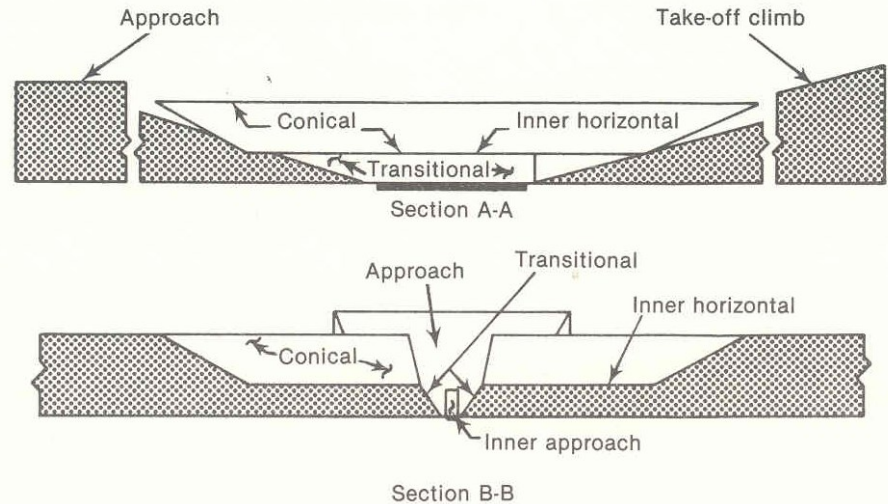
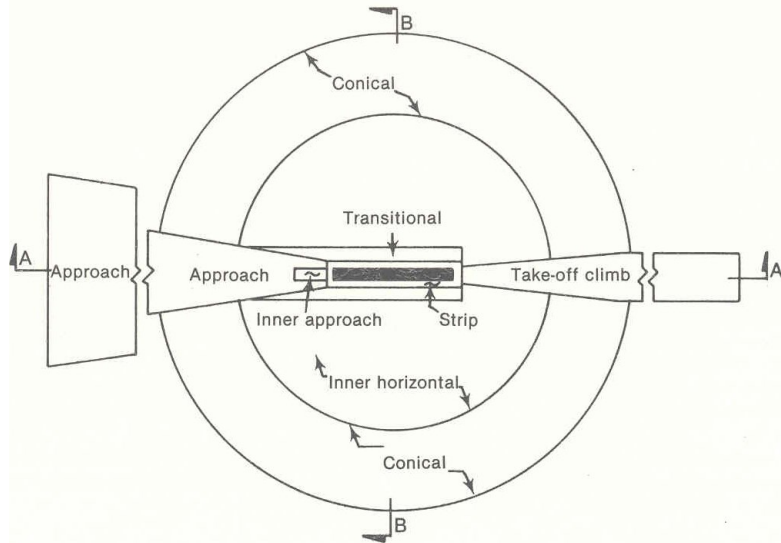
Note.— The figure shows the obstacle limitation surfaces at an aerodrome with two runways, an instrument runway and a non-instrument runway. Both are also take-off runways.



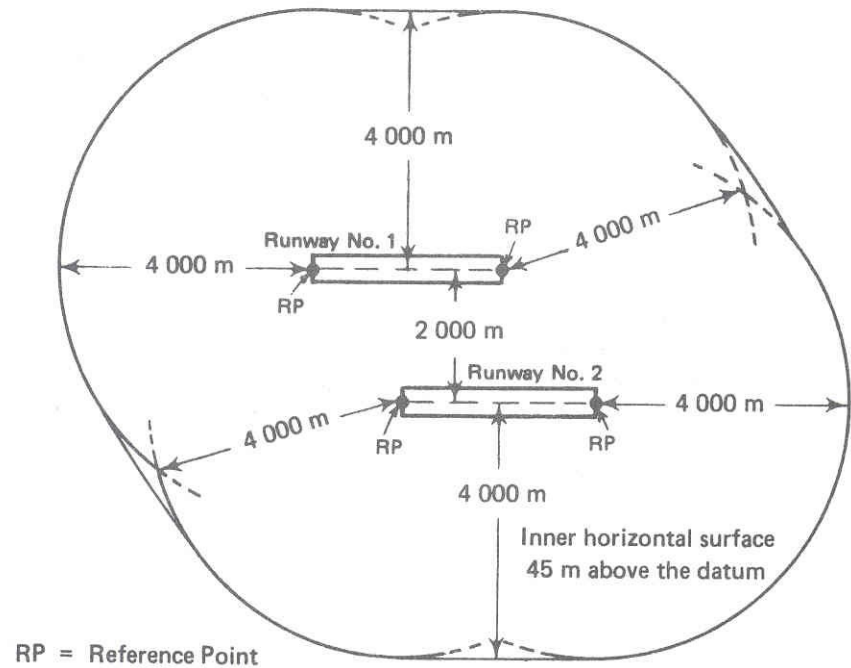
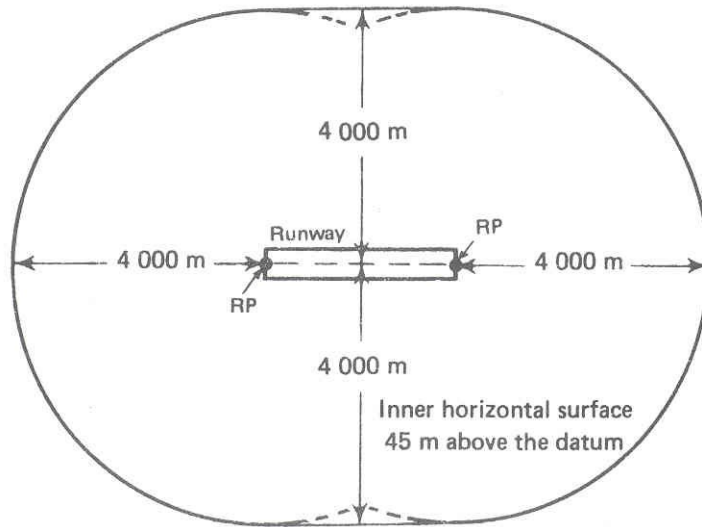
Superficie orizzontale e conica

RUNWAY CLASSIFICATION

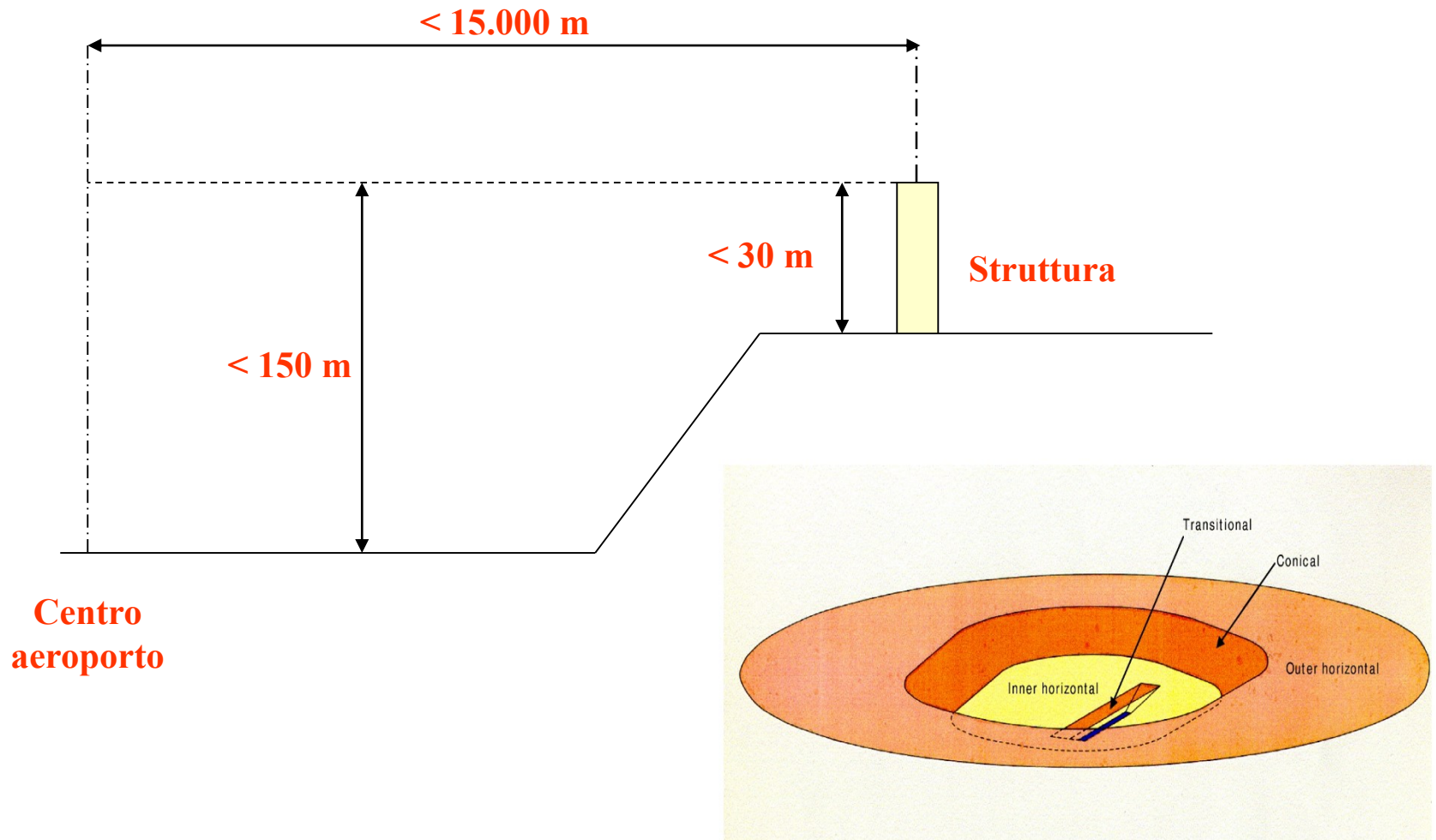
| Surface and dimensions ^a (1) | Non-instrument | | | | Non-precision approach | | | Precision approach category | | |
|--|----------------|---------|---------|---------|------------------------|---------|---------|-----------------------------|-------------|-------------|
| | Code number | | | | Code number | | | I | II or III | |
| | 1 | 2 | 3 | 4 | 1,2 | 3 | 4 | Code number | Code number | Code number |
| (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | |
| CONICAL | | | | | | | | | | |
| Slope | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% |
| Height | 35 m | 55 m | 75 m | 100 m | 60 m | 75 m | 100 m | 60 m | 100 m | 100 m |
| INNER HORIZONTAL | | | | | | | | | | |
| Height | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m |
| Radius | 2 000 m | 2 500 m | 4 000 m | 4 000 m | 3 500 m | 4 000 m | 4 000 m | 3 500 m | 4 000 m | 4 000 m |



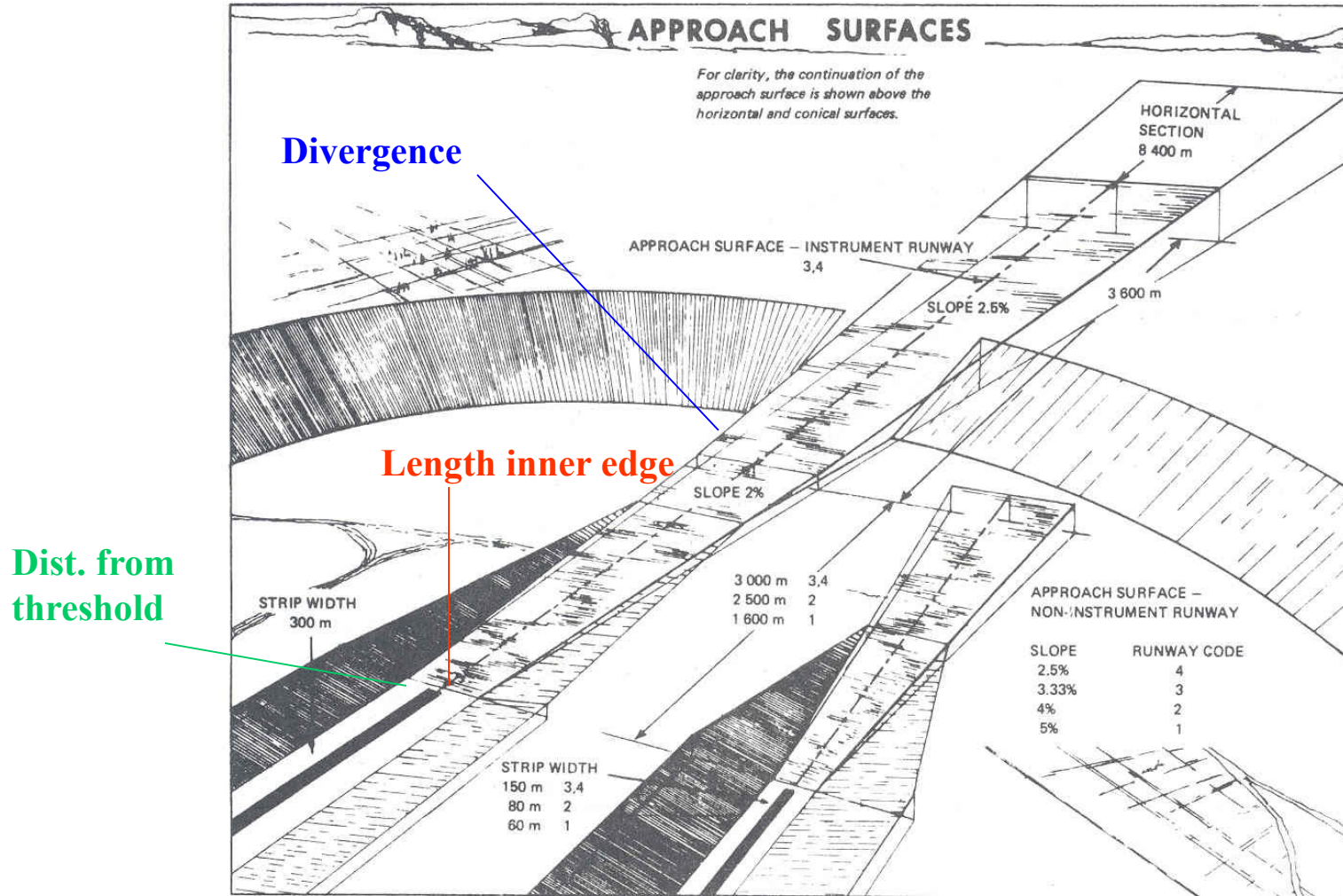
Superfici orizzontali composte



Superficie orizzontale esterna



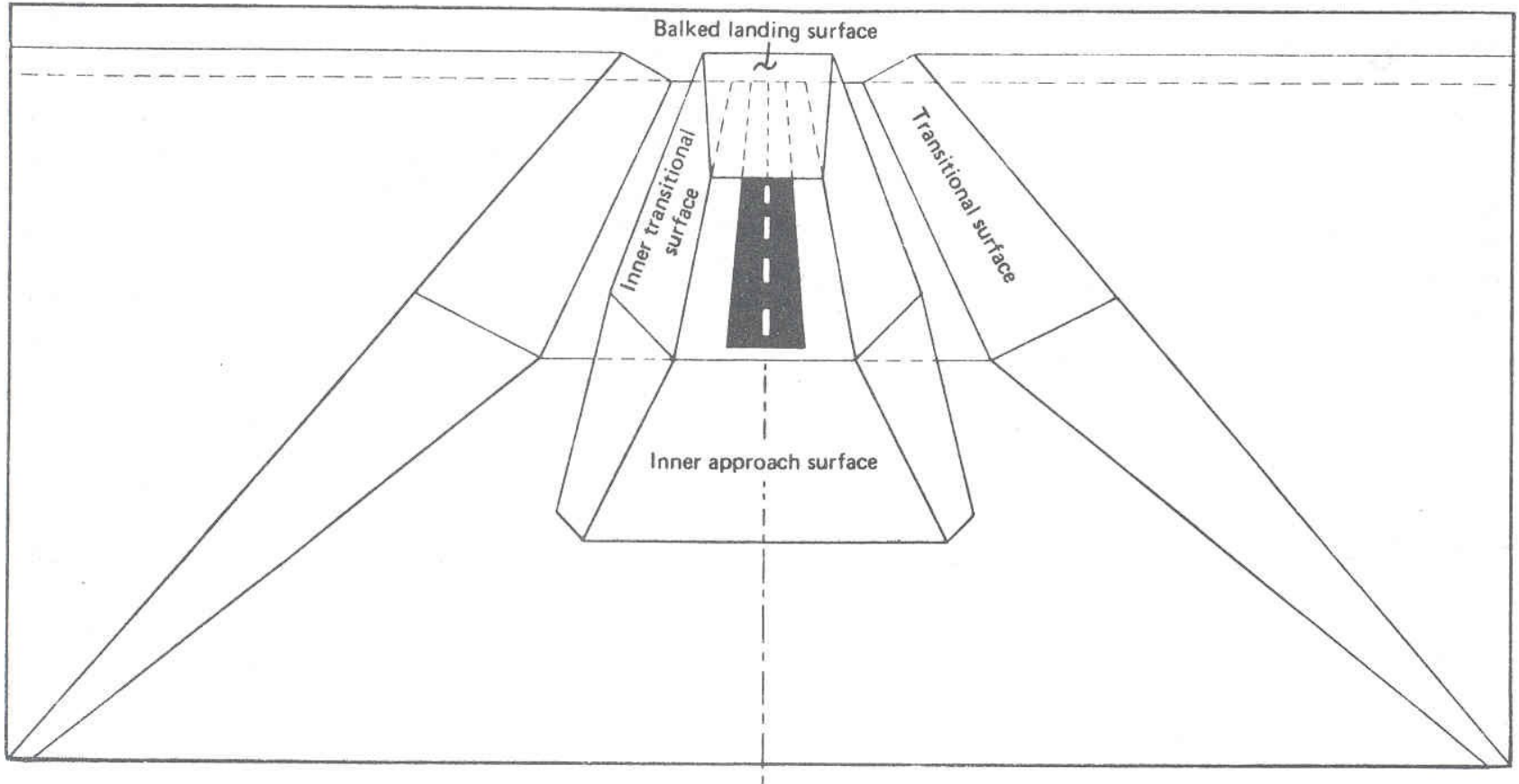
Superficie di transizione e avvicinamento (1)



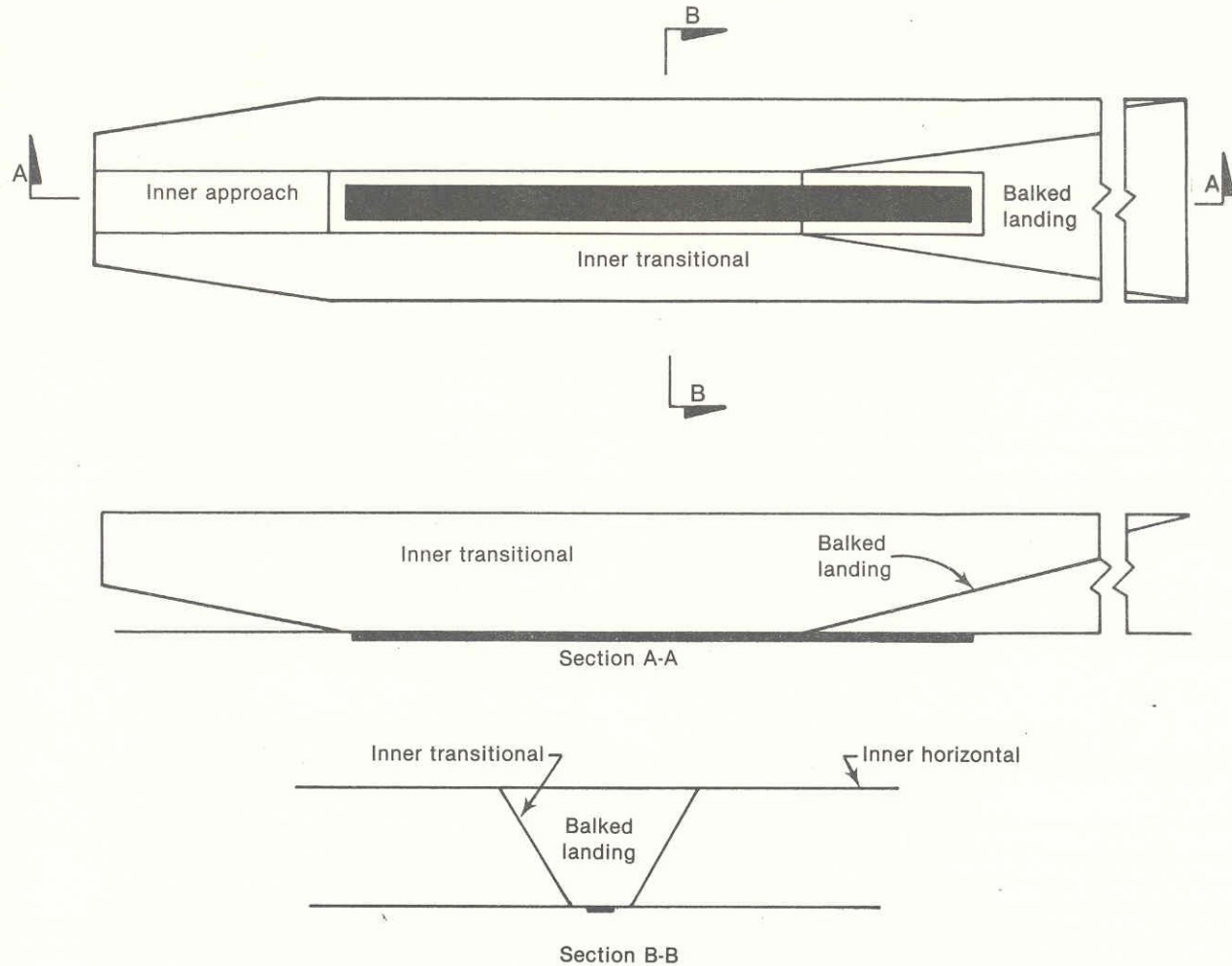
Superficie di transizione e avvicinamento (2)

| Surface and dimensions ^a | RUNWAY CLASSIFICATION | | | | | | | | | |
|-------------------------------------|-----------------------|----------------|---------|---------|------------------------|----------------------|----------------------|-----------------------------|----------------------|----------------------|
| | 1 | Non-instrument | | | Non-precision approach | | | Precision approach category | | |
| | | Code number | | 4 | Code number | | I | | II or III | |
| | | 2 | 3 | | 1,2 | 3 | 4 | Code number | Code number | |
| | 1,2 | 3,4 | 3,4 | | | | | | | |
| APPROACH | | | | | | | | | | |
| Length of inner edge | 60 m | 80 m | 150 m | 150 m | 150 m | 300 m | 300 m | 150 m | 300 m | 300 m |
| Distance from threshold | 30 m | 60 m | 60 m | 60 m | 60 m | 60 m | 60 m | 60 m | 60 m | 60 m |
| Divergence (each side) | 10% | 10% | 10% | 10% | 15% | 15% | 15% | 15% | 15% | 15% |
| First section | | | | | | | | | | |
| Length | 1 600 m | 2 500 m | 3 000 m | 3 000 m | 2 500 m | 3 000 m | 3 000 m | 3 000 m | 3 000 m | 3 000 m |
| Slope | 5% | 4% | 3.33% | 2.5% | 3.33% | 2% | 2% | 2.5% | 2% | 2% |
| Second section | | | | | | | | | | |
| Length | — | — | — | — | — | 3 600 m ^b | 3 600 m ^b | 12 000 m | 3 600 m ^b | 3 600 m ^b |
| Slope | — | — | — | — | — | 2.5% | 2.5% | 3% | 2.5% | 2.5% |
| Horizontal section | | | | | | | | | | |
| Length | — | — | — | — | — | 8 400 m ^b | 8 400 m ^b | — | 8 400 m ^b | 8 400 m ^b |
| Total length | — | — | — | — | — | 15 000 m | 15 000 m | 15 000 m | 15 000 m | 15 000 m |
| TRANSITIONAL | | | | | | | | | | |
| Slope | 20% | 20% | 14.3% | 14.3% | 20% | 14.3% | 14.3% | 14.3% | 14.3% | 14.3% |

Superfici interne (1)



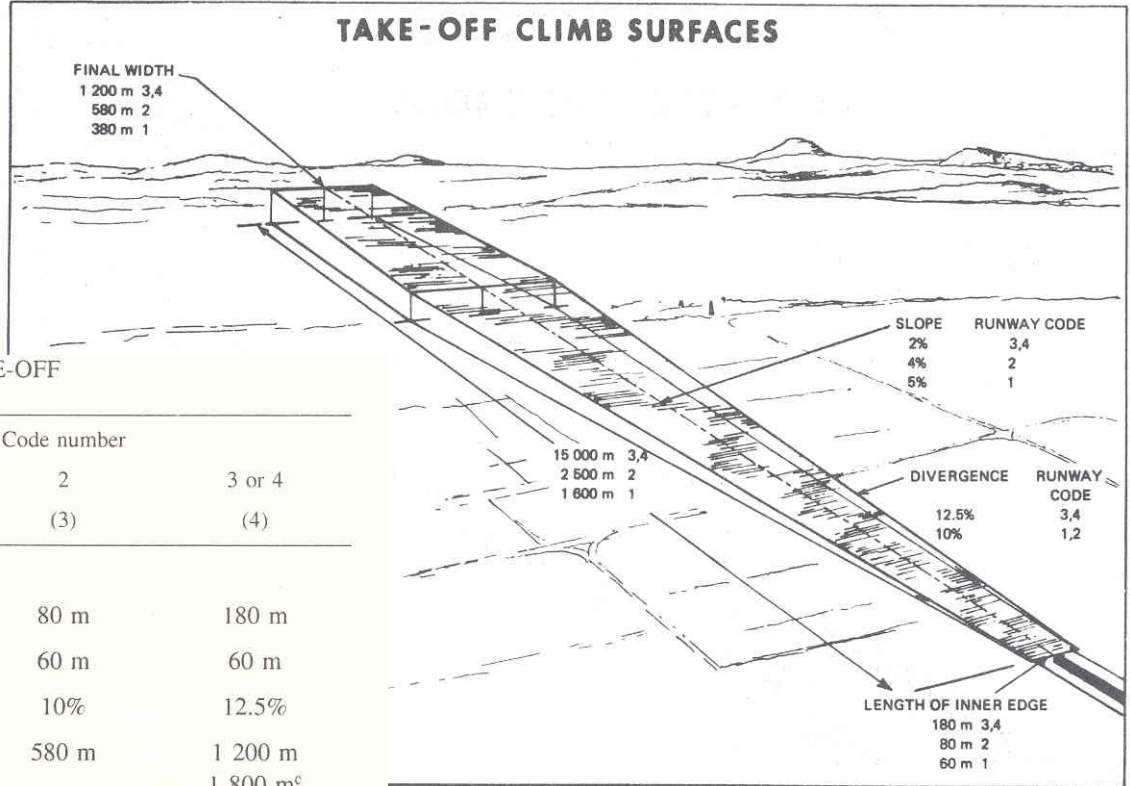
Superficie interne (2)



Superfici interne (3)

| Surface and dimensions ^a | RUNWAY CLASSIFICATION | | | | | | | | | |
|-------------------------------------|-----------------------|----------------|-----|-----|------------------------|-----|-----|-----------------------------|----------------------|----------------------|
| | 1 | Non-instrument | | | Non-precision approach | | | Precision approach category | | |
| | | Code number | | | Code number | | | I | II or III | |
| | | 2 | 3 | 4 | 1,2 | 3 | 4 | 1,2 | 3,4 | 3,4 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| INNER APPROACH | | | | | | | | | | |
| Width | — | — | — | — | — | — | — | 90 m | 120 m | 120 m |
| Distance from threshold | — | — | — | — | — | — | — | 60 m | 60 m | 60 m |
| Length | — | — | — | — | — | — | — | 900 m | 900 m | 900 m |
| Slope | | | | | | | | 2.5% | 2% | 2% |
| INNER TRANSITIONAL | | | | | | | | | | |
| Slope | — | — | — | — | — | — | — | 40% | 33.3% | 33.3% |
| BALKED LANDING SURFACE | | | | | | | | | | |
| Length of inner edge | — | — | — | — | — | — | — | 90 m | 120 m | 120 m |
| Distance from threshold | — | — | — | — | — | — | — | ^c | 1 800 m ^d | 1 800 m ^d |
| Divergence (each side) | — | — | — | — | — | — | — | 10% | 10% | 10% |
| Slope | — | — | — | — | — | — | — | 4% | 3.33% | 3.33% |

Superficie di decollo



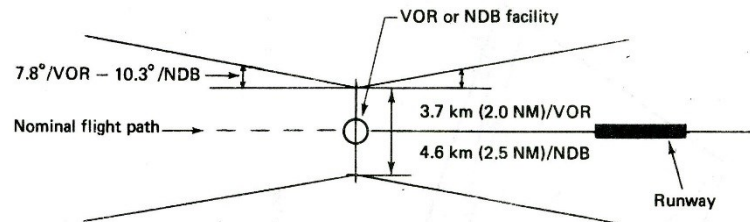
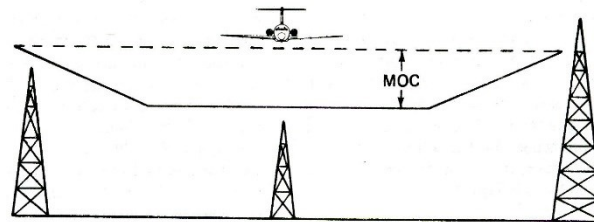
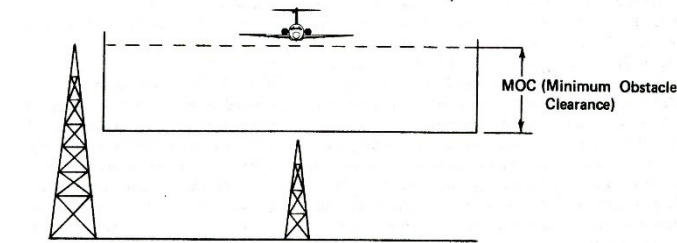
RUNWAYS MEANT FOR TAKE-OFF

| Surface and dimensions ^a | Code number | | |
|---------------------------------------|-------------|---------|---------------------------------|
| | 1 | 2 | 3 or 4 |
| (1) | (2) | (3) | (4) |
| TAKE-OFF CLIMB | | | |
| Length of inner edge | 60 m | 80 m | 180 m |
| Distance from runway end ^b | 30 m | 60 m | 60 m |
| Divergence (each side) | 10% | 10% | 12.5% |
| Final width | 380 m | 580 m | 1 200 m 1 800 m ^c |
| Length | 1 600 m | 2 500 m | 15 000 m |
| Slope | 5% | 4% | 2% ^d |

- a. All dimensions are measured horizontally unless specified otherwise.
 b. The take-off climb surface starts at the end of the clearway if the clearway length exceeds the specified distance.
 c. 1 800 m when the intended track includes changes of heading greater than 15° for operations conducted in IMC, VMC by night.
 d. See 4.2.24 and 4.2.26.

Superfici PANS – OPS (1)

PANS-OPS (Procedures for Air Navigation Services- aircraft OPerationS)



Superfici PANS – OPS (2)

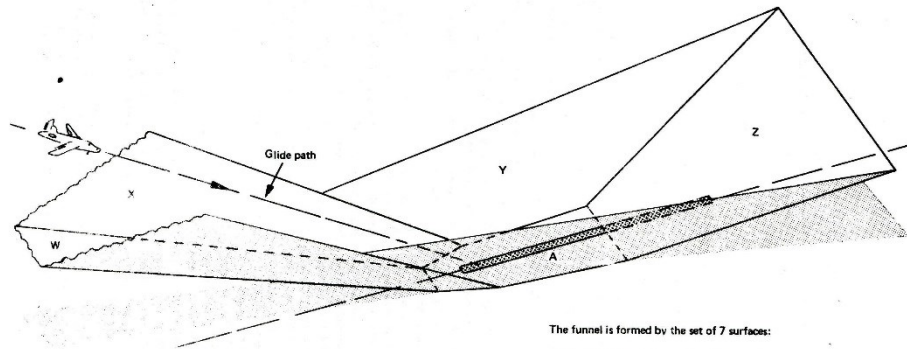


Figure 1-7. The approach funnel (OAS)

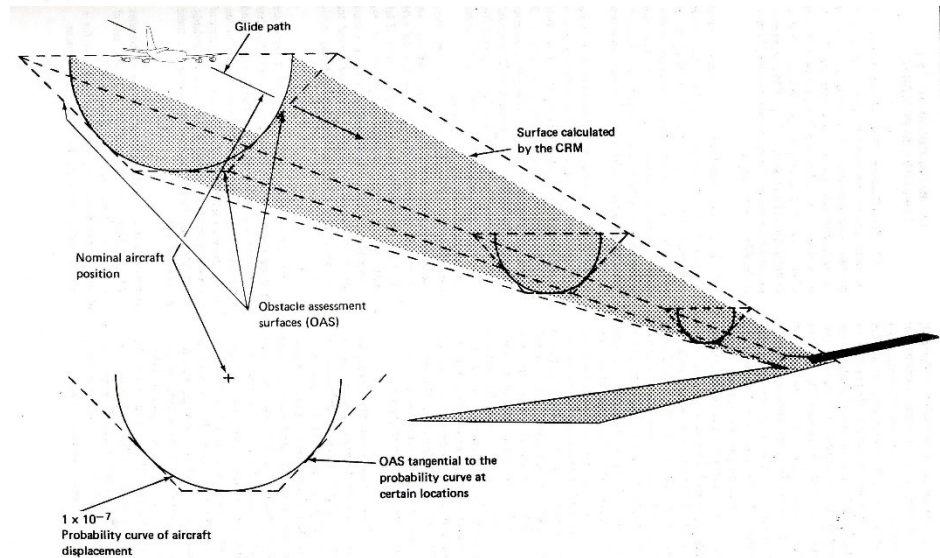


Figure 1-8. The approach funnel (CRM)

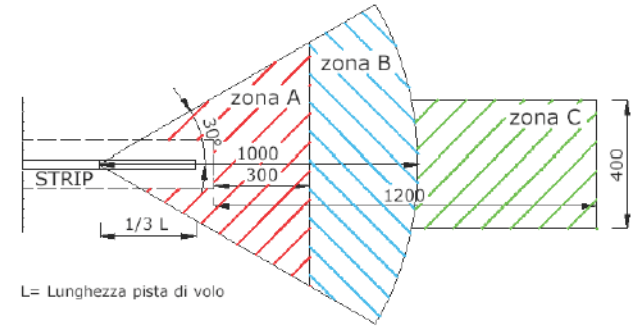
Normativa italiana

Tabella 4.2 - Dimensioni e pendenze delle superfici di separazione dagli ostacoli

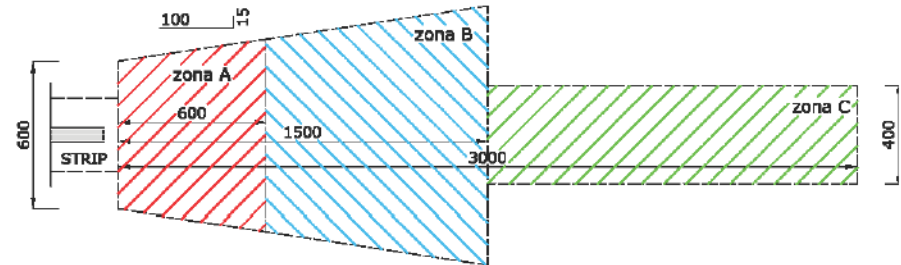
| Superficie e dimensioni ^a | CLASSIFICAZIONE DELLE PISTE | | | | | | | | Avvicinamenti di precisione di categoria | | |
|--------------------------------------|-----------------------------|--------|--------|--------|---------------------------------|---------------------|---------------------|---------|--|---------------------|--|
| | Non strumentali | | | | Avvicinamenti non di precisione | | | | I o III | | |
| | Numero di codice | | | | Numero di codice | | | | N° di codice | | |
| (1) | 1 (2) | 2 (3) | 3 (4) | 4 (5) | 1,2 (6) | 3 (7) | 4 (8) | 1,2 (9) | 3,4 (10) | 3,4 (11) | |
| Conica | | | | | | | | | | | |
| Pendenza | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | |
| Altezza | 35 m | 55 m | 75 m | 100 m | 60 m | 75 m | 100 m | 60 m | 100 m | 100 m | |
| Orizzontale | | | | | | | | | | | |
| interna | | | | | | | | | | | |
| Altezza | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m | 45 m | |
| Raggio | 2000 m | 2500 m | 4000 m | 4000 m | 3500 m | 4000 m | 4000 m | 3500 m | 4000 m | 4000 m | |
| Interna | | | | | | | | | | | |
| Avvicinamento | | | | | | | | | | | |
| Larghezza | --- | --- | --- | --- | --- | --- | --- | 90 m | 120 m ^a | 120 m ^a | |
| Distanza dalla soglia | --- | --- | --- | --- | --- | --- | --- | 60 m | 60 m | 60 m | |
| Lunghezza | --- | --- | --- | --- | --- | --- | --- | 900 m | 900 m | 900 m | |
| Pendenza | --- | --- | --- | --- | --- | --- | --- | 2.5% | 2% | 2% | |
| Avvicinamento | | | | | | | | | | | |
| Lunghezza bordo interno | 60 m | 80 m | 150 m | 150 m | 150 m | 300 m | 300 m | 150 m | 300 m | 300 m | |
| Distanza dalla soglia | 30 m | 60 m | 60 m | 60 m | 60 m | 60 m | 60 m | 60 m | 60 m | 60 m | |
| Divergenza (su entrambi i lati) | 10% | 10% | 10% | 10% | 15% | 15% | 15% | 15% | 15% | 15% | |
| Prima sezione | | | | | | | | | | | |
| Lunghezza | 1600 m | 2500 m | 3000 m | 3000 m | 2500 m | 3000 m | 3000 m | 3000 m | 3000 m | 3000 m | |
| Pendenza | 5% | 4% | 3.33% | 2.5% | 3.33% | 2% | 2% | 2.5% | 2% | 2% | |
| Seconda sezione | | | | | | | | | | | |
| Lunghezza | --- | --- | --- | --- | --- | 3600 m ^b | 3600 m ^b | 12000 m | 3600 m ^b | 3600 m ^b | |
| Pendenza | --- | --- | --- | --- | --- | 2.5% | 2.5% | 3% | 2.5% | 2.5% | |
| Sezione orizzontale | | | | | | | | | | | |
| Lunghezza | --- | --- | --- | --- | --- | 8400 m ^b | 8400 m ^b | --- | 8400 m ^b | 8400 m ^b | |
| Lunghezza totale | --- | --- | --- | --- | --- | 15000 m | 15000 m | 15000 m | 15000 m | 15000 m | |
| Transizione | | | | | | | | | | | |
| Pendenza | 20% | 20% | 14.3% | 14.3% | 20% | 14.3% | 14.3% | 14.3% | 14.3% | 14.3% | |
| Transizione interna | | | | | | | | | | | |
| Pendenza | --- | --- | --- | --- | --- | --- | --- | 40% | 33.3% | 33.3% | |
| Atterraggio interrotto | | | | | | | | | | | |
| Lunghezza bordo interno | --- | --- | --- | --- | --- | --- | --- | 90 m | 120 m ^a | 120 m ^a | |
| Distanza dalla soglia | --- | --- | --- | --- | --- | --- | --- | --- | 1800 m ^d | 1800 m ^d | |
| Divergenza (su entrambi i lati) | --- | --- | --- | --- | --- | --- | --- | 10% | 10% | 10% | |
| Pendenza | --- | --- | --- | --- | --- | --- | --- | 4% | 3.33% | 3.33% | |

(a) Tutte le dimensioni sono misurate in orizzontale, ove non sia specificato altrimenti
 (b) Lunghezza variabile
 (c) Distanza fino alla fine delle strisce di sicurezza
 (d) O fine della pista, quale fra le due risulti inferiore
 (e) Per piste di codice F la larghezza è aumentata a 155 m

Per piste di volo di codice 1 e piste di volo di codice 2:



Per piste di volo di codice 3 e piste di volo di codice 4:

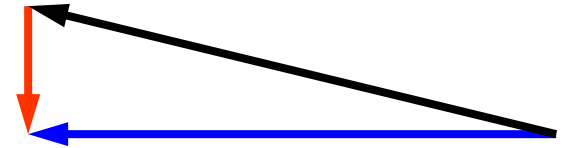
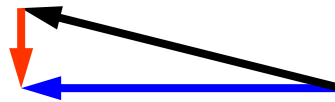
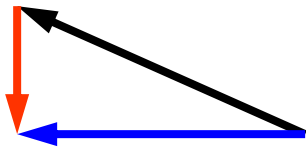
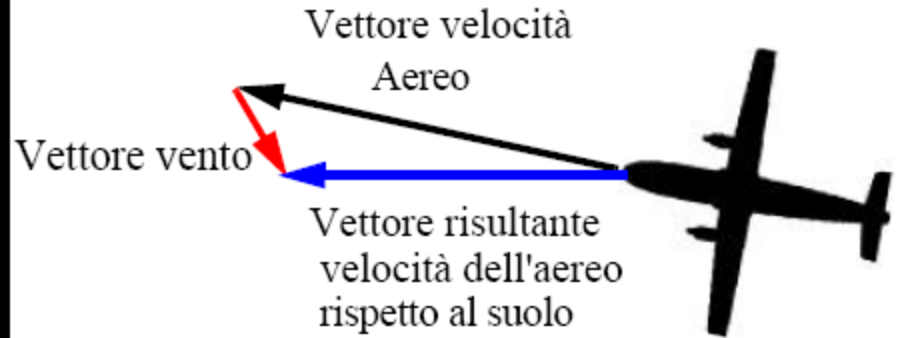
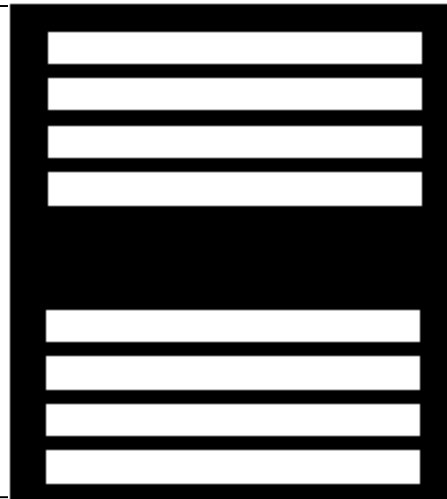


Zone di tutela (PSZ Public Safety Zones)

Orientamento delle piste e regime dei venti

SOGLIA

RUNWAY



Norme ICAO e FAA

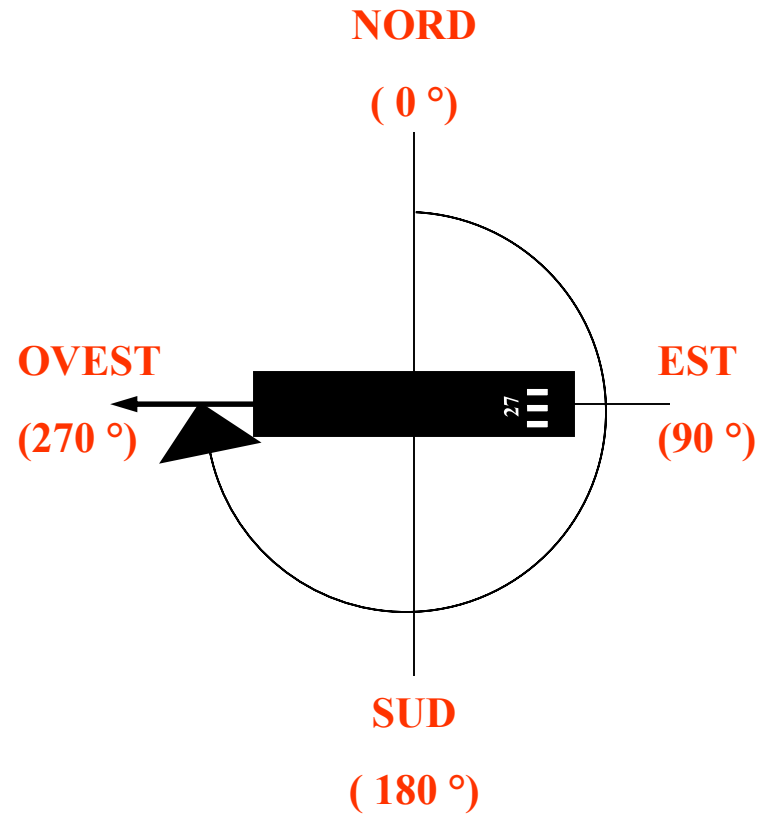
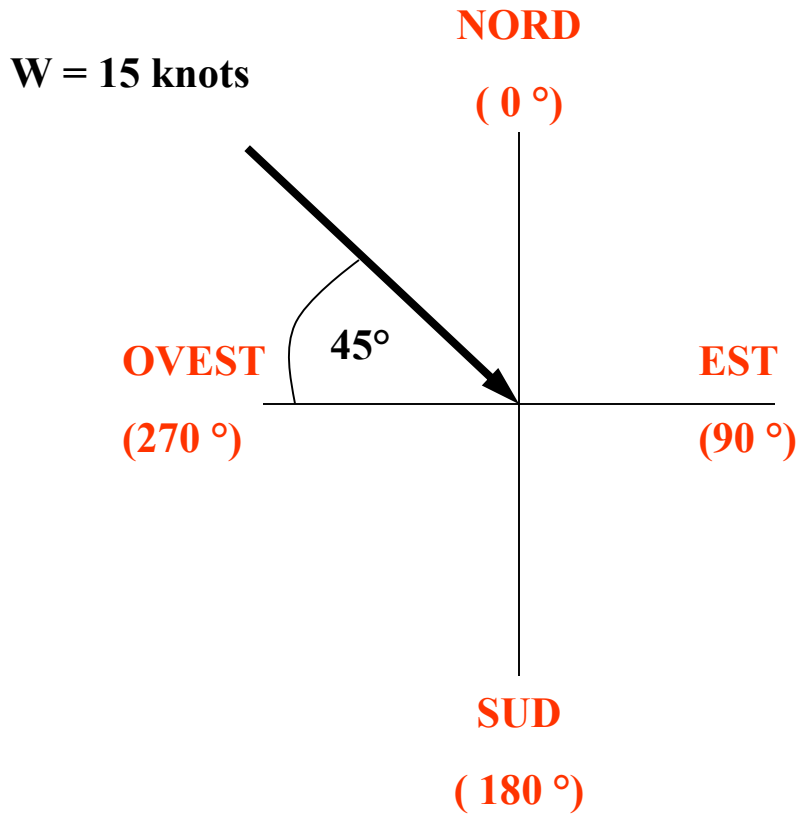
| Lunghezza di campo Aereo [m] | Vento trasversale max [km/h (nodi)] |
|------------------------------|-------------------------------------|
| < 1200 | 19 (10) |
| 1200 - 1500 | 24 (13) |
| > 1500 | 37 (20) |

NORMA ICAO

| Codice Aeroporto | Vento trasversale max [km/h (nodi)] |
|---------------------------|-------------------------------------|
| AI - BI | 10,5 |
| AII - BII | 13,0 |
| AIII, BIII e da CI a DIII | 16,0 |
| Da AIV a DIV | 20,0 |

NORMA FAA

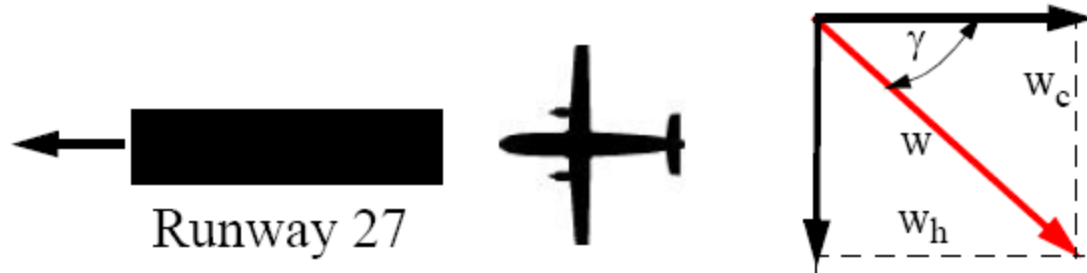
Regime dei venti (1)



VENTO DA 315 ° A 15 KNOTS

PISTA 27

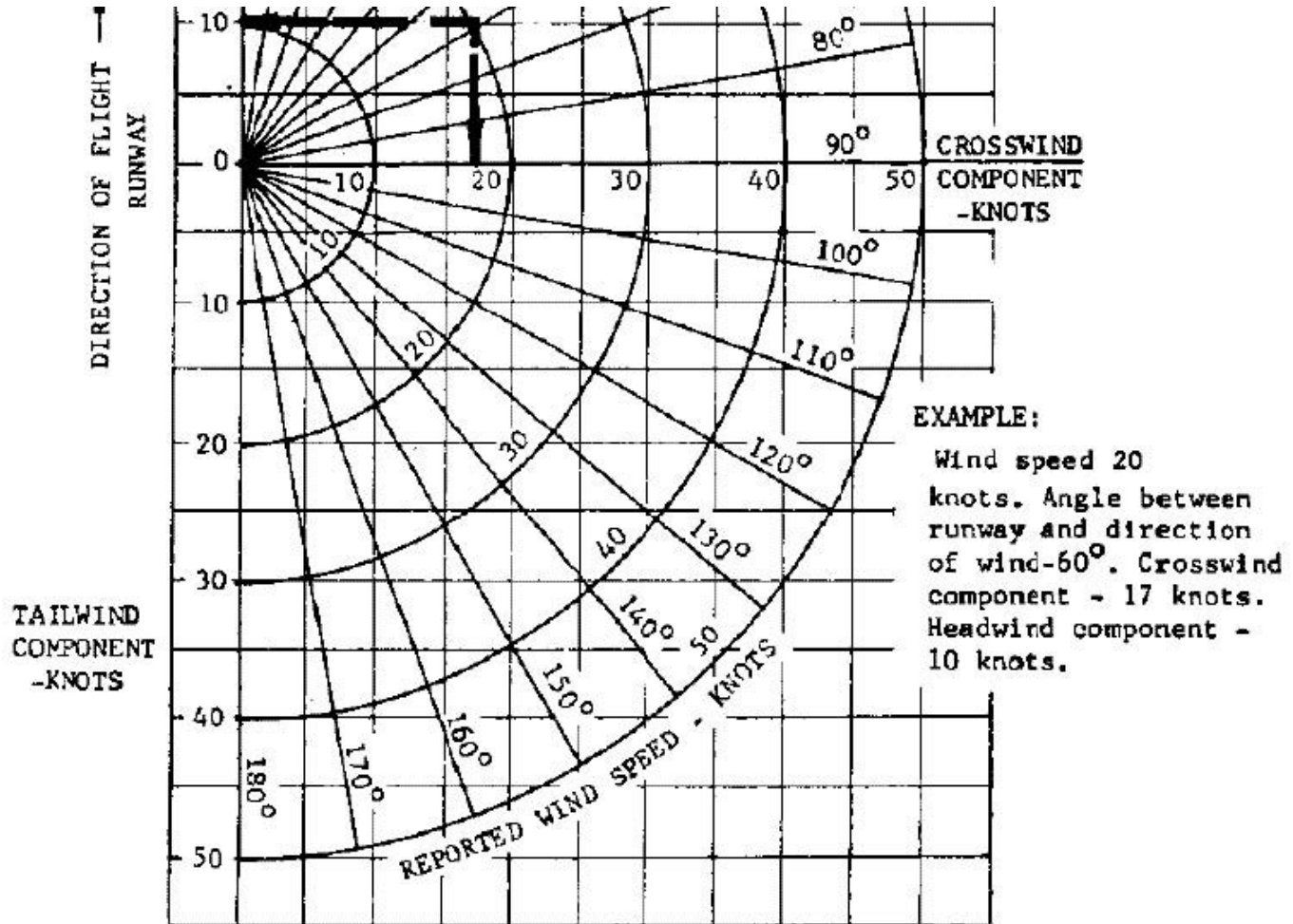
Regime dei venti (2)



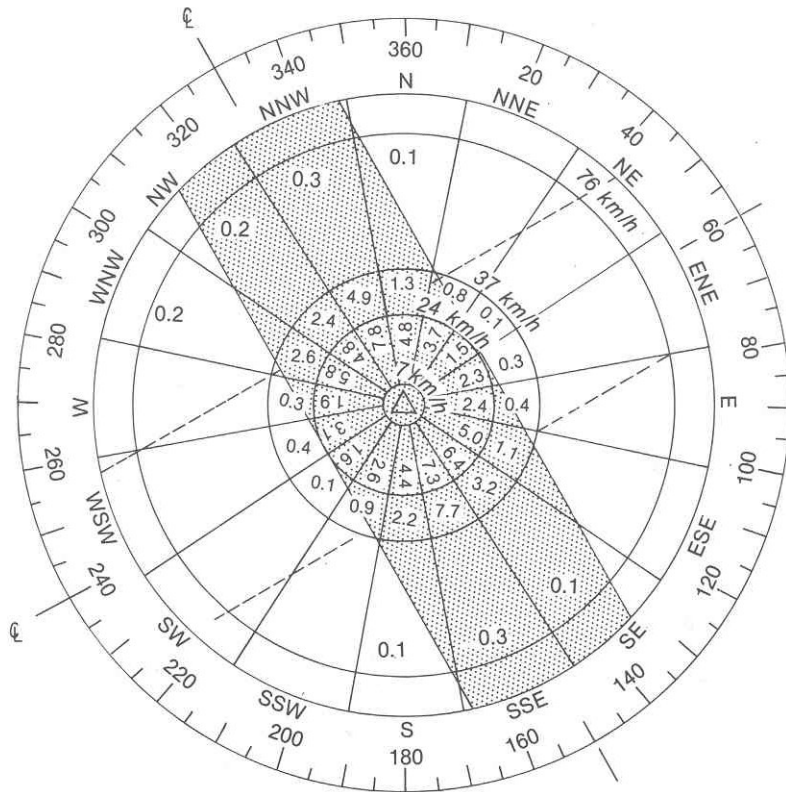
$$W_c = W * \sin (\gamma)$$

$$W_h = W * \cos (\gamma)$$

Regime dei venti (3)



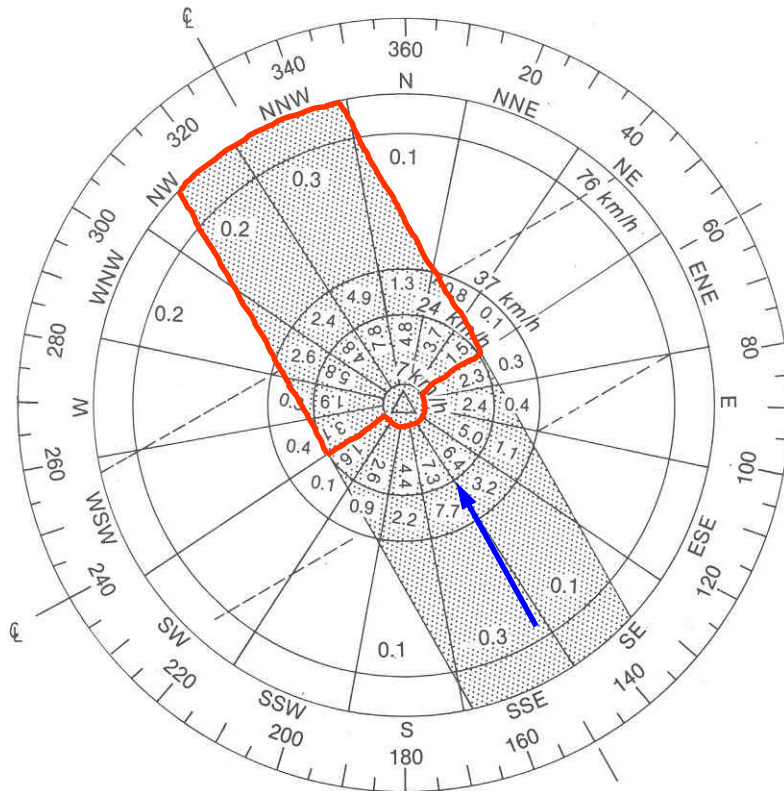
Calcolo del coefficiente anemometrico (1)



△ 4.6% calms, 0~6 km/h

| Wind direction | Percentage of winds | | | Total |
|------------------------------|------------------------|--------------------------|--------------------------|-------|
| | 7~24 km/h (4~13 kt) | 26~37 km/h (14~20 kt) | 39~76 km/h (21~41 kt) | |
| N | 4.8 | 1.3 | 0.1 | 6.2 |
| NNE | 3.7 | 0.8 | --- | 4.5 |
| NE | 1.5 | 0.1 | --- | 1.6 |
| ENE | 2.3 | 0.3 | --- | 2.6 |
| E | 2.4 | 0.4 | --- | 2.8 |
| ESE | 5.0 | 1.1 | --- | 6.1 |
| SE | 6.4 | 3.2 | 0.1 | 9.7 |
| SSE | 7.3 | 7.7 | 0.3 | 15.3 |
| S | 4.4 | 2.2 | 0.1 | 6.7 |
| SSW | 2.6 | 0.9 | --- | 3.5 |
| SW | 1.6 | 0.1 | --- | 1.7 |
| WSW | 3.1 | 0.4 | --- | 3.5 |
| W | 1.9 | 0.3 | --- | 2.2 |
| WNW | 5.8 | 2.6 | 0.2 | 8.6 |
| NW | 4.8 | 2.4 | 0.2 | 7.4 |
| NNW | 7.8 | 4.9 | 0.3 | 13.0 |
| Calms — (0~6 km/hr (0~3 kt)) | | | | 4.6 |
| Total | | | | 100.0 |

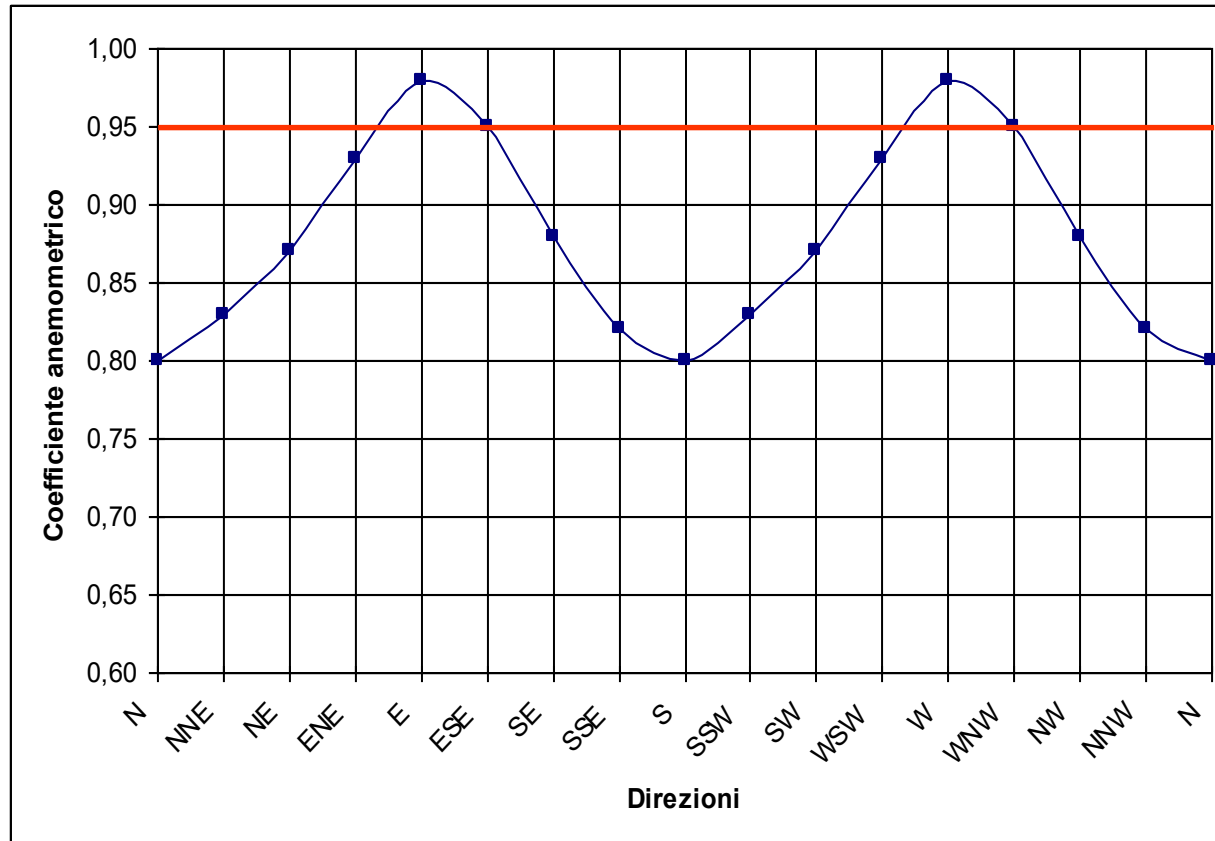
Calcolo del coefficiente anemometrico (2)



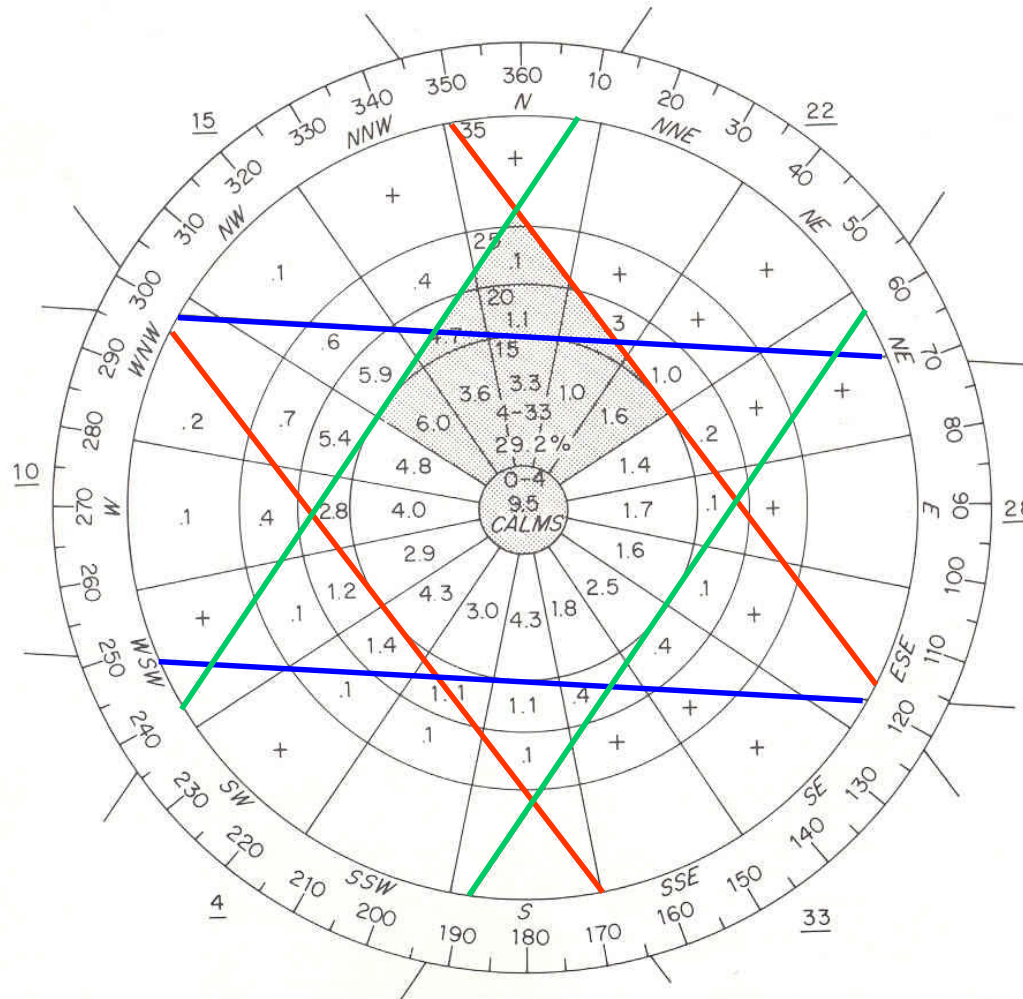
△ 4.6% calms, 0~6 km/h

| Wind direction | Percentage of winds | | | Total |
|------------------------------|------------------------|--------------------------|--------------------------|-------|
| | 7~24 km/h (4~13 kt) | 26~37 km/h (14~20 kt) | 39~76 km/h (21~41 kt) | |
| N | 4.8 | 1.3 | 0.1 | 6.2 |
| NNE | 3.7 | 0.8 | --- | 4.5 |
| NE | 1.5 | 0.1 | --- | 1.6 |
| ENE | 2.3 | 0.3 | --- | 2.6 |
| E | 2.4 | 0.4 | --- | 2.8 |
| ESE | 5.0 | 1.1 | --- | 6.1 |
| SE | 6.4 | 3.2 | 0.1 | 9.7 |
| SSE | 7.3 | 7.7 | 0.3 | 15.3 |
| S | 4.4 | 2.2 | 0.1 | 6.7 |
| SSW | 2.6 | 0.9 | --- | 3.5 |
| SW | 1.6 | 0.1 | --- | 1.7 |
| WSW | 3.1 | 0.4 | --- | 3.5 |
| W | 1.9 | 0.3 | --- | 2.2 |
| WNW | 5.8 | 2.6 | 0.2 | 8.6 |
| NW | 4.8 | 2.4 | 0.2 | 7.4 |
| NNW | 7.8 | 4.9 | 0.3 | 13.0 |
| Calms — (0~6 km/hr (0~3 kt)) | | | | 4.6 |
| Total | | | | 100.0 |

Calcolo del coefficiente anemometrico (3)

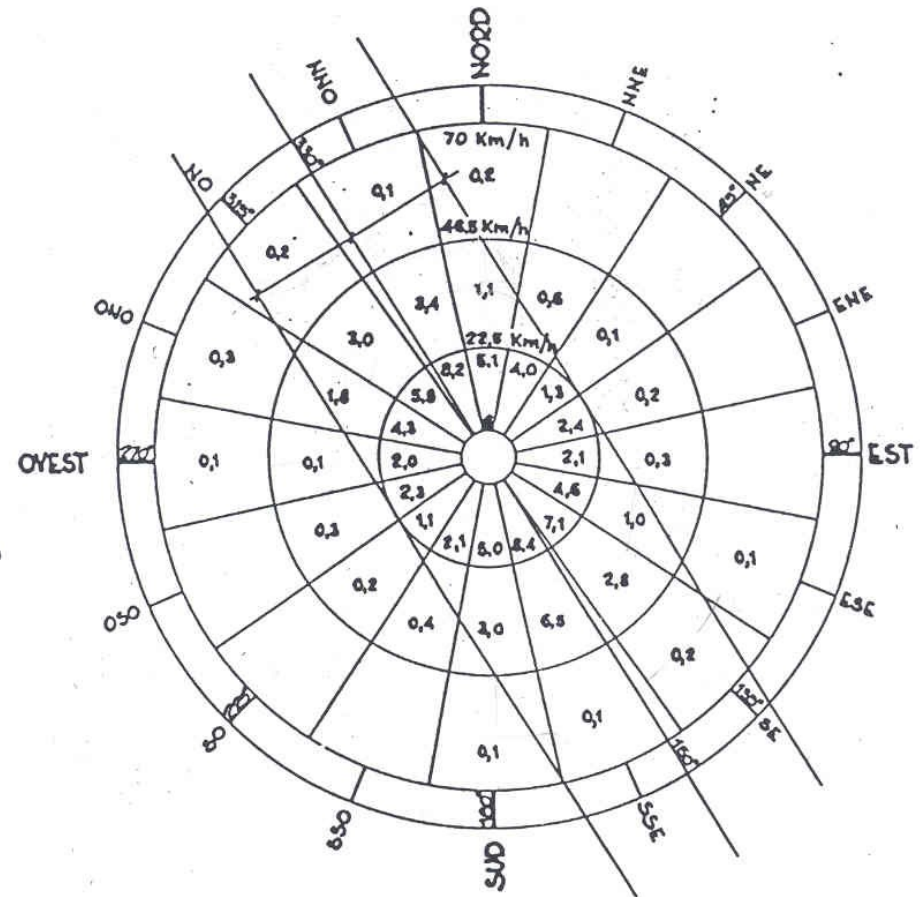


Coefficiente per più piste



Esempio di calcolo

| Direzione del vento | Frequenza | | | Totale |
|---------------------|------------------|---------------------|-------------------|--------|
| | Da 6 a 22,5 km/h | Da 22,5 a 46,5 km/h | Da 46,5 a 70 km/h | |
| N | 5,1 | 1,1 6/8 | 0,2 1/4 | 6,4 |
| NNE | 4,0 | 0,6 1/4 | - | 4,6 |
| NE | 1,3 | 0,1 | - | 1,4 |
| ENE | 2,4 | 0,2 | - | 2,6 |
| E | 2,1 | 0,3 1/4 | - | 2,4 |
| ESE | 4,6 | 1,0 2/3 | 0,1 | 5,7 |
| SE | 7,1 | 2,8 | 0,2 7/8 | 10,1 |
| SSE | 8,4 | 6,5 | 0,1 | 15,0 |
| S | 5,0 | 3,0 6/8 | 0,1 1/4 | 8,1 |
| SSO | 2,1 | 0,4 1/4 | - | 2,5 |
| SO | 1,1 | 0,2 | - | 1,3 |
| OSO | 2,3 | 0,3 | - | 2,6 |
| O | 2,0 | 0,1 1/4 | 0,1 | 2,2 |
| ONO | 4,3 | 1,8 2/3 | 0,3 | 6,4 |
| NO | 5,9 | 3,0 | 0,2 7/8 | 9,1 |
| NNO | 8,2 | 3,4 | 0,1 | 11,7 |
| Calma | Da 0 a 6 km/h | | | 7,9 |
| Totale | | | | 100,0t |



Dati aeroporto di Ronchi

| direzione | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW |
|-----------------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|-----|---|-----|----|-----|
| Intensità Vento | | | | | | | | | | | | | | | | |
| 0 - 4 nodi | 81,768 | | | | | | | | | | | | | | | |
| 4 - 10 | 0,787 | 0,513 | 1,267 | 1,917 | 4,863 | 1,095 | 1,232 | 0,924 | 0,958 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 - 13 | 0 | 0,102 | 0,376 | 0,41 | 1,13 | 0,102 | 0,205 | 0 | 0 | 0,136 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 - 20 | 0,068 | 0,102 | 0,136 | 0,205 | 1,061 | 0,064 | 0,034 | 0,068 | 0,068 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| > 20 | 0 | 0 | 0 | 0,136 | 0,171 | 0,034 | 0,034 | 0 | 0,034 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Dati di riferimento di un aerodromo

Punto di riferimento

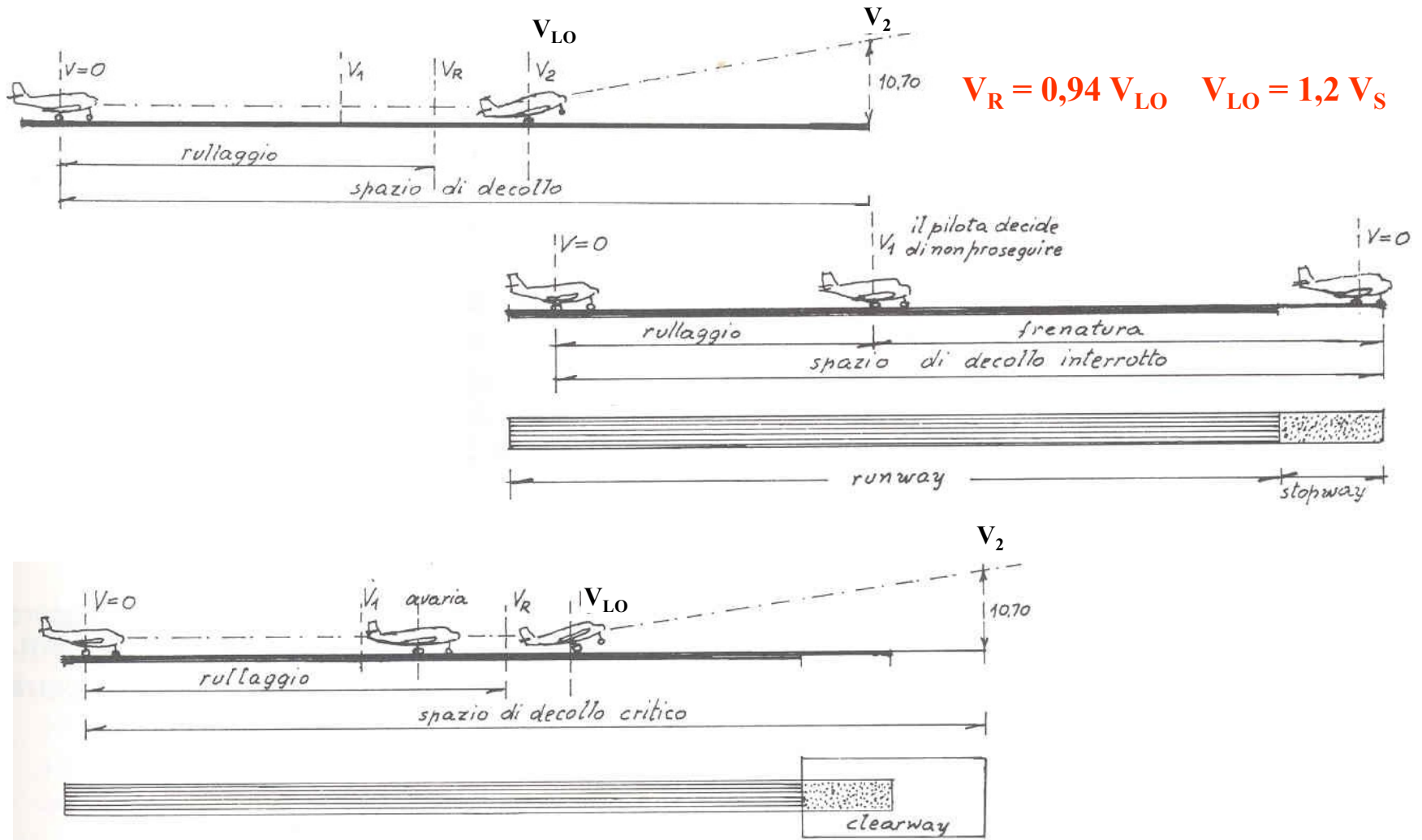
Altitudine aerodromo e piste

Temperatura di riferimento

Dimensioni e informazioni aerodromo

Distanze dichiarate

Le manovre di decollo (1)



Le manovre di decollo (2)

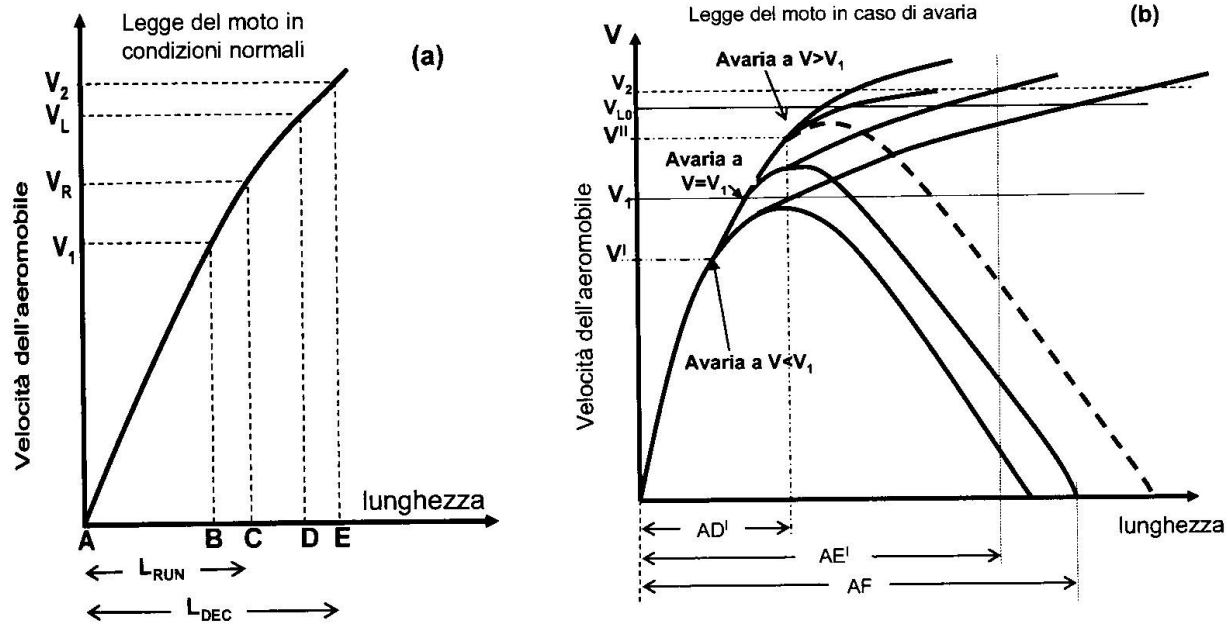
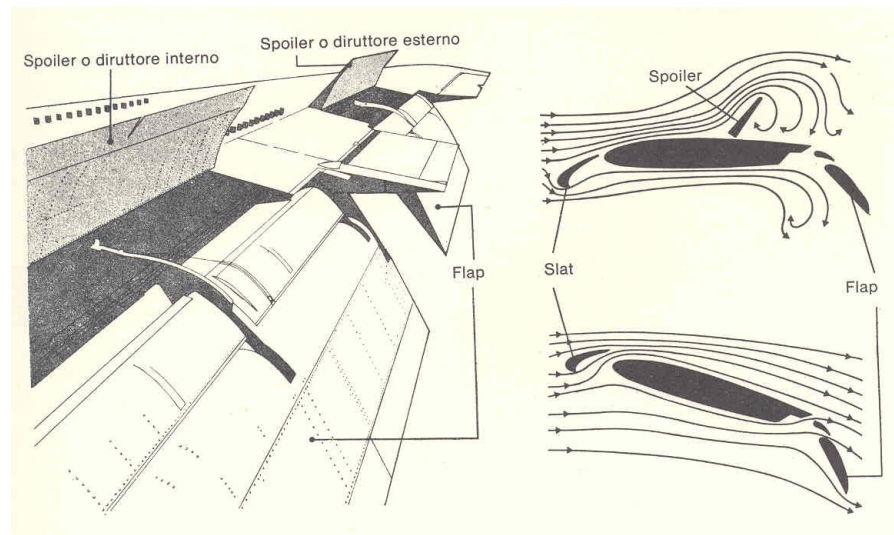
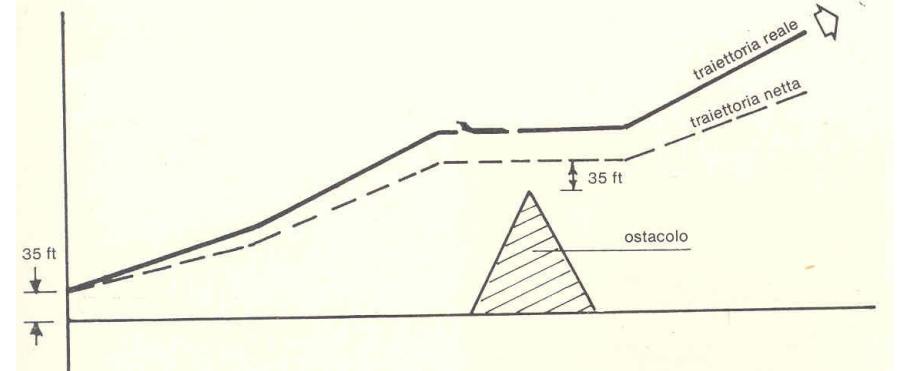
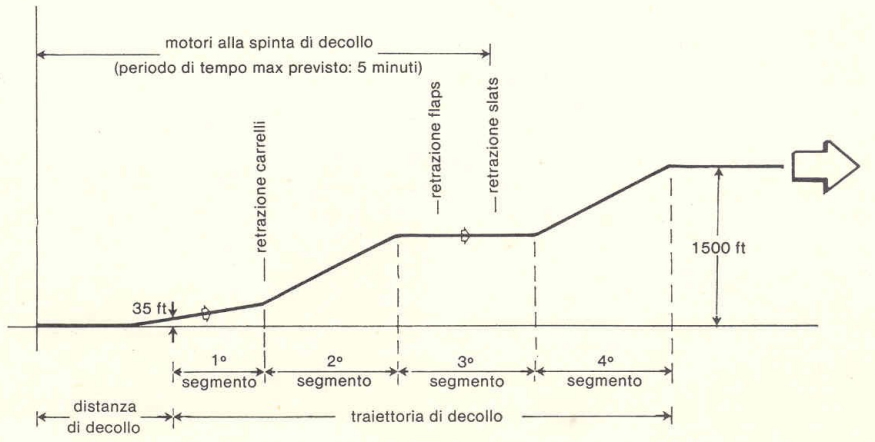
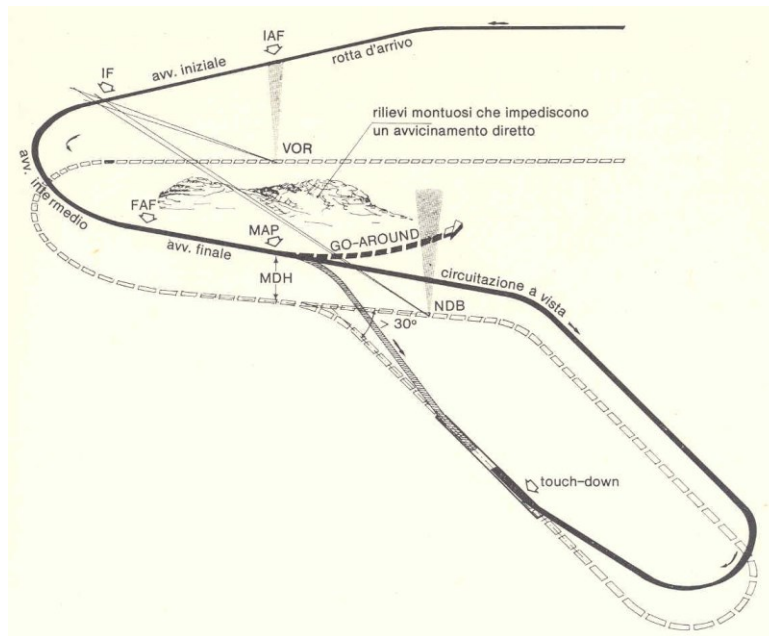
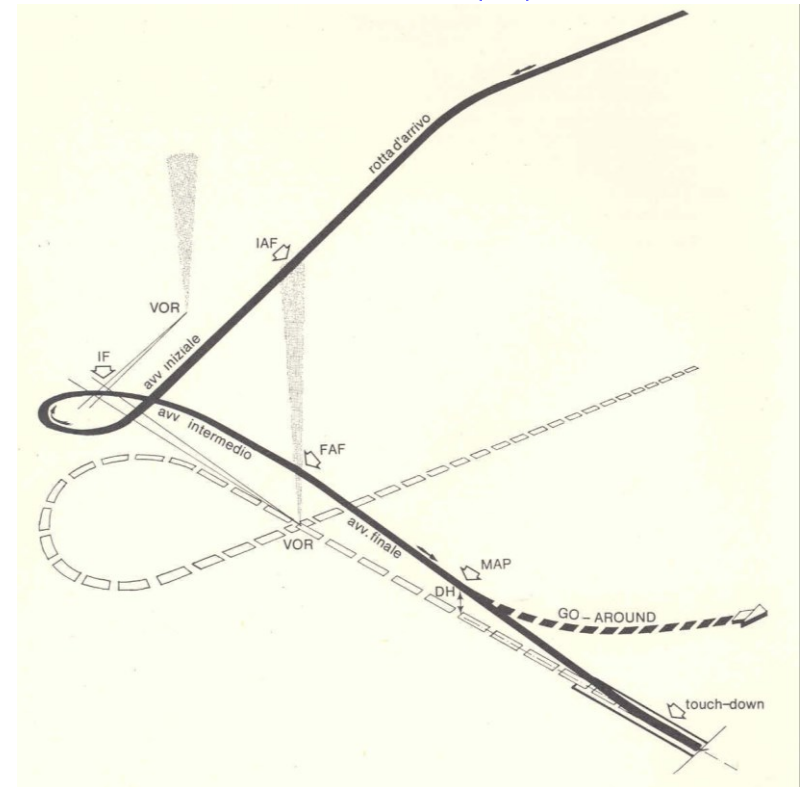
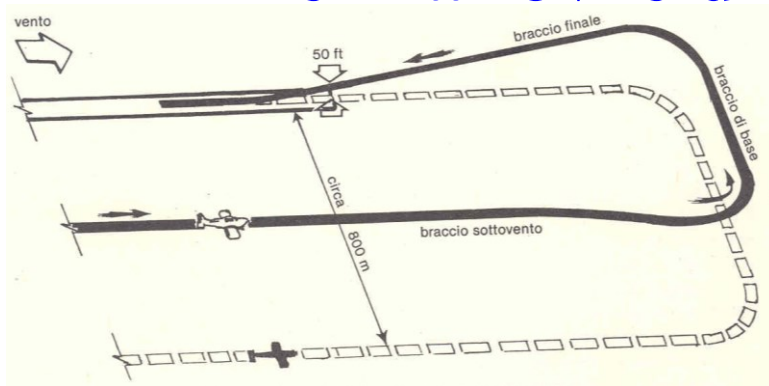


Figura 10. 6: Legge del moto dell'aeromobile in fase di decollo in condizioni normali (a) ed in caso di avaria ad un motore (b).

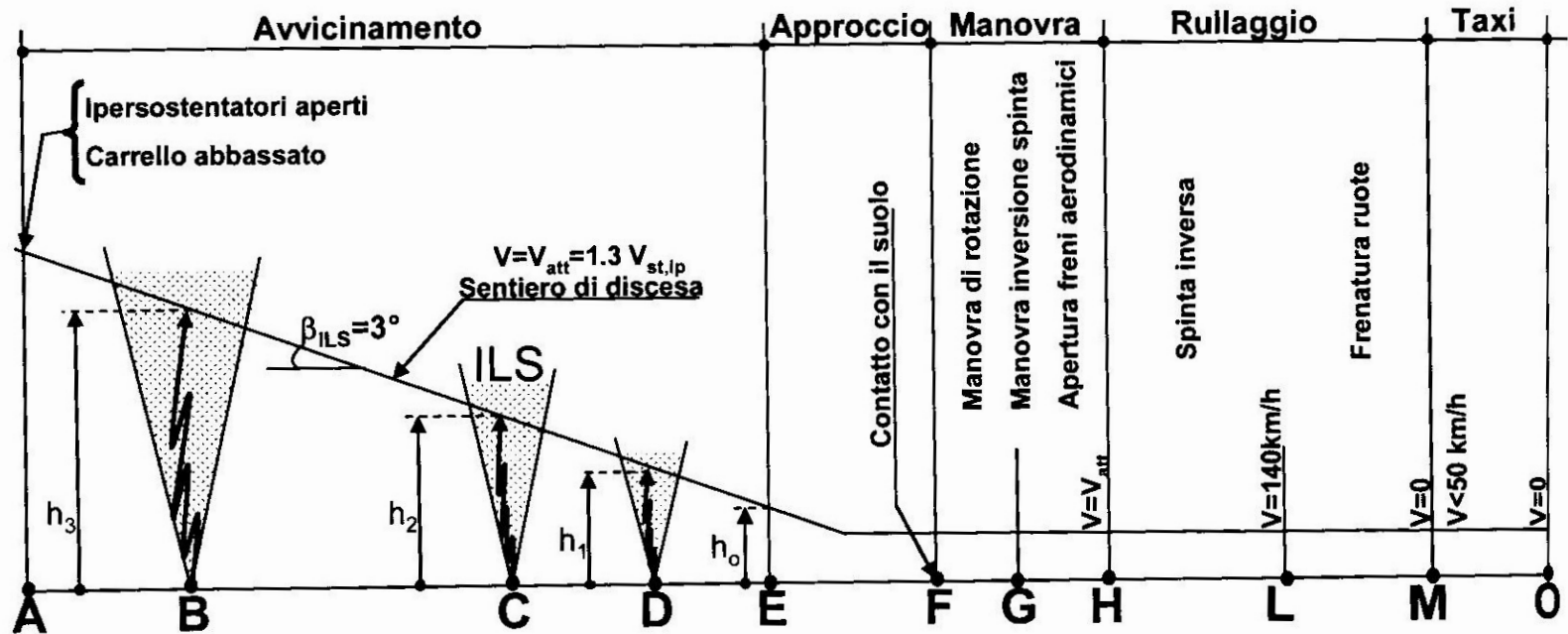
La salita di decollo



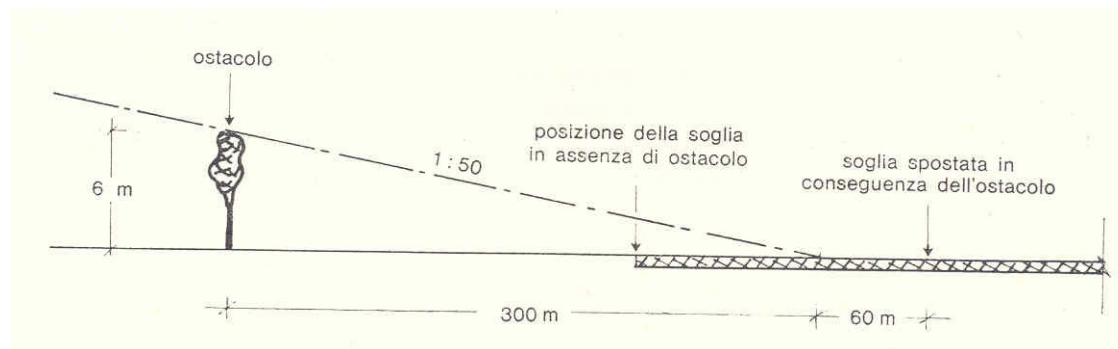
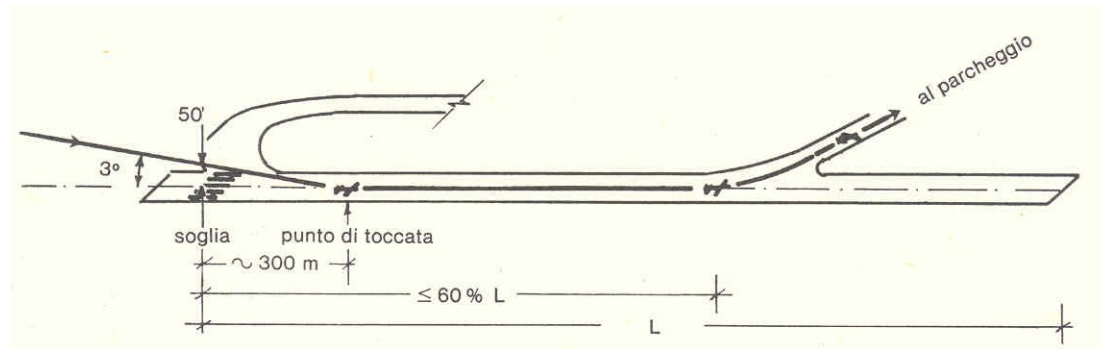
Le manovre di avvicinamento (1)



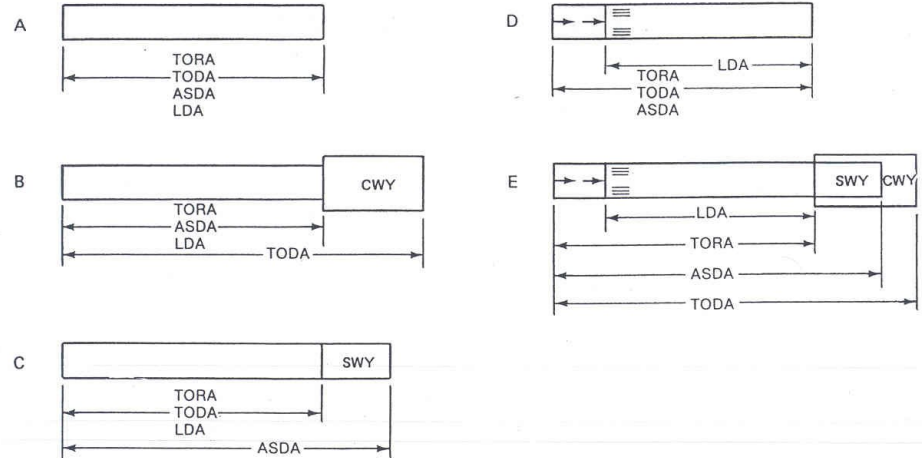
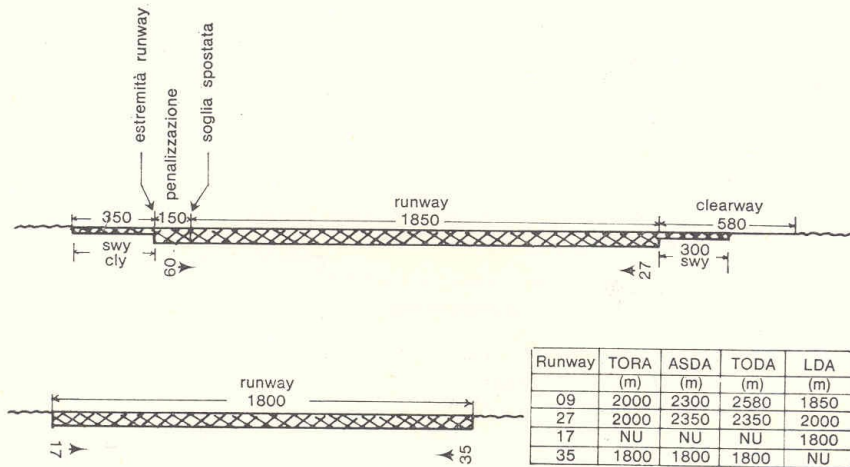
Le manovre di avvicinamento (2)



Le manovre di atterraggio



Le distanze dichiarate



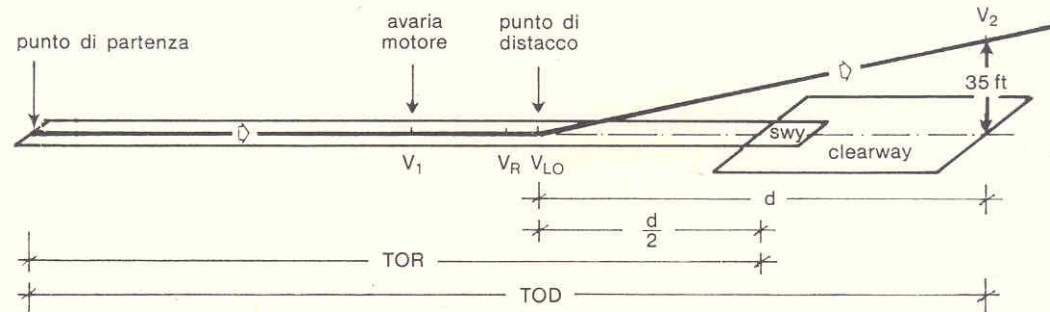
TORA (Take-Off Run Available, corsa di decollo disponibile) lunghezza di pista dichiarata disponibile e adatta alla corsa a terra di un aereo che decolla;

TODA (Take-Off Distance Available, distanza di decollo disponibile) TORA + clearway se esistente;

ASDA (Accelerate Stop Distance Available, distanza di accelerazione ed arresto disponibile) TORA + stopway se esistente;

LDA (Landing Distance Available, distanza di atterraggio disponibile) lunghezza di pista dichiarata disponibile e adatta per un aereo in fase di atterraggio;

Le distanze richieste (1)



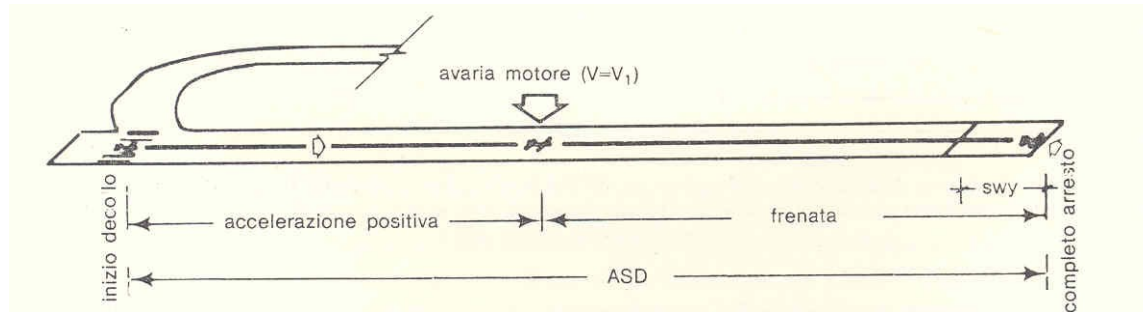
TOD (Take-Off Distance) è la maggiore delle seguenti distanze:

- Distanza orizzontale compresa fra il punto di partenza per il decollo ed il punto in cui un aeromobile con il motore critico inoperativo alla V_1 raggiunge con la sua parte più bassa la quota di 35 piedi (10,7 m);**
- La stessa distanza del punto “a”, con tutti i motori operativi, incrementata del 15 %.**

TOR (Take-Off Run) è la maggiore delle seguenti distanze:

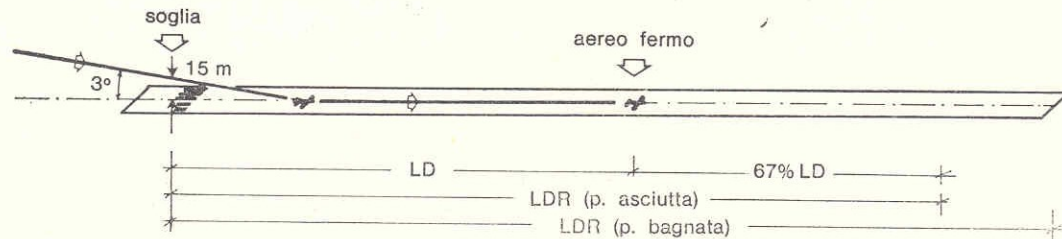
- Distanza orizzontale compresa fra il punto di partenza ed il punto intermedio fra il punto di distacco (V_{LO} Velocità di Lift-Off) ed il punto finale di decollo (quota di 35 piedi), nel caso di avaria al motore critico in corrispondenza di V_1 ;**
- La stessa distanza del punto “a” con tutti i motori operativi, incrementata del 15%.**

Le distanze richieste (2)



ASD (Accelerate-Stop Distance) è la distanza compresa tra il punto di inizio decollo ed il punto di completo arresto del veivolo, nel caso di avaria al raggiungimento della velocità V_1 .

Le distanze richieste (3)



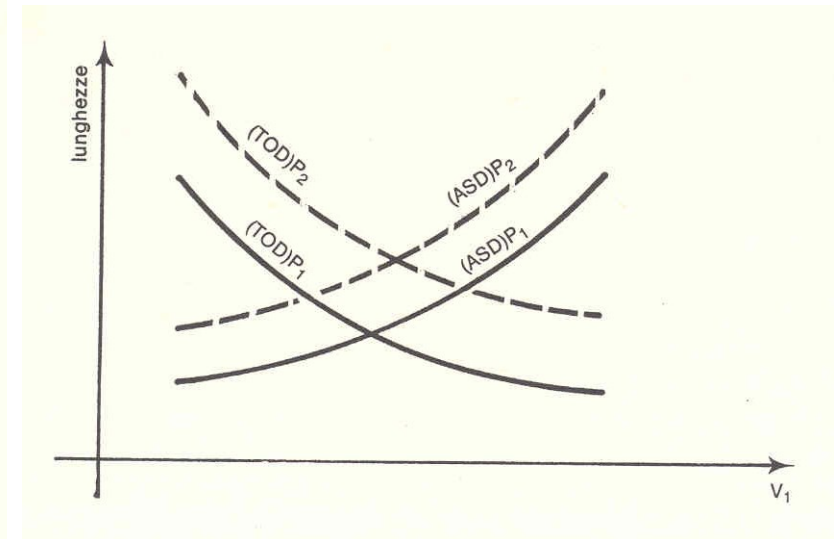
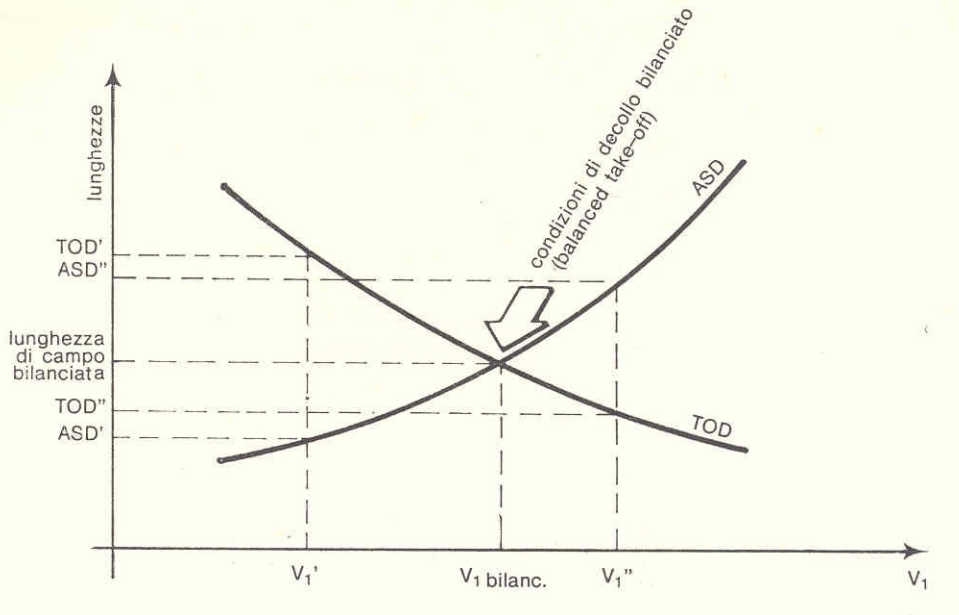
LDR (Landing Distance Required) Metodo A: è la maggiore delle seguenti distanze:

- distanza orizzontale necessaria in configurazione di atterraggio, con angolo di discesa 3° e con tutti i motori operativi per fermarsi su pista bagnata a partire da un punto alto 10,7 m sulla superficie di atterraggio, incrementata del 15 %;
- La stessa distanza del punto "a" ipotizzando il motore critico inoperativo, incrementata del 10 %.

LDR (Landing Distance Required) Metodo B:

- Su pista asciutta è costituita dalla distanza orizzontale necessaria per atterrare e fermarsi a partire da 15 metri in corrispondenza della soglia, incrementata del 67 %.
- Su pista bagnata si ottiene la LDR incrementando del 15% il valore su pista asciutta precedente

Compatibilità tra distanze richieste e dichiarate (1)



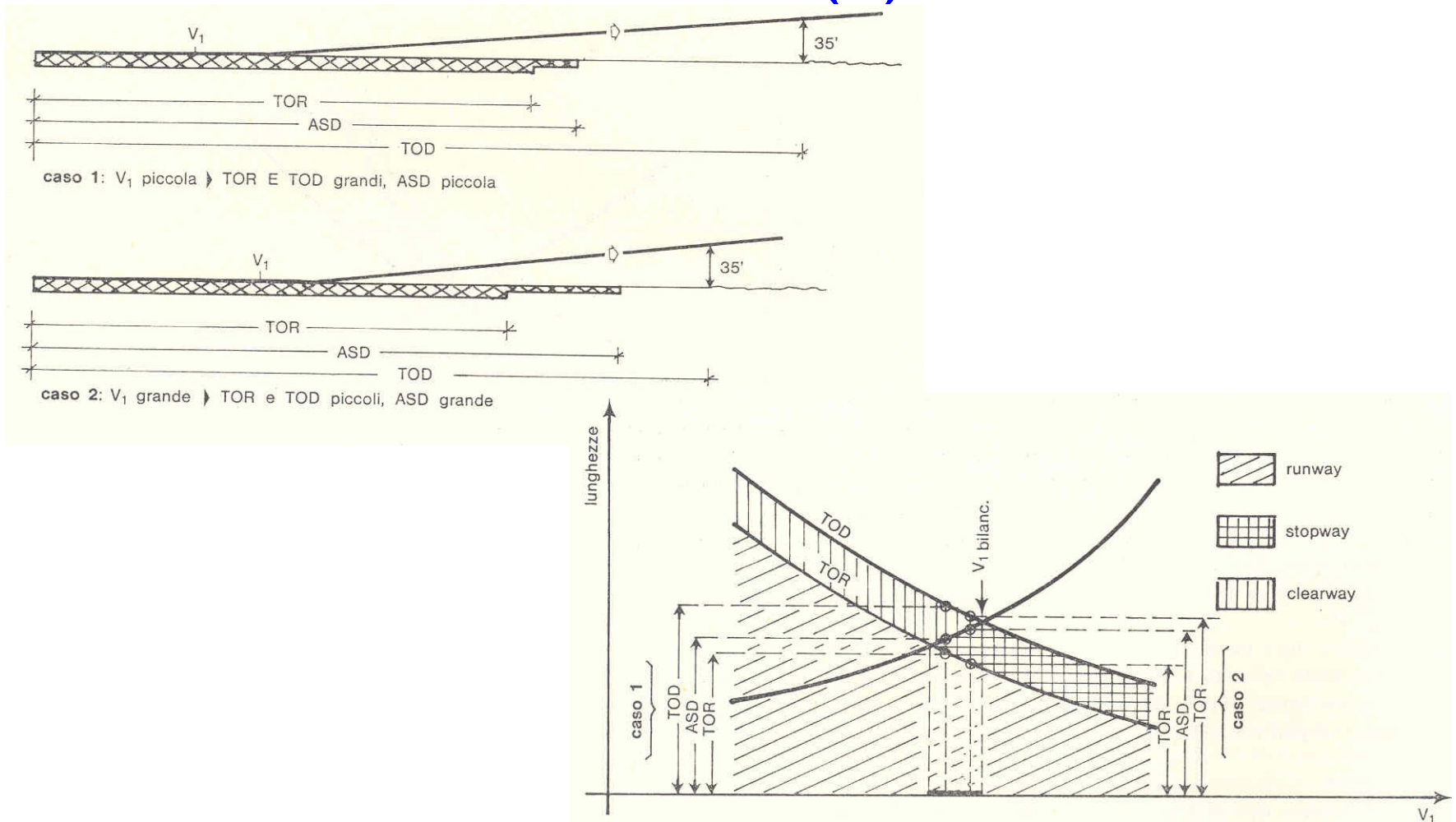
TOR < TORA

TOD < TODA

ASD < ASDA

LDR < LDA

Compatibilità tra distanze richieste e dichiarate (2)



Lo spazio di decollo (1)

$$R_{\text{aer.}} = \frac{1}{2} \cdot C_r \cdot \rho \cdot S_m \cdot v^2$$

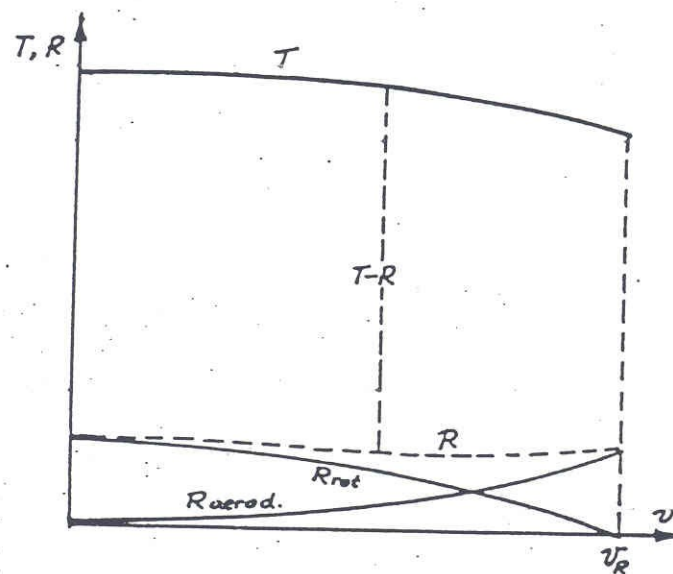
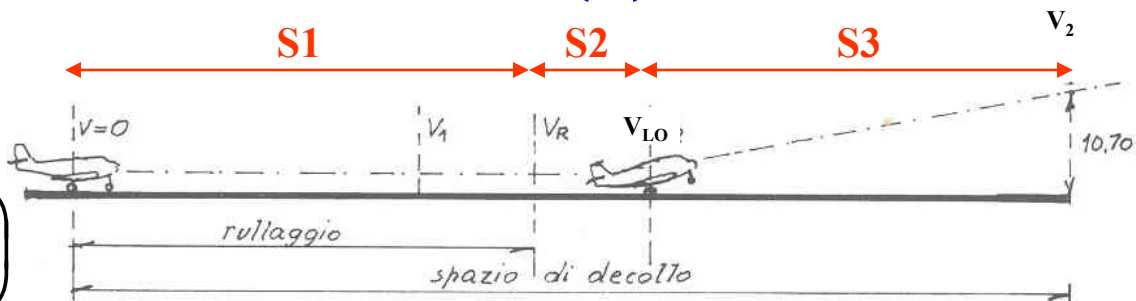
$$R_{\text{rot.}} = f_{\text{rot.}} \cdot \left(Q - \frac{1}{2} \cdot C_p \cdot \rho \cdot S_a \cdot v^2 \right)$$

$$R = R_{\text{aer.}} + R_{\text{rot.}}$$

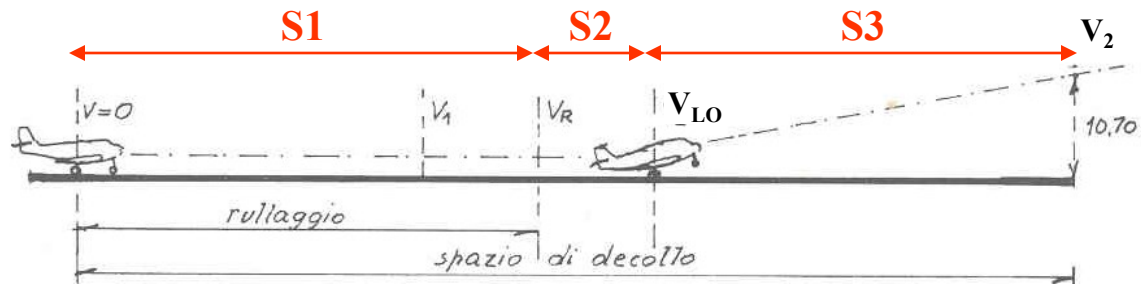
$$T - R = \frac{Q}{g} \cdot a$$

$$ds = v \cdot dt = v \cdot \frac{dv}{a}$$

$$S_1 = \int_{v=0}^{v_R} \frac{v}{a} \cdot dv$$



Lo spazio di decollo (2)



$$S_1 = \int_{v=0}^{v_R} \frac{v}{a} \cdot dv$$

$$S_2 = v_m \cdot t_m$$

$$S_3 = 10,7 / \text{tg}(3^\circ)$$

$$v_m = \frac{v_R + v_2}{2}$$

$$t_m \cong 3 \text{ [s]}$$

Fattori che influenzano lo spazio di decollo

$$Q = P = \frac{1}{2} \cdot C_p \cdot \rho_0 \cdot S_a \cdot v_0^2 = \frac{1}{2} \cdot C_p \cdot \rho_h \cdot S_a \cdot v_h^2$$

$$v_h = \frac{v_0}{\sqrt{\frac{\rho_h}{\rho_0}}} = \frac{v_0}{\sqrt{\delta}}$$

TABELLA V.1 - Aria tipo internazionale (unità tecniche)

| Quota campo m | Temperatura media °C | Pressione mm (Hg) | Peso specifico γ kg _p /m ³ | Densità ρ kg _p /m ³ | Densità relativa $\delta = \rho/\rho_0$ |
|------------------|-------------------------|----------------------|---|---|--|
| 0 | 15 | 760 | 1,2250 | 0,1249 | 1 |
| 500 | 11,75 | 715,9 | 1,1673 | 0,1190 | 0,9528 |
| 1000 | 8,50 | 674,1 | 1,1117 | 0,1133 | 0,9075 |
| 1500 | 5,25 | 634,2 | 1,0581 | 0,1079 | 0,8638 |
| 2000 | 2,00 | 596,2 | 1,0064 | 0,1026 | 0,8216 |
| 2500 | -1,25 | 560,1 | 0,9569 | 0,0975 | 0,7810 |
| 3000 | -4,50 | 525,8 | 0,9091 | 0,0927 | 0,7421 |

$$L_{\text{real.}} = L_{\text{base}} K1 * K2 * K3$$

$$K1 = 1 + 0,07 * (H/300)$$

$$K2 = 1 + 0,01 * (T_R - T_S)$$

$$K3 = 1 + 0,1 * (i)$$

$$T_S = 15 - 0,0065 * H$$

Esempio di calcolo

$L_{\text{base}} = 1700 \text{ m};$ Quota aeroporto: $H = 150 \text{ m};$

Temperatura di riferimento $T_R = 24 \text{ }^\circ$ Pendenza media pista $i = 0,5 \%$

$T_S = 15 - 0,0065 * H = 14,025 \text{ }^\circ$

$$L_{\text{real.}} = L_{\text{base}} * K1 * K2 * K3 = 1700 * 1,035 * 1,100 * 1,050 \cong 2033$$

$$K1 = 1 + 0,07 * (H/300) = 1 + 0,07 * (150/300) = 1,035$$

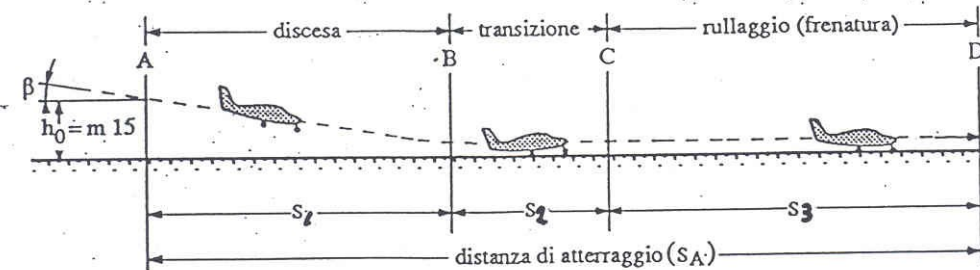
$$K2 = 1 + 0,01 * (T_R - T_S) = 1 + 0,01 * (24 - 14,025) = 1,100$$

$$K3 = 1 + 0,1 * (i) = 1 + 0,1 (0,5) = 1,050$$

Lo spazio di atterraggio

$$S_1 = 15/\text{tg}(3^\circ)$$

$$S_2 = v_m \cdot t_m$$



$$Q = m \cdot g = \frac{1}{2} \cdot C_p \cdot \rho \cdot S_a \cdot v_a^2$$

$$\frac{Q}{g} \cdot \frac{dv}{dt} = - \left[f \cdot Q + \frac{1}{2} (C_r - f \cdot C_p) \cdot \rho \cdot S_a \cdot v^2 \right]$$

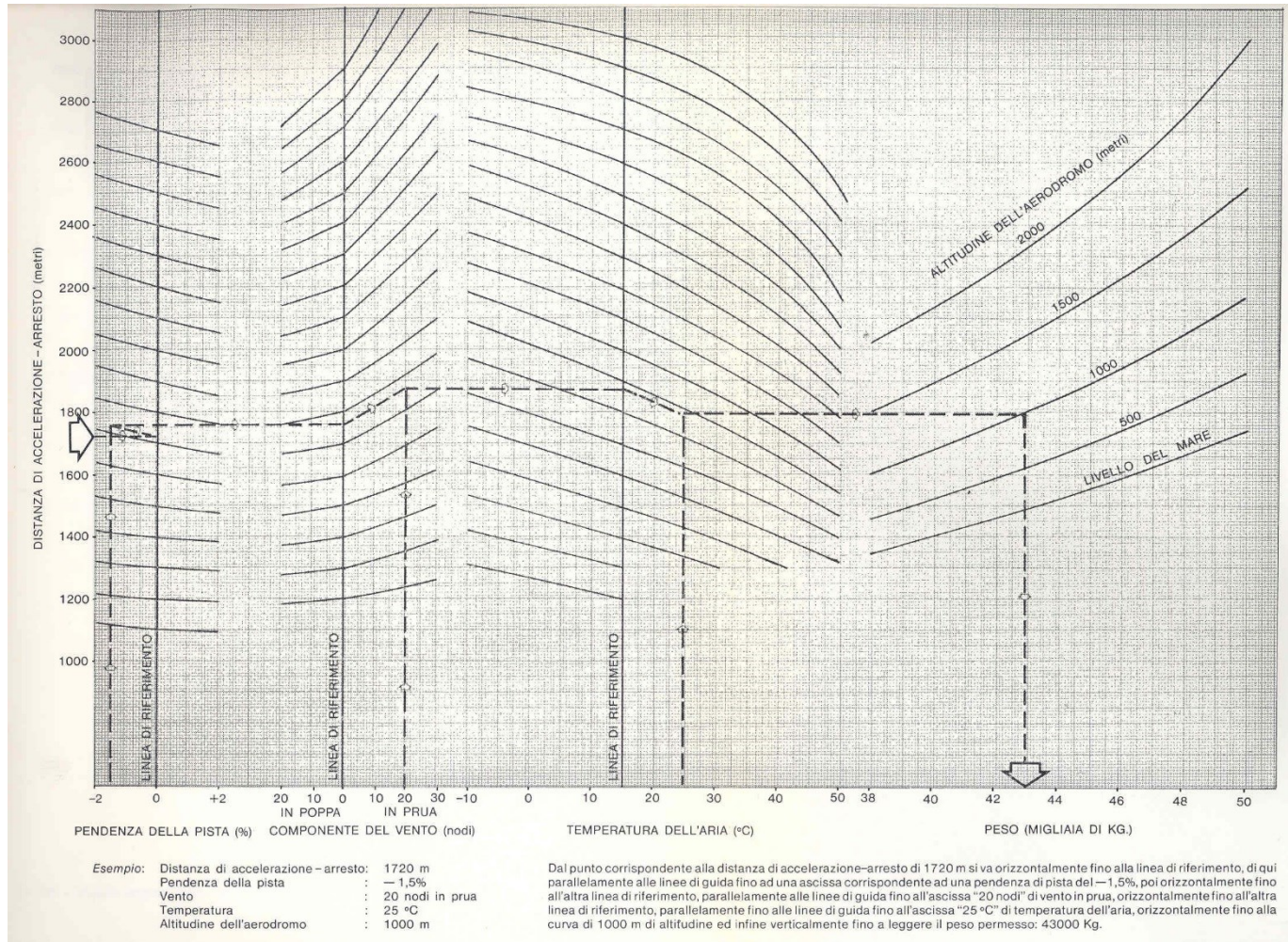
$$ds = v \cdot dt = v \cdot \frac{dv}{a}$$

$$\frac{v}{g} \cdot \frac{dv}{ds} = - \left[f + \left(\frac{C_r}{C_p} - f \right) \cdot \frac{v^2}{v_a^2} \right]$$

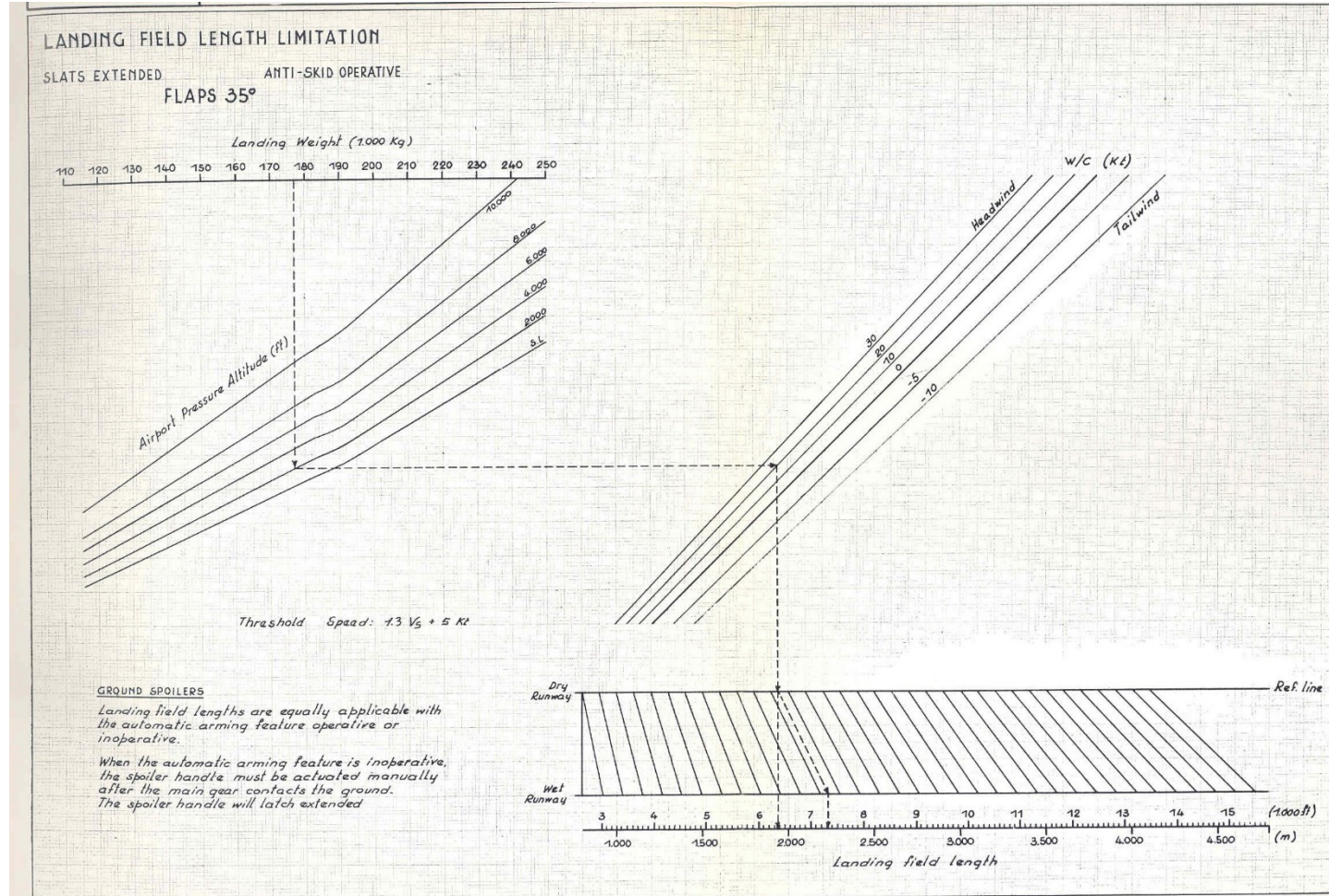
$$\mu = \frac{C_r}{C_p}$$

$$S_3 = \frac{\ln \frac{f}{\mu}}{2 \cdot (f - \mu) \cdot g} \cdot v_a^2$$

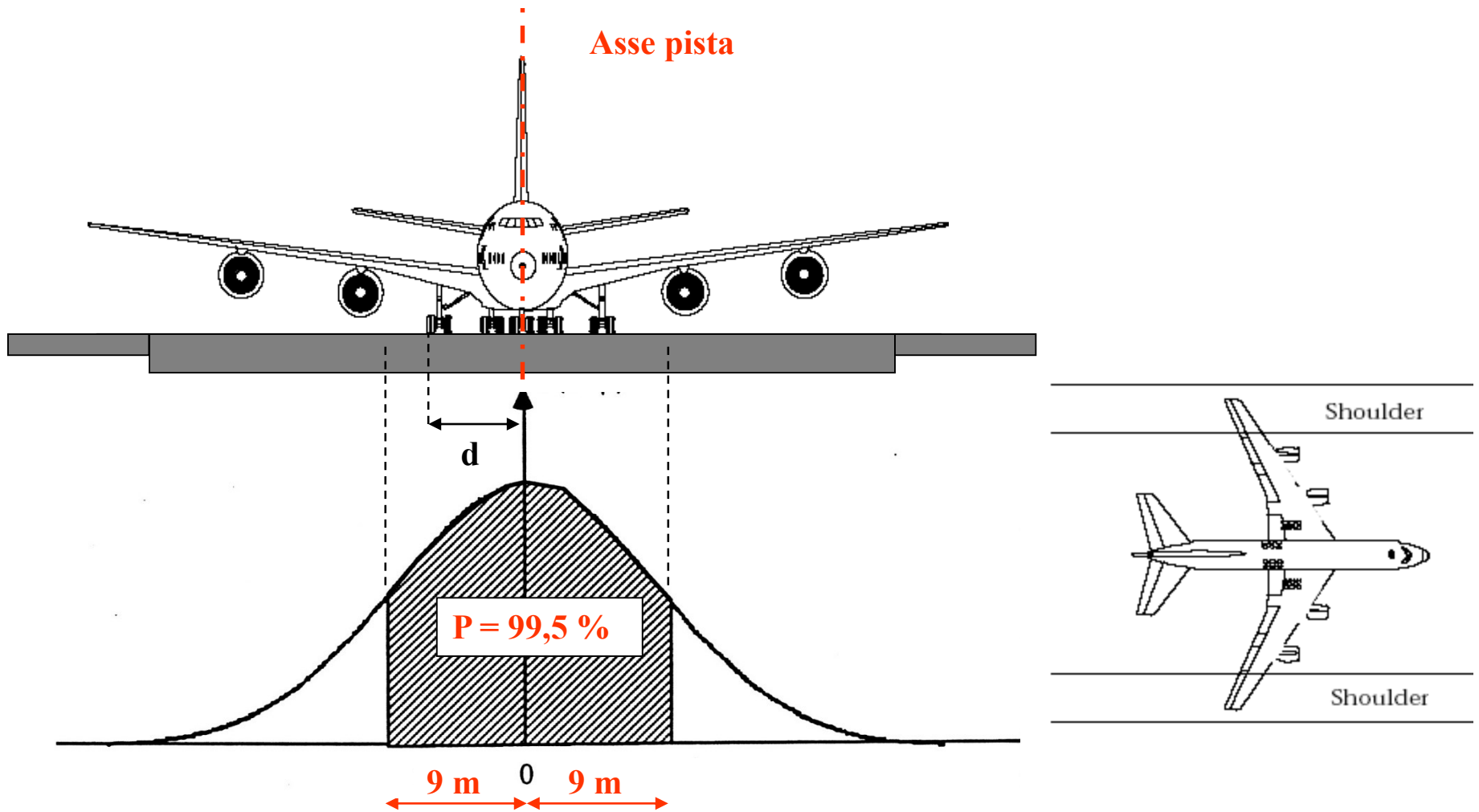
I diagrammi di prestazione (1)



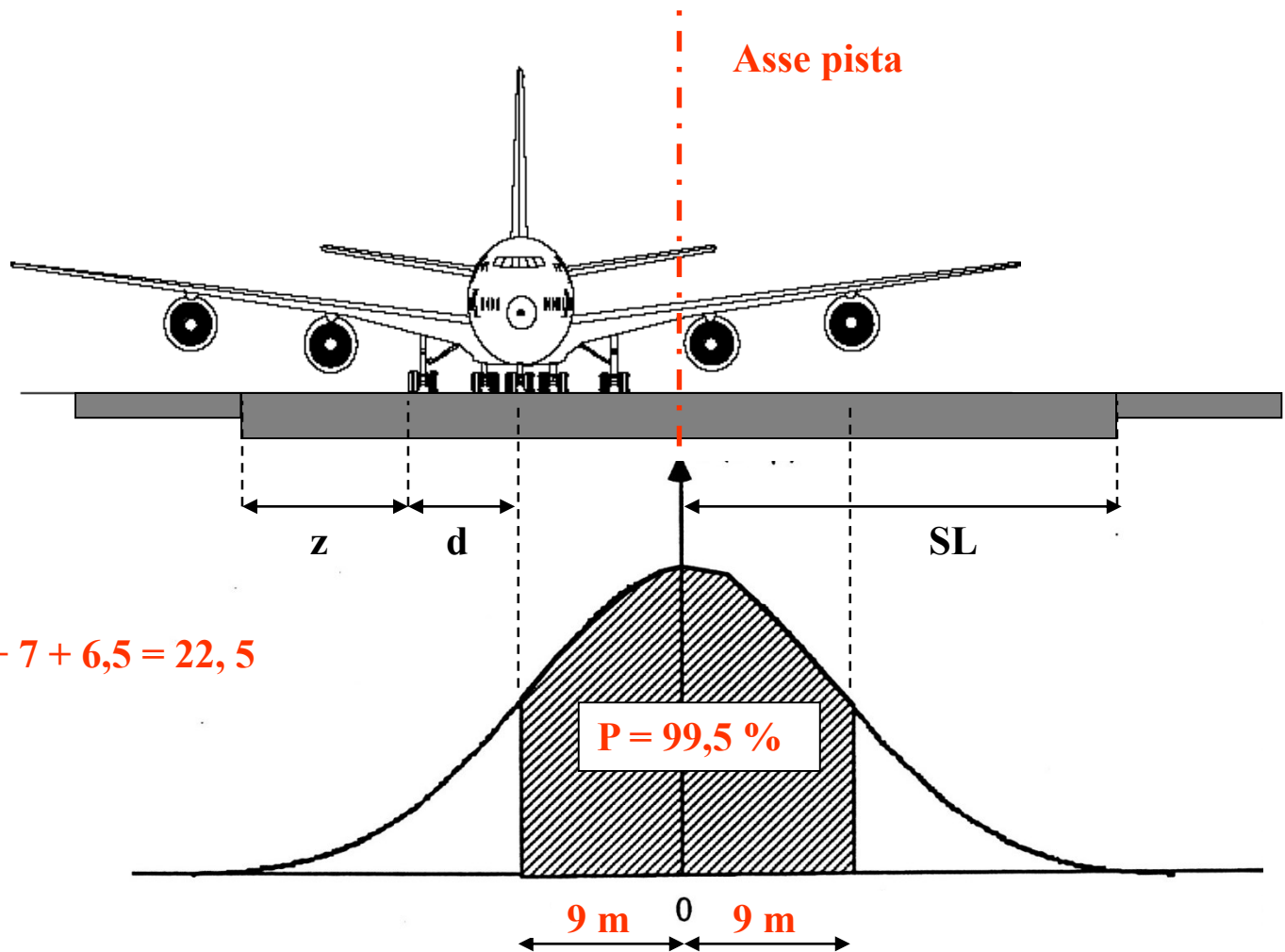
I diagrammi di prestazione (2)



Larghezza della runway (1)



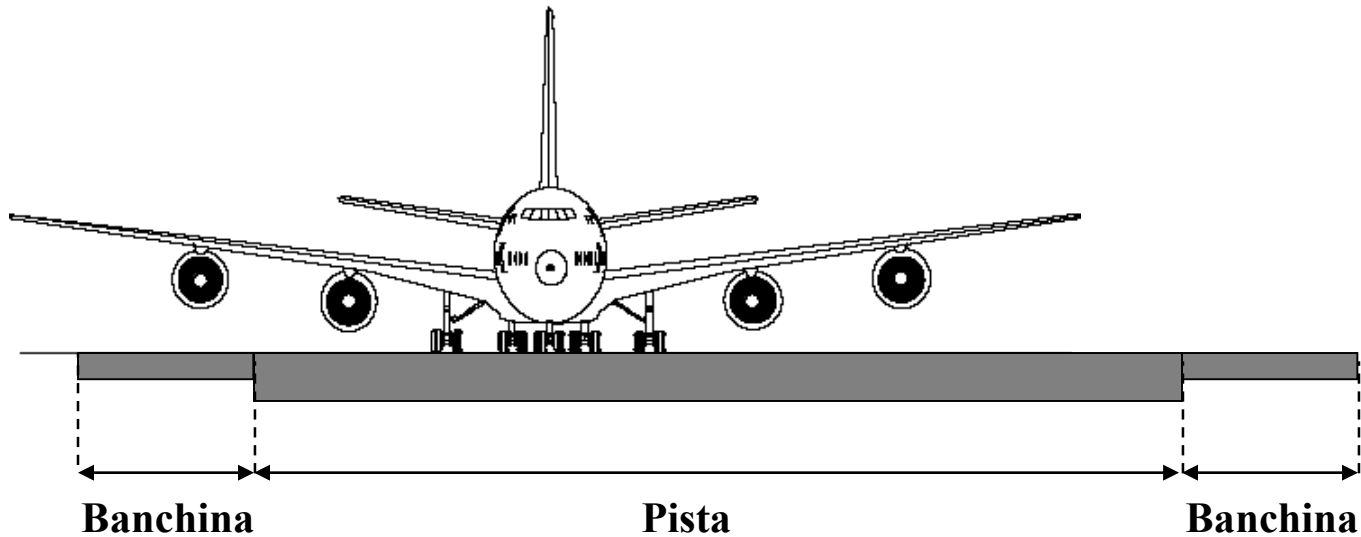
Larghezza della runway (2)



$$SL = 9 + d + z = 9 + 7 + 6,5 = 22,5$$

$$L = 2 * SL = 45 \text{ m}$$

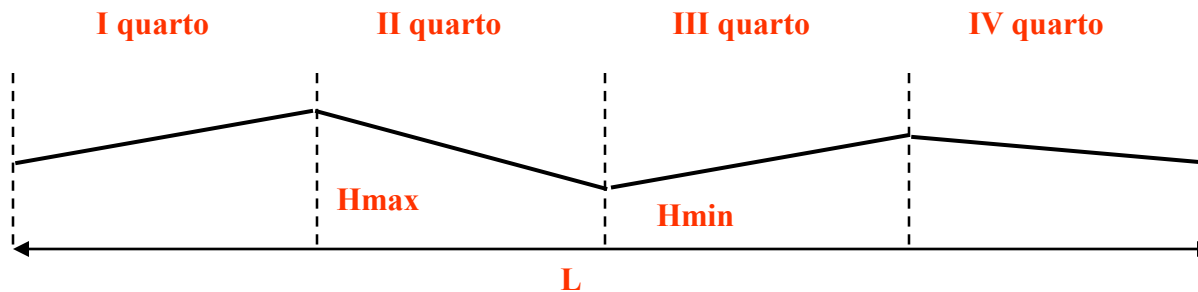
Larghezza della runway (3)



| Cod. alfabetico | A | B | C | D | E | F |
|-----------------|-----|-----|-----|-----|-----|-----|
| Cod. numerico | [m] | [m] | [m] | [m] | [m] | [m] |
| 1 | 18 | 18 | 23 | | | |
| 2 | 23 | 23 | 30 | | | |
| 3 | 30 | 30 | 30 | 45 | | |
| 4 | | | 45 | 45 | 45 | 60 |

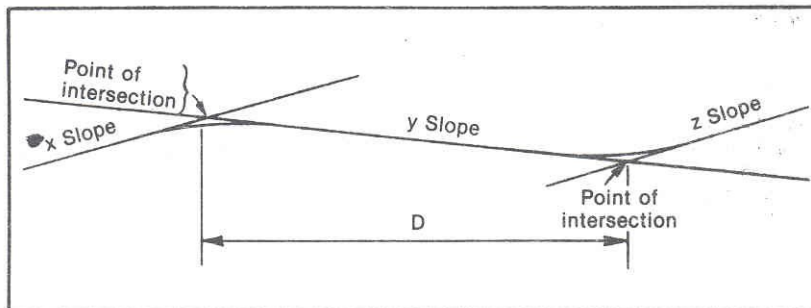
Pendenze longitudinali della runway (1)

| Cod. numerico | 1 | 2 | 3 | 4 |
|--|------------------------|------------------------|-------------------------|-------------------------|
| Pendenza longitudinale media $(H_{max} - H_{min})/L$ | $\leq 2 \%$ | $\leq 2 \%$ | $\leq 1 \%$ | $\leq 1 \%$ |
| Pendenza massima | $\leq 2 \%$ | $\leq 2 \%$ | $\leq 1,5 \%$ | $\leq 1,25 \%$ |
| Pendenza massima I e IV quarto | - | - | $\leq 0,8 \%$ * | $\leq 0,8 \%$ |
| Variazione di pendenza | $\leq 2 \%$ | $\leq 2 \%$ | $\leq 1,5 \%$ | $\leq 1,5 \%$ |
| Raggio raccordi verticali | $\geq 7.500 \text{ m}$ | $\geq 7.500 \text{ m}$ | $\geq 15.000 \text{ m}$ | $\geq 30.000 \text{ m}$ |



Pendenze longitudinali della runway (2)

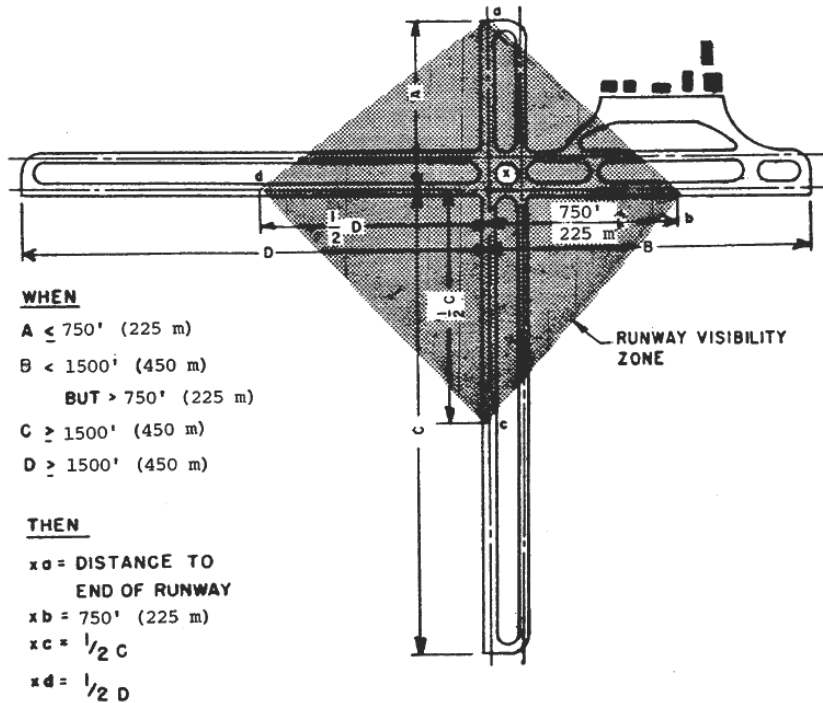
| Cod. numerico | 1 | 2 | 3 | 4 |
|---------------|---------|---------|----------|----------|
| A | 5.000 m | 5.000 m | 15.000 m | 30.000 m |
| R | 7.500 m | 7.500 m | 15.000 m | 30.000 m |



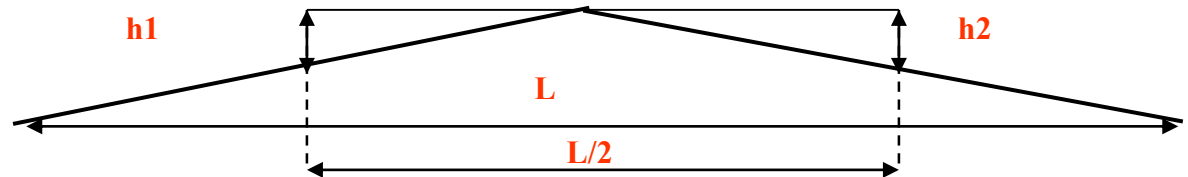
$$D \geq A * (|x - y| + |y - z|)$$

$$D \geq 45 \text{ m}$$

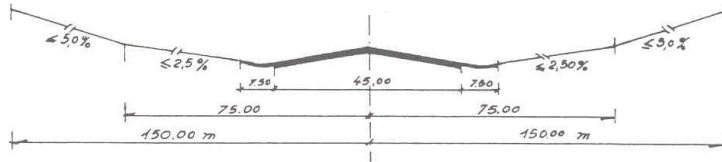
Distanze visibilità



| Cod. alfabetico | A | B | C | D | E | F |
|------------------|-----|-----|-----|-----|-----|-----|
| | [m] | [m] | [m] | [m] | [m] | [m] |
| h1 | 1,5 | 2 | 3 | 3 | 3 | 3 |
| h2 | 1,5 | 2 | 3 | 3 | 3 | 3 |
| Distanza di vis. | L/2 | L/2 | L/2 | L/2 | L/2 | L/2 |



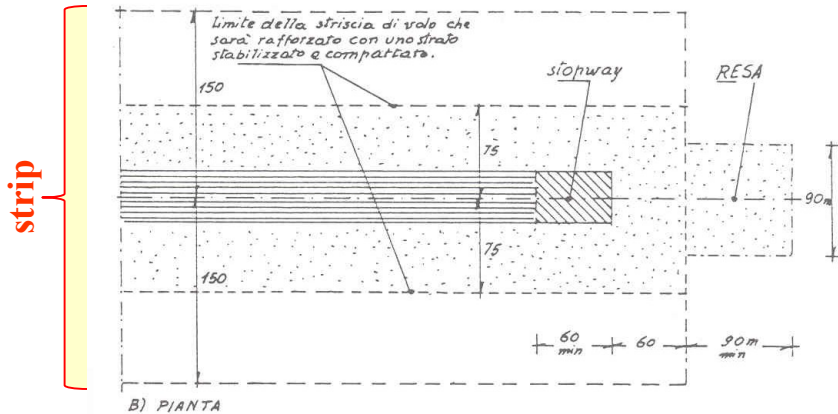
Sezione trasversale



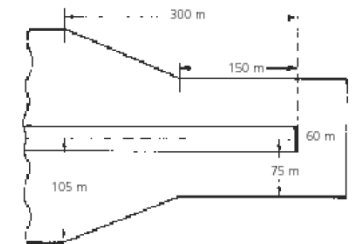
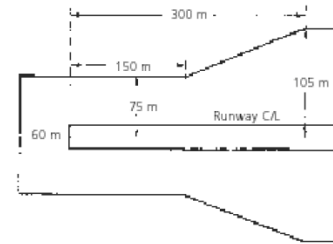
A) SEZIONE TRASVERSALE

Runway End Safety Area

CGA, (Cleared and Graded Area)



B) PIANTA



Code number

Runway

maximum transverse slope

2% where the code letter is A or B; and 1.5% where the code letter is C, D, or E

Width of runway strip

precision and non-precision runway
non-instrument runway

| | 1 | 2 | 3 | 4 |
|------------------------------------|-------|-------|-------|-------|
| precision and non-precision runway | 150 m | 150 m | 300 m | 300 m |
| non-instrument runway | 60 m | 80 m | 150 m | 150 m |

Strip

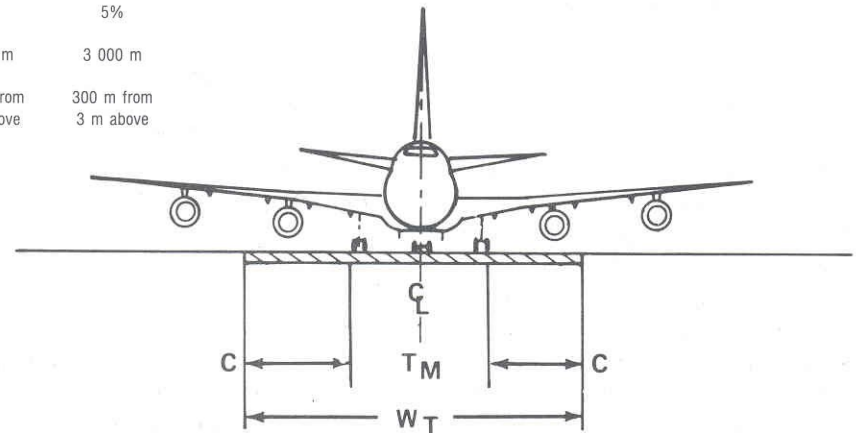
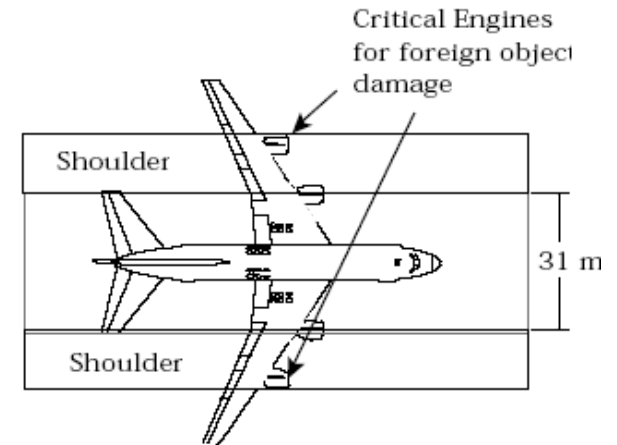
maximum longitudinal slope
maximum transverse slope

| | 1 | 2 | 3 | 4 |
|----------------------------|----|----|-------|------|
| maximum longitudinal slope | 2% | 2% | 1.75% | 1.5% |
| maximum transverse slope | 3% | 3% | 2.5% | 2.5% |

Larghezza piste di circolazione

| Physical characteristics | Code letter | | | | |
|--|---------------------------|-------------------------|--|--|-------------------------|
| | A | B | C | D | E |
| Minimum width of: | | | | | |
| taxiway pavement | 7.5 m | 10.5 m | 18 m ^a 15 m ^b | 23 m ^c 18 m ^d | 23 m |
| taxiway pavement and shoulder | — | — | 25 m | 38 m | 44 m |
| taxiway strip | 27 m | 39 m | 57 m | 85 m | 93 m |
| graded portion of taxiway strip | 22 m | 25 m | 25 m | 38 m | 44 m |
| Minimum clearance distance of outer main wheel to taxiway edge | 1.5 m | 2.25 m | 4.5 m ^a 3 m ^b | 4.5 m | 4.5 m |
| Maximum longitudinal slope of taxiway: | | | | | |
| pavement | 3% | 3% | 1.5% | 1.5% | 1.5% |
| change in slope | 1% per 25 m | 1% per 25 m | 1% per 30 m | 1% per 30 m | 1% per 30 m |
| Maximum transverse slope of: | | | | | |
| taxiway pavement | 2% | 2% | 1.5% | 1.5% | 1.5% |
| graded portion of taxiway strip upwards | 3% | 3% | 2.5% | 2.5% | 2.5% |
| graded portion of taxiway strip downwards | 5% | 5% | 5% | 5% | 5% |
| ungraded portion of strip upwards | 5% | 5% | 5% | 5% | 5% |
| Minimum radius of longitudinal vertical curve | 2 500 m | 2 500 m | 3 000 m | 3 000 m | 3 000 m |
| Minimum taxiway sight distance | 150 m from 1.5 m above | 200 m from 2 m above | 300 m from 3 m above | 300 m from 3 m above | 300 m from 3 m above |

F
30.5 m
55 m
115 m
60 m
6 m

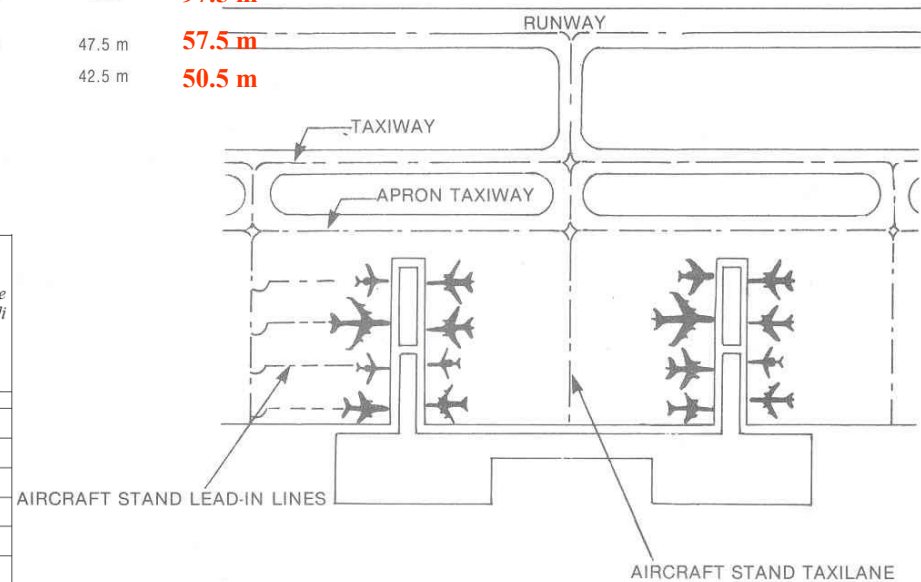


Le distanze di separazione (1)

| Physical characteristics | Code letter | | | | | F |
|--|-------------|--------|--------|--------|---------|---------------|
| | A | B | C | D | E | |
| Minimum separation distance between taxiway centre line and: | | | | | | |
| centre line of instrument runway code number 1 | 82.5 m | 87 m | — | — | — | |
| 2 | 82.5 m | 87 m | — | — | — | |
| 3 | — | — | 168 m | 176 m | — | |
| 4 | — | — | — | 176 m | 182.5 m | 190 m |
| centre line of non-instrument runway code number 1 | 37.5 m | 42 m | — | — | — | |
| 2 | 47.5 m | 52 m | — | — | — | |
| 3 | — | — | 93 m | 101 m | — | |
| 4 | — | — | — | 101 m | 107.5 m | 115 m |
| taxiway centre line | 23.75 m | 33.5 m | 44 m | 66.5 m | 80 m | 97.5 m |
| object | | | | | | |
| taxiway ^e | 16.25 m | 21.5 m | 26 m | 40.5 m | 47.5 m | 57.5 m |
| aircraft stand taxilane | 12 m | 16.5 m | 24.5 m | 36 m | 42.5 m | 50.5 m |

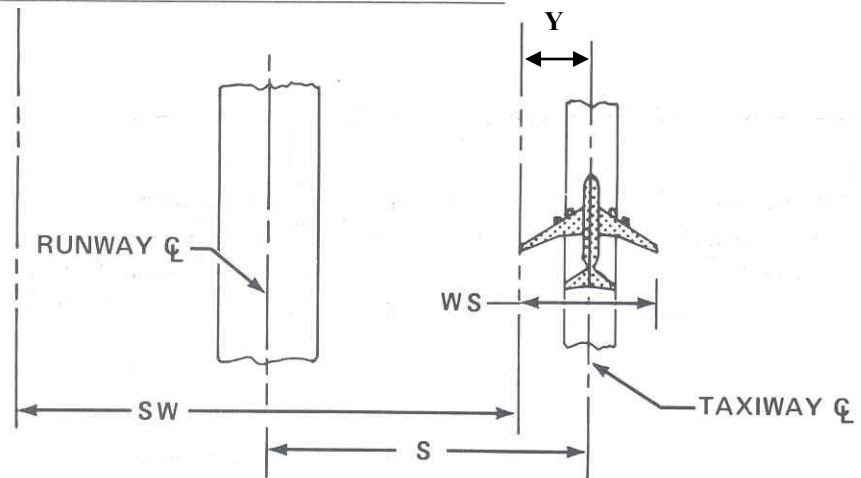
Tabella 3.4 - Distanze di separazione delle taxiway

| Lettera di codice | Distanze tra asse pista e asse delle taxiway | | | | | | | | Distanza interasse taxiway | Distanza tra asse taxiway e manufatti, escluse vie d'accesso alle piazzole | Distanza tra manufatti e asse vie di accesso alle piazzole |
|-------------------|--|------|-----|-------|-----------------------|------|-----|-----|----------------------------|--|--|
| | Piste strumentali | | | | Piste non strumentali | | | | | | |
| | Numero di codice | | | | Numero di codice | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| A | 82,5 | 82,5 | | | 37,5 | 47,5 | | | 23,75 | 16,25 | 12 |
| B | 87 | 87 | | | 42 | 52 | | | 33,5 | 21,5 | 16,5 |
| C | | | 168 | | | | 93 | | 44 | 26 | 24,5 |
| D | | | 176 | 176 | | | 101 | 101 | 66,5 | 40,5 | 36 |
| E | | | | 182,5 | | | | | 80 | 47,5 | 42,5 |
| F | | | | 190 | | | | | 115 | 97,5 | 50,5 |



Le distanze di separazione (2)

| Code number | 1 | | 2 | | 3 | | | | 4 | | | |
|--|------|----|------|----|-------|-----|-----|-----|-----|-----|-------|------------|
| Code letter | A | B | A | B | A | B | C | D | C | D | E | F |
| 1/2 wing span (Y) + 1/2 strip width (non-instrument approach runway) | 7.5 | 12 | 7.5 | 12 | 7.5 | 12 | 18 | 26 | 18 | 26 | 32.5 | |
| Total | 30.0 | 30 | 40.0 | 40 | 75.0 | 75 | 75 | 75 | 75 | 75 | 75.0 | |
| | 37.5 | 42 | 47.5 | 52 | 82.5 | 87 | 93 | 101 | 93 | 101 | 107.5 | 115 |
| or | | | | | | | | | | | | |
| 1/2 wing span (Y) + 1/2 strip width (instrument approach runway) | 7.5 | 12 | 7.5 | 12 | 7.5 | 12 | 18 | 26 | 18 | 26 | 32.5 | |
| Total | 75.0 | 75 | 75.0 | 75 | 150.0 | 150 | 150 | 150 | 150 | 150 | 150.0 | |
| | 82.5 | 87 | 82.5 | 87 | 157.5 | 162 | 168 | 176 | 168 | 176 | 182.5 | 190 |



Le distanze di separazione (3)

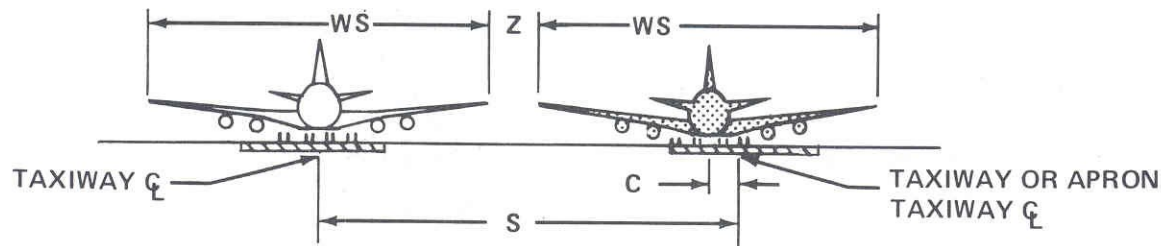
Code letter

Separation distances

A B C D E **F**

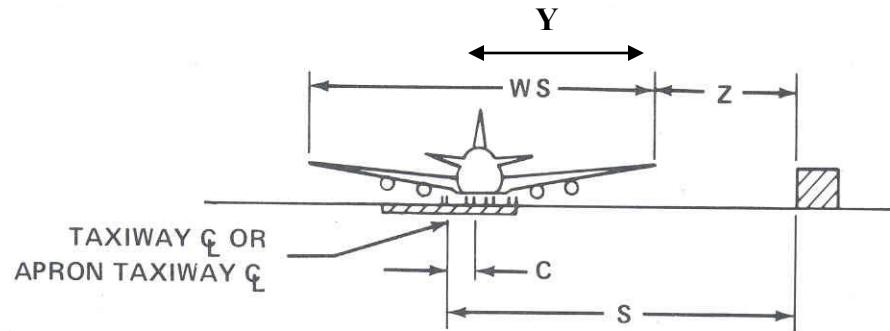
Between apron taxiway/taxiway centre line and taxiway centre line:

| | | | | | | |
|--|-------|-------|----|------|------|-------------|
| wing span (WS) | 15.00 | 24.00 | 36 | 52.0 | 65.0 | |
| + maximum lateral deviation (C) | 1.50 | 2.25 | 3 | 4.5 | 4.5 | |
| + increment (Z) | 7.25 | 7.25 | 5 | 10.0 | 10.5 | |
| Total separation distance (S) | 23.75 | 33.50 | 44 | 66.5 | 80.0 | 97,5 |



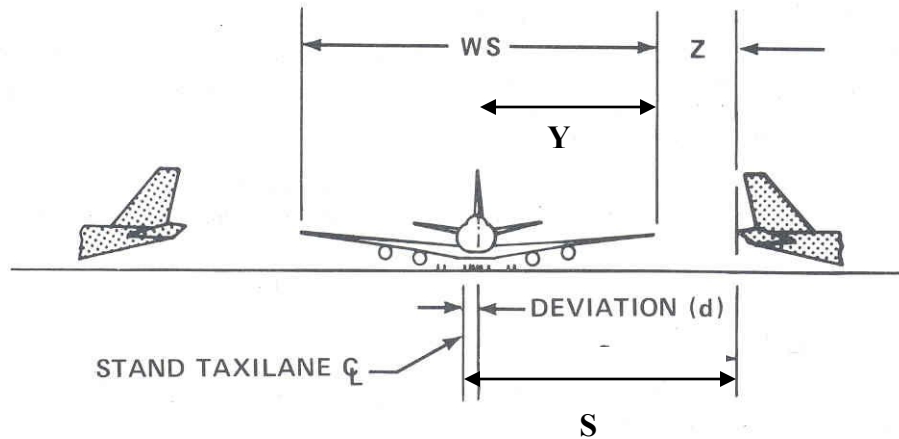
Le distanze di separazione (4)

| Separation distances | Code letter | | | | | |
|---|-------------|-------|----|------|------|-------------|
| | A | B | C | D | E | F |
| Between taxiway centre line and object: | | | | | | |
| ½ wing span (Y) | 7.50 | 12.00 | 18 | 26.0 | 32.5 | |
| + maximum lateral deviation (C) | 1.50 | 2.25 | 3 | 4.5 | 4.5 | |
| + increment (Z) | 7.25 | 7.25 | 5 | 10.0 | 10.5 | |
| Total separation distance (S) | 16.25 | 21.50 | 26 | 40.5 | 47.5 | 57,5 |
| Between apron taxiway centre line and object: | | | | | | |
| ½ wing span (Y) | 7.50 | 12.00 | 18 | 26.0 | 32.5 | |
| + maximum lateral deviation (C) | 1.50 | 2.25 | 3 | 4.5 | 4.5 | |
| + increment (Z) | 7.25 | 7.25 | 5 | 10.0 | 10.5 | |
| Total separation distance (S) | 16.25 | 21.50 | 26 | 40.5 | 47.5 | 57,5 |



Le distanze di separazione (5)

| Separation distances | Code letter | | | | | |
|---|-------------|-------|------|------|------|------|
| | A | B | C | D | E | F |
| Between aircraft stand taxilane centre line and object: | | | | | | |
| ½ wing span (Y) | 7.5 | 12.00 | 18.0 | 26.0 | 32.5 | |
| + gear deviation | 1.5 | 1.50 | 2.0 | 2.5 | 2.5 | |
| + increment (Z) | 3.0 | 3.00 | 4.5 | 7.5 | 7.5 | |
| Total separation distance (V) | 12.0 | 16.50 | 24.5 | 36.0 | 42.5 | 50,5 |

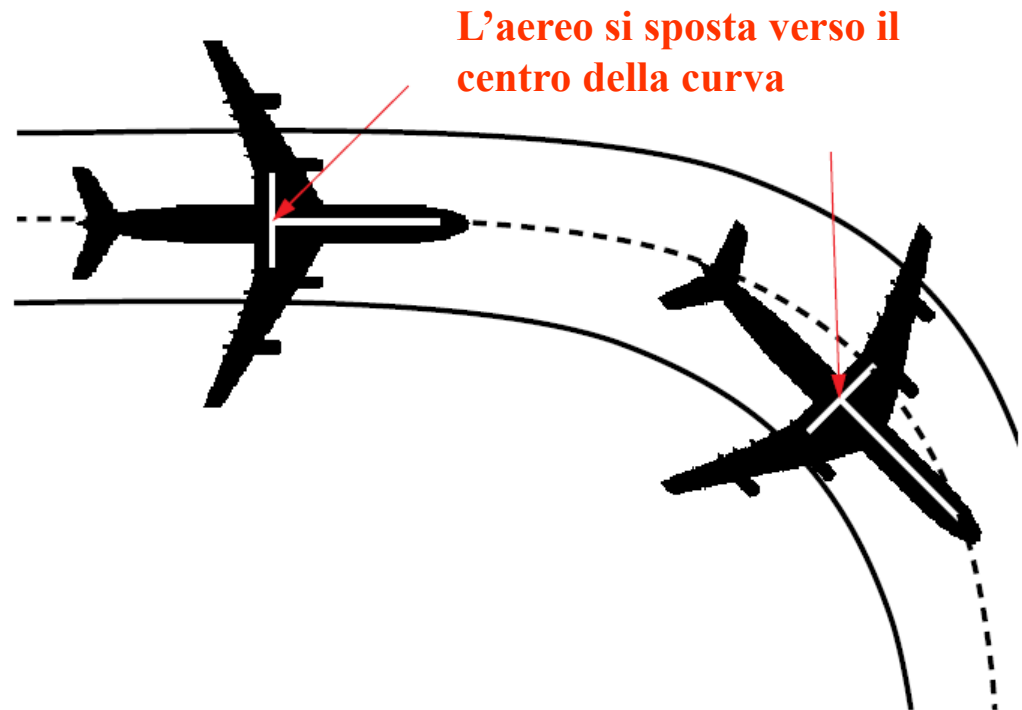


Le curve delle taxiway (1)

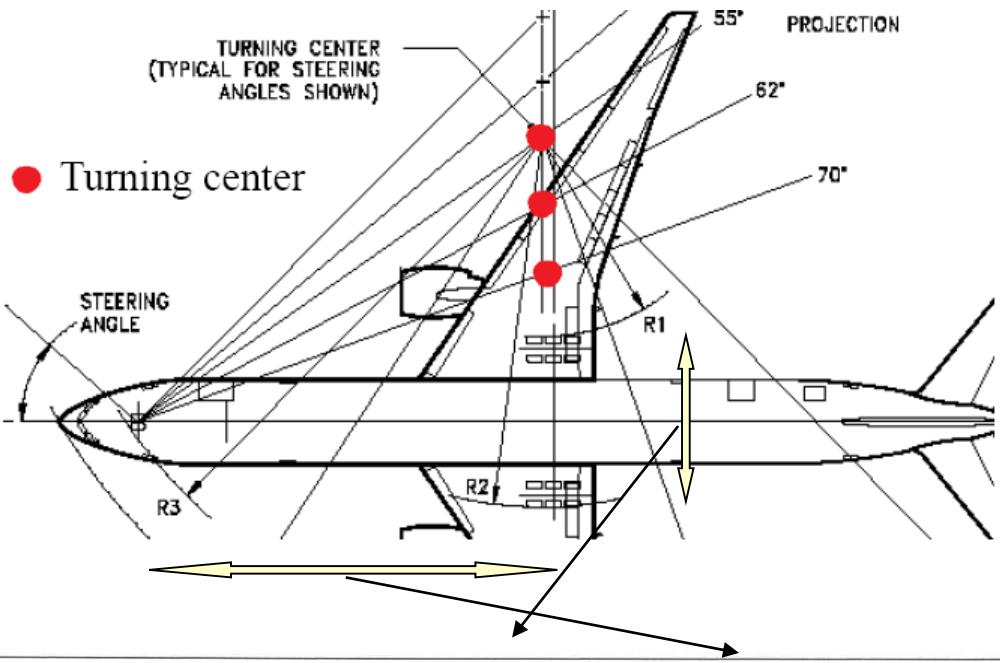
$$\frac{V^2}{R} = 127,133 \cdot [\cancel{\text{tg}(\alpha)} + f_T]$$

↑
0,133

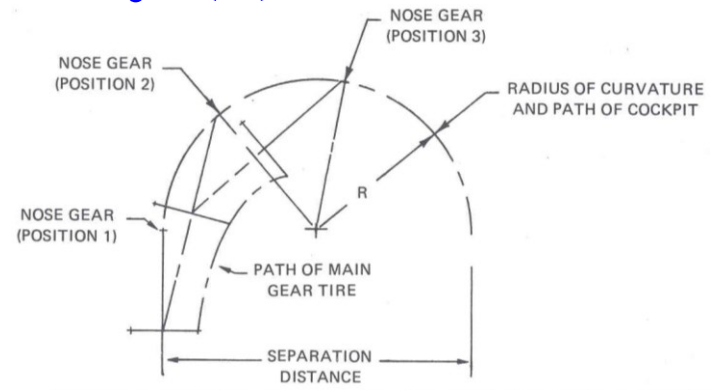
| Speed (km/h) | Radius of curve (m) |
|--------------|---------------------|
| 16 | 15 |
| 32 | 60 |
| 48 | 135 |
| 64 | 240 |
| 80 | 375 |
| 96 | 540 |



Le curve delle taxiway (2)



● Turning center

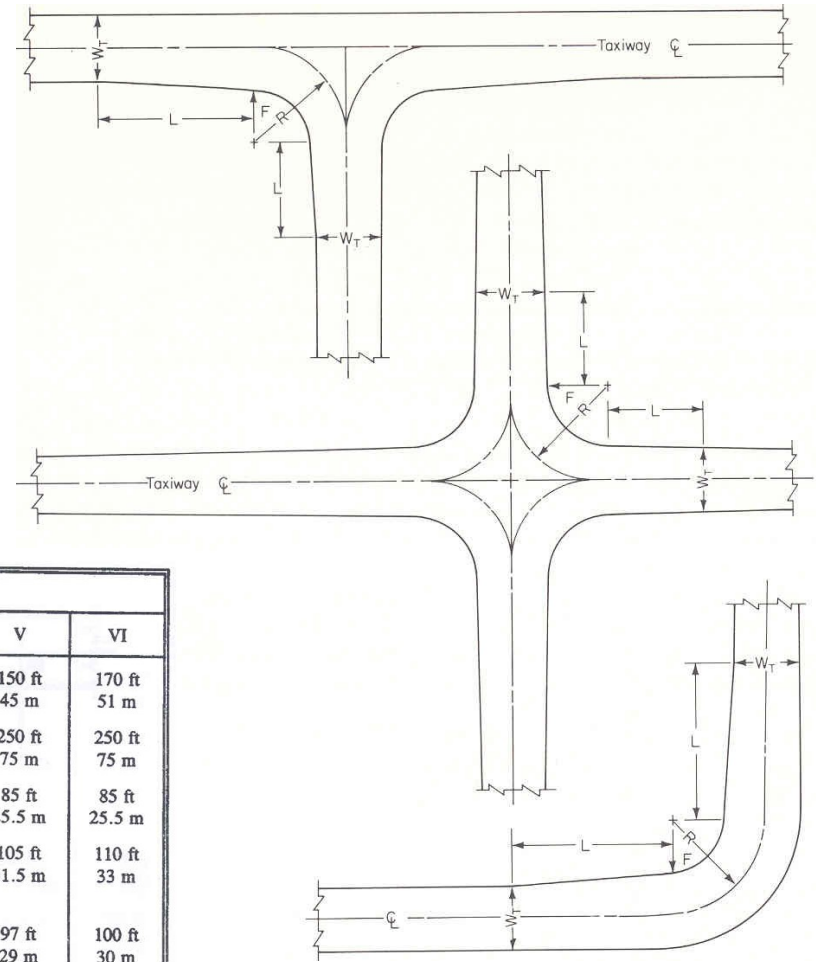
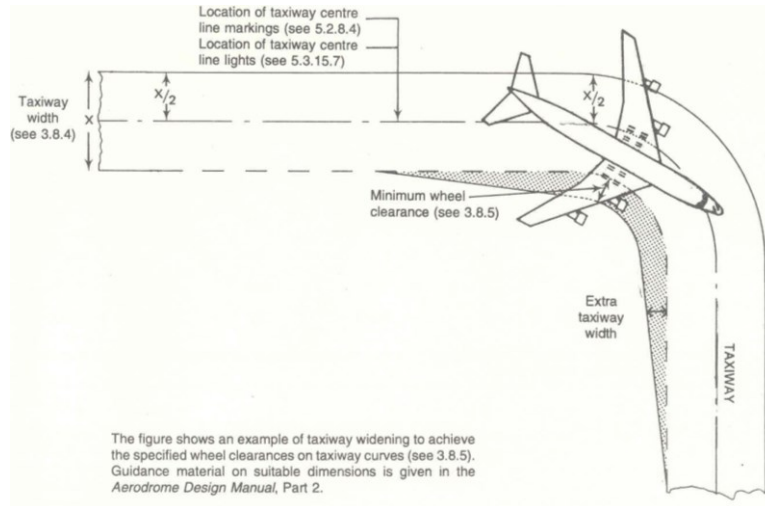


| Aircraft model | Maximum steering angle | Approx. maximum steering angle during 180° turn |
|----------------|------------------------|---|
| Lear 55 | 55° | 40° |
| F28-2000 | 76° | 45° |
| MD80 | 82° | 65° |
| Concorde | 60° | 85° |
| MD11 | 70° | 60° |
| B747 | 70° | 50° |

| Code letter | Aircraft model | Outer main gear wheel span (m) | Main gear to cockpit (m) | Radius of curvature (m) |
|-------------|----------------|--------------------------------|--------------------------|-------------------------|
| A | Lear 55 | 4.5 | 5.7 | 11.875 |
| B | F28-2000 | 6.0 | 11.9 | 16.75 |
| C | MD80 | 9.0 | 20.3 | 22.0 |
| C | Concorde | 9.0 | 29.6 | 22.0 |
| D | MD11 | 14.0 | 31.0 | 33.25 |
| E | B747 | 14.0 | 28.0 | 40.0 |

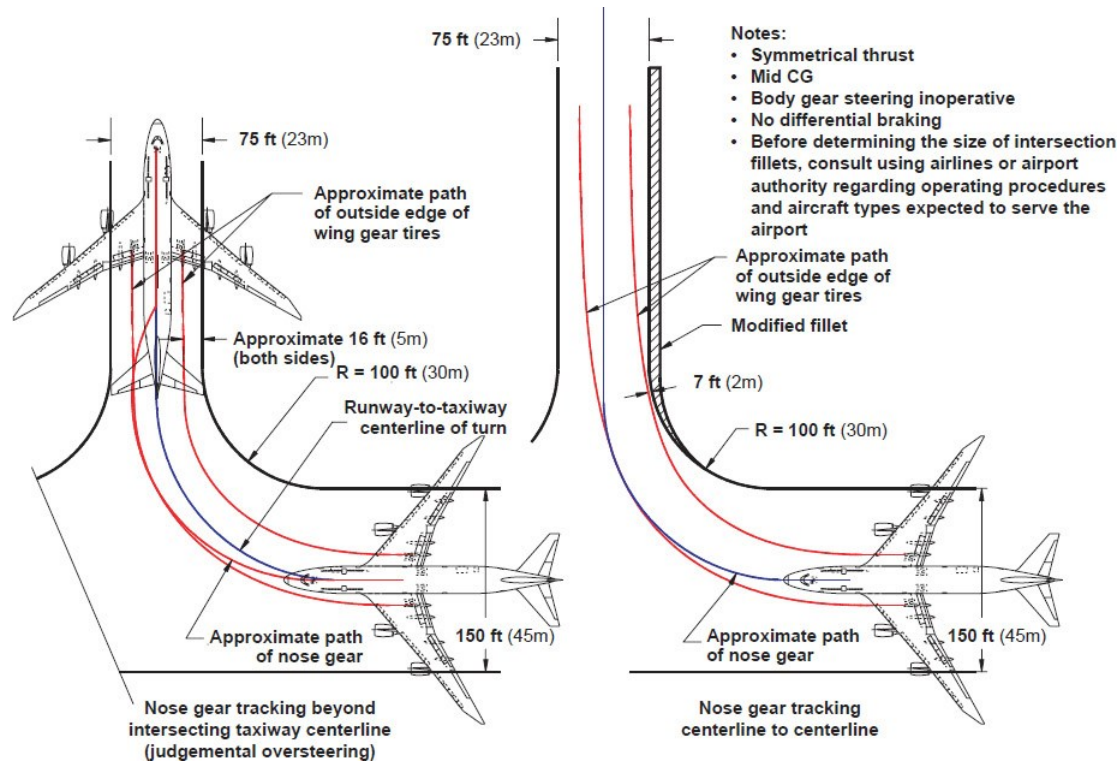
| Code letter | Radius (m) | Velocity $V = 4.1120 (R^{1/2})$ (km/h) |
|-------------|------------|--|
| A | 11.875 | 14.17 |
| B | 16.75 | 16.83 |
| C | 22.0 | 19.29 |
| D | 33.25 | 23.71 |
| E | 40.0 | 26.01 |

I raccordi planimetrici nelle taxiway (1)

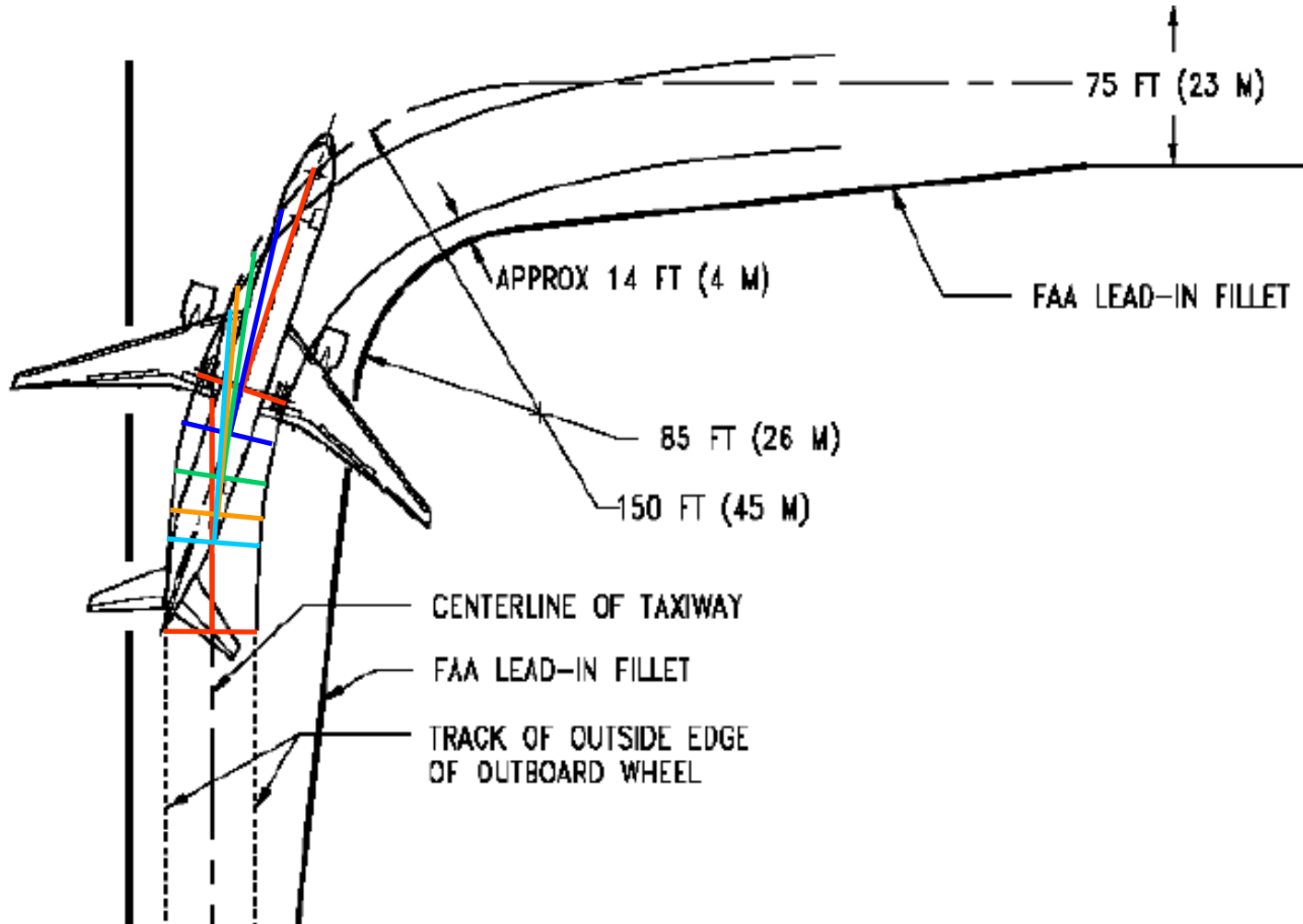


| ITEM | DIM 1/ | AIRPLANE DESIGN GROUP | | | | | |
|---|-----------|-----------------------|--------------------|-----------------|------------------|------------------|-----------------|
| | | I | II | III 2/ | IV | V | VI |
| Radius of Taxiway Turn 3/ | R | 75 ft 22.5 m | 75 ft 22.5 m | 100 ft 30 m | 150 ft 45 m | 150 ft 45 m | 170 ft 51 m |
| Length of Lead-in to Fillet | L | 50 ft 15 m | 50 ft 15 m | 150 ft 45 m | 250 ft 75 m | 250 ft 75 m | 250 ft 75 m |
| Fillet Radius for Tracking Centerline | F | 60 ft 18 m | 55 ft 16.5 m | 55 ft 16.5 m | 85 ft 25.5 m | 85 ft 25.5 m | 85 ft 25.5 m |
| Fillet Radius for Judgmental Oversteering Symmetrical Widening 4/ | F | 62.5 ft 18.75 m | 57.5 ft 17.25 m | 68 ft 20.4 m | 105 ft 31.5 m | 105 ft 31.5 m | 110 ft 33 m |
| Fillet Radius for Judgmental Oversteering One Side Widening 5/ | F | 62.5 ft 18.75 m | 57.5 ft 17.25 m | 60 ft 18 m | 97 ft 29 m | 97 ft 29 m | 100 ft 30 m |

I raccordi planimetrici nelle taxiway (1)



I raccordi planimetrici nelle taxiway (2)



Le bretelle di uscita rapida (1)

| Codice numerico | R [m] | V [km/h] |
|-----------------|-------|----------|
| 3, 4 | 550 | 93 |
| 1,2 | 275 | 65 |

$$\frac{V^2}{R} = 127,133 \cdot f_T$$

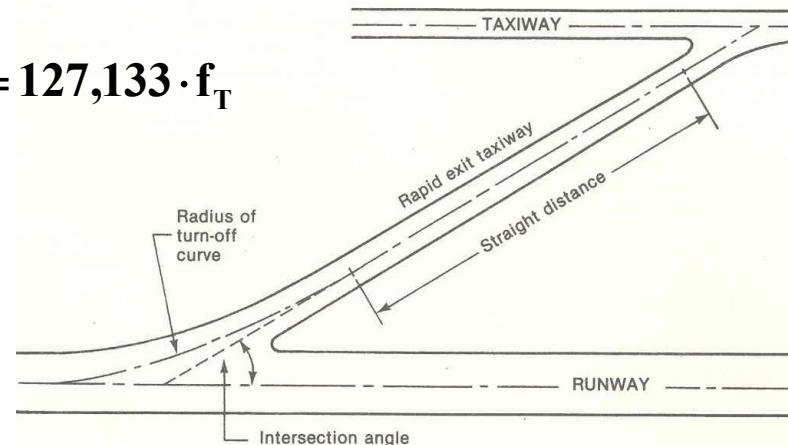
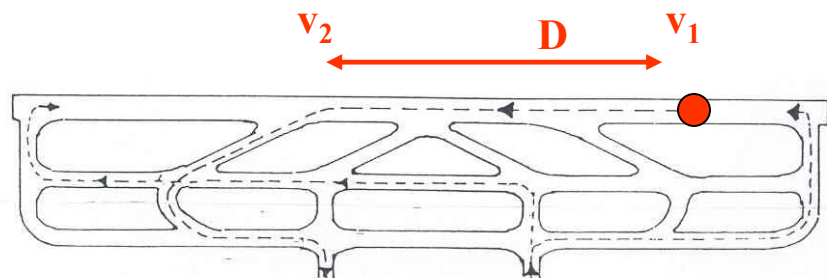


Table 1-11. Accumulated rapid exit usage by distance from threshold (metres)

| Aircraft category | 50% | 60% | 70% | 80% | 90% | 95% | 100% |
|-------------------|-------|-------|-------|-------|-------|-------|-------|
| A | 1 170 | 1 320 | 1 440 | 1 600 | 1 950 | 2 200 | 2 900 |
| B | 1 370 | 1 480 | 1 590 | 1 770 | 2 070 | 2 300 | 3 000 |
| C | 1 740 | 1 850 | 1 970 | 2 150 | 2 340 | 2 670 | 3 100 |
| D | 2 040 | 2 190 | 2 290 | 2 480 | 2 750 | 2 950 | 4 000 |

$$D = \frac{v_1^2 - v_2^2}{2 \cdot d}$$

$$d = 1,52 \text{ m/s}^2$$

nei rettilinei

$$d = 0,76 \text{ m/s}^2$$

nelle curve

Le bretelle di uscita rapida (2)

Programma REDIM al sito www.atsl.cce.vt.edu/index.htm

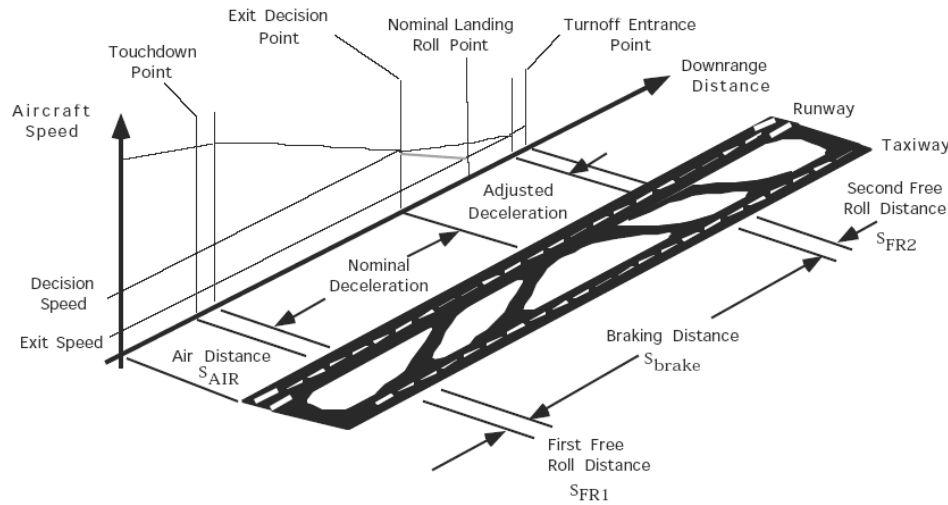
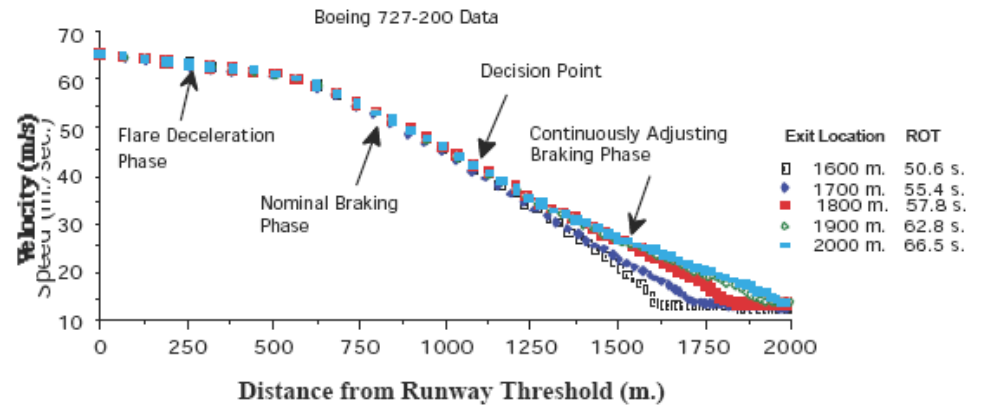


Figure 1.1 Aircraft Landing Segmentation.



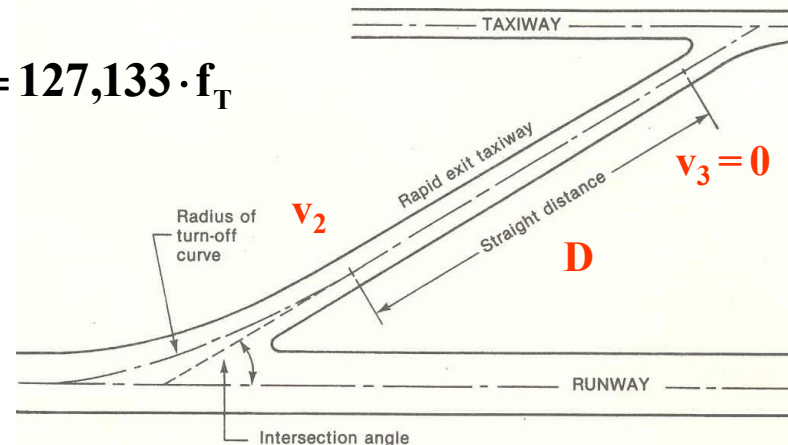
Le bretelle di uscita rapida (3)

| Codice numerico | R [m] | V [km/h] |
|-----------------|-------|----------|
| 3, 4 | 550 | 93 |
| 1,2 | 275 | 65 |

$$\frac{V^2}{R} = 127,133 \cdot f_T$$

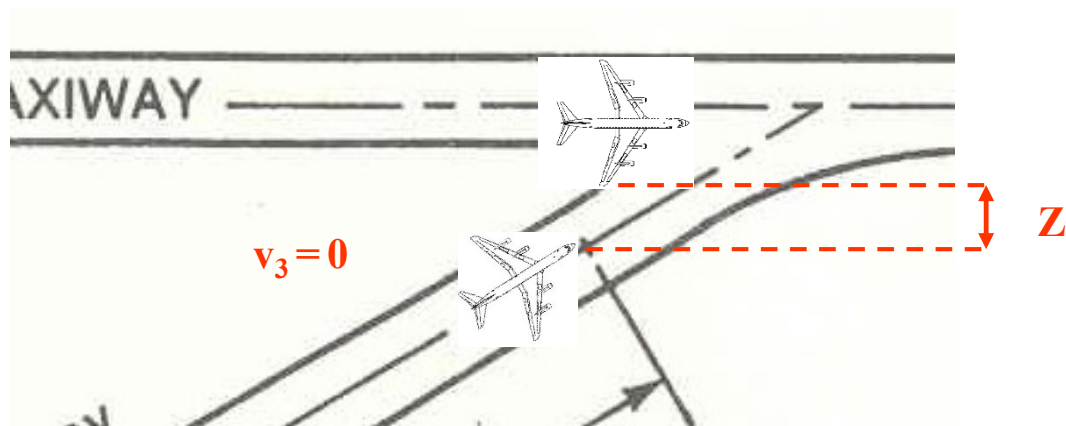
$$D = \frac{v_1^2 - v_2^2}{2 \cdot d} \quad \begin{array}{l} d = 1,52 \text{ m/s}^2 \\ d = 0,76 \text{ m/s}^2 \end{array}$$

nei rettilinei
nelle curve



Dmin = 35 m per codici 1,2

Dmin = 75 m per codici 3,4



Le bretelle di uscita rapida (4)

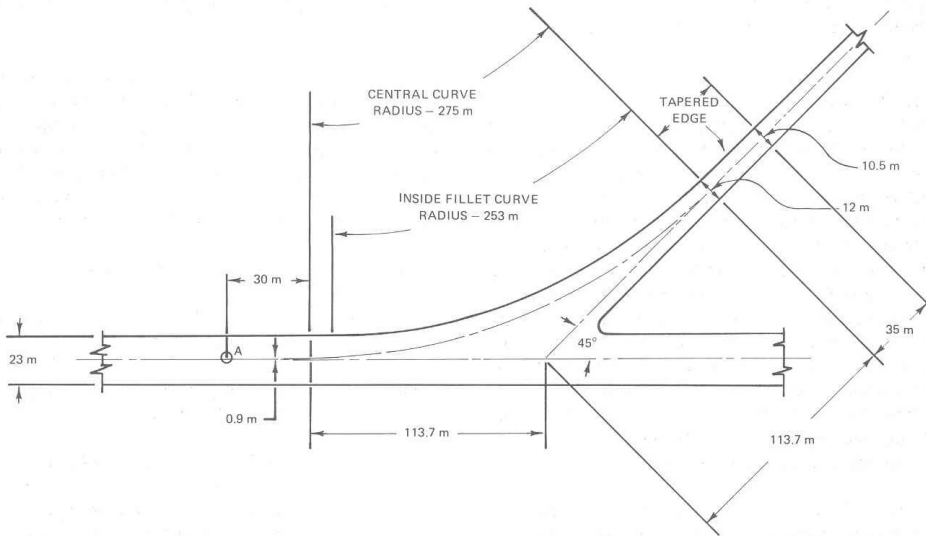


Figure 1-8. Design for rapid exit taxiways (code number 1 or 2)

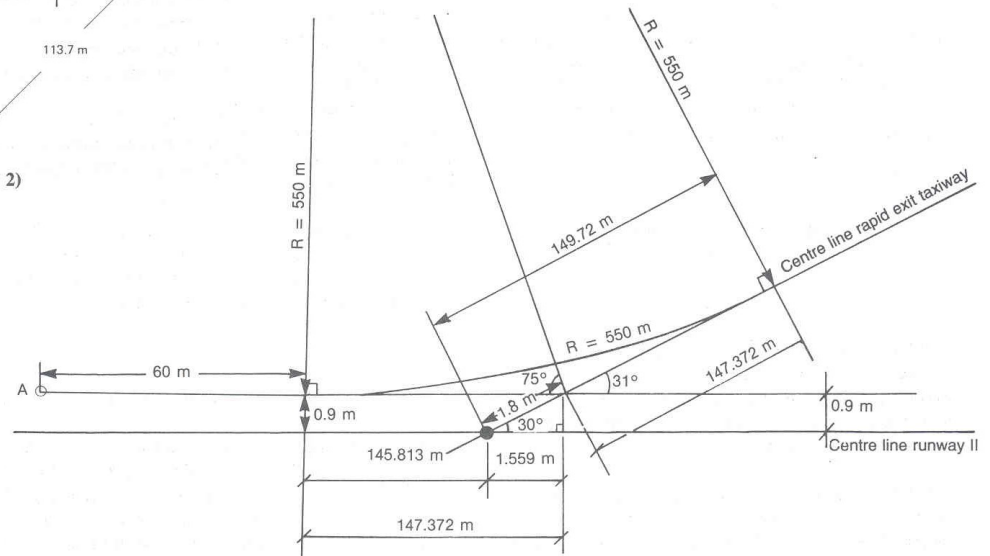
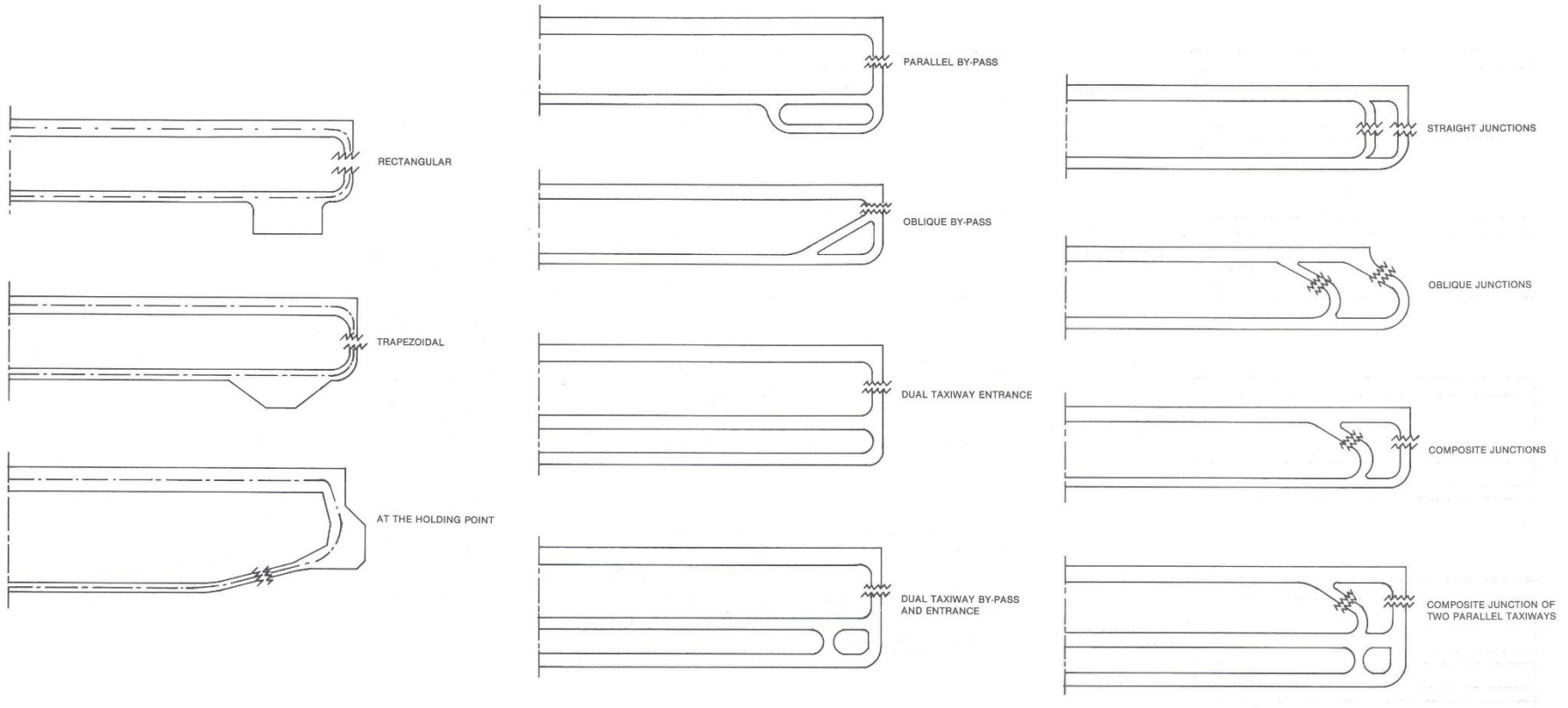


Figure 1-7. Design for rapid exit taxiways (code number 3 or 4)

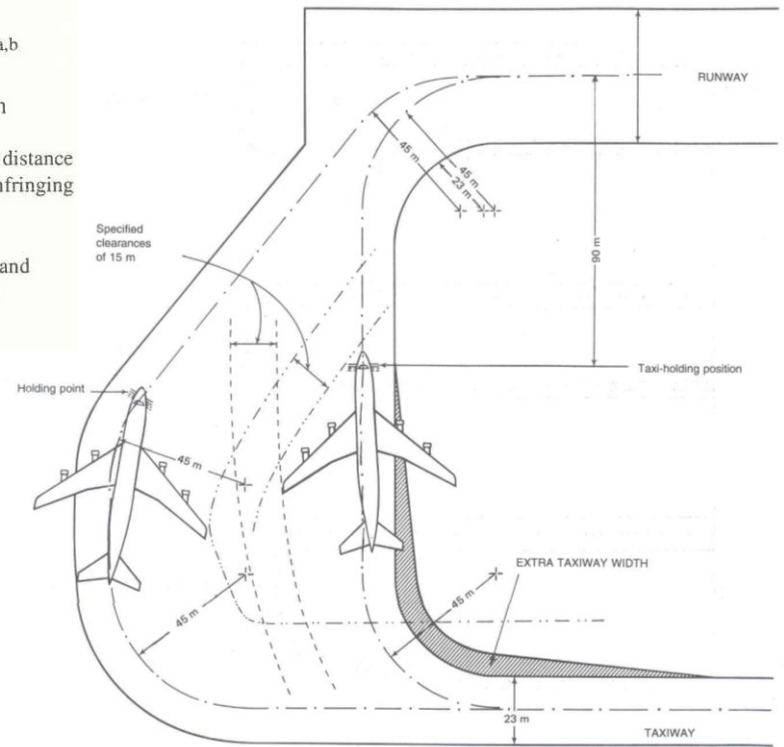
Le aeree di attesa (1)



Le aeree di attesa (2)

| Type of runway | Code number | | | |
|--|-------------------|-------------------|---------------------|---------------------|
| | 1 | 2 | 3 | 4 |
| Non-instrument | 30 m | 40 m | 75 m | 75 m |
| Non-precision approach | 40 m | 40 m | 75 m | 75 m |
| Precision approach category I | 60 m ^b | 60 m ^b | 90 m ^{a,b} | 90 m ^{a,b} |
| Precision approach categories II and III | – | – | 90 m ^{a,b} | 90 m ^{a,b} |
| Take-off runway | 30 m | 40 m | 75 m | 75 m |

- a. If a holding bay, taxi-holding position or road-holding position is at a lower elevation compared to the threshold, the distance may be decreased 5 m for every metre the bay or holding position is lower than the threshold, contingent upon not infringing the inner transitional surface.
- b. This distance may need to be increased to avoid interference with radio navigation aids, particularly the glide path and localizer facilities. Information on critical and sensitive areas of ILS and MLS is contained in Annex 10, Volume I, Attachments C and G to Part I, respectively (see also 3.11.5).



Esercitazione (1)

USO DEI DIAGRAMMI DI PRESTAZIONE PER IL CALCOLO DELLA LUNGHEZZA DI PISTA AL DECOLLO E ALL'ATTERRAGGIO

DATI:

Lunghezza pista: 3000 m

Quota di riferimento dell'aeroporto: 12,5 m s.l.m

Temperatura di riferimento dell'aeroporto: 28,6 ° C

Pendenza longitudinale della pista. Vedi profilo allegato

| AEREI | Peso al decollo [kg] | Peso all'atterraggio [kg] | Velocità in soglia [km/h] |
|-------------|-------------------------|------------------------------|------------------------------|
| MD80 | 67.000 | 55.000 | 250 |
| ATR42 | 14.500 | - | 200 |
| BAE 146/300 | 44.000 | 38.000 | 200 |

DETERMINARE: Lunghezza base della pista; Classe ICAO dell'aeroporto; verificare il profilo in funzione della classe ICAO; Distanze dichiarate; distanze richieste per ogni aereo; verifica delle uscite per i vari aerei;

Le problematiche dell'area terminale

- Capacità, adeguata alla domanda **TERMINAL**
- Distanze pedonali limitate
- Ambiente piacevole e comodo
- Servizi disponibili e vicini
- Sicurezza

**PIAZZALI
(APRON)**



ACCESSI

Tipologie dei terminal

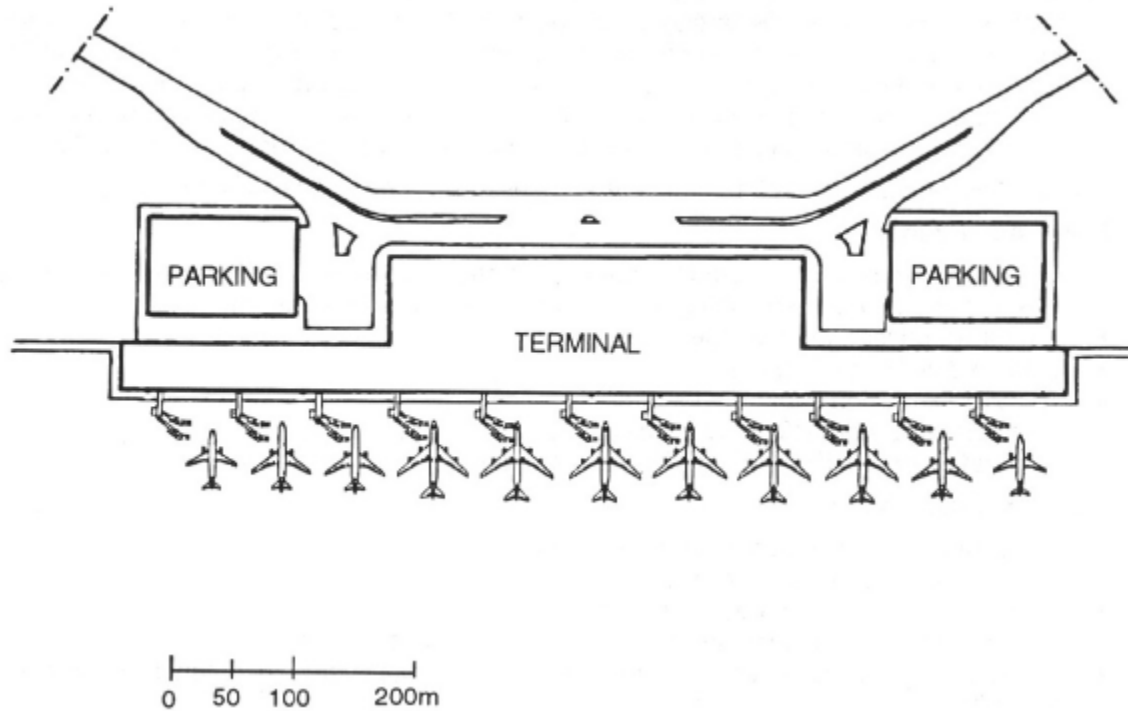
DISTRIBUZIONE ORIZZONTALE:

- **Lineare**
- **Moli**
- **Satellite**
- **Piazzale aperto (Transporter)**

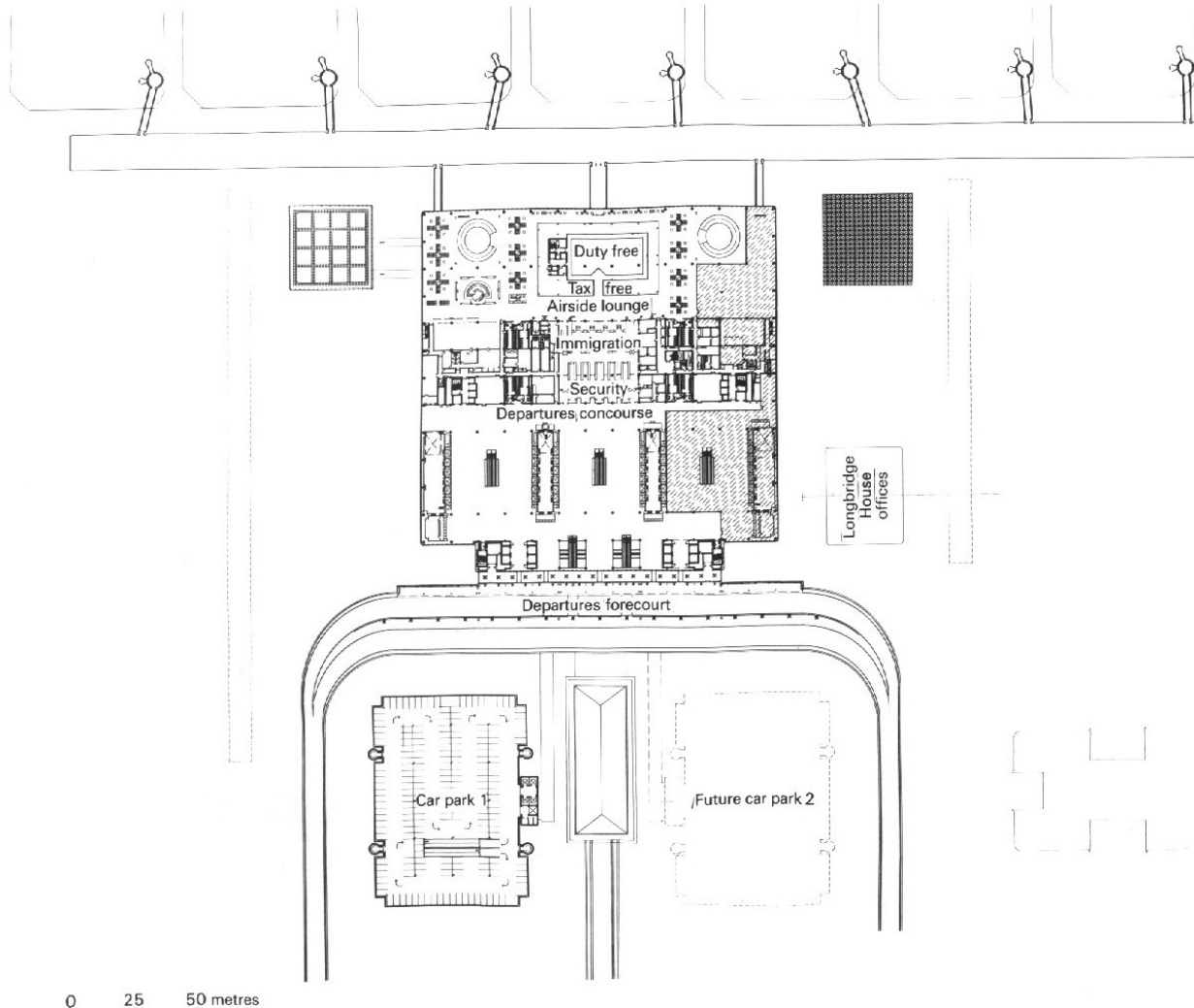
DISTRIBUZIONE VERTICALE

- **Piano singolo**
- **Un piano e mezzo**
- **Due piani**

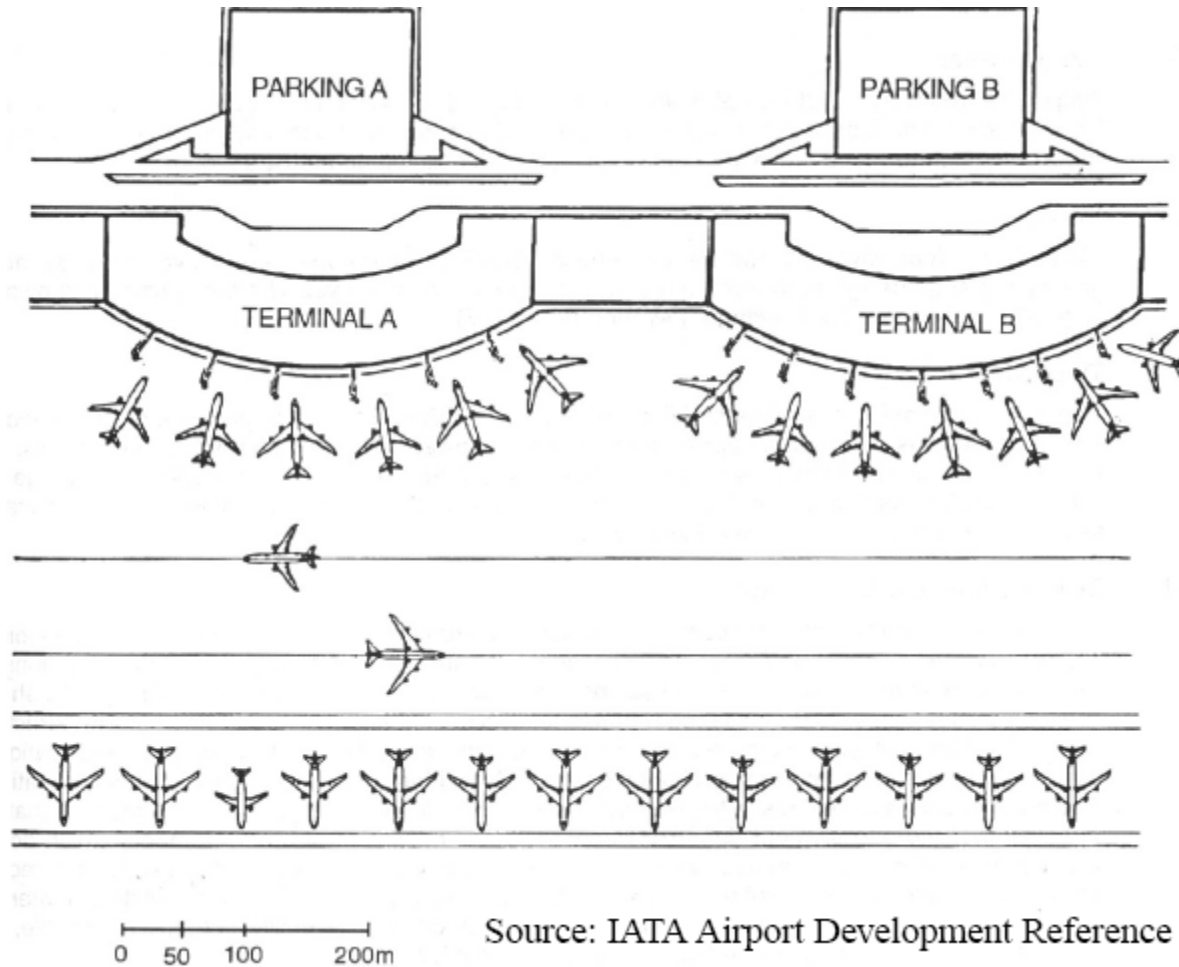
Terminal lineare centralizzato



Terminal lineare centralizzato

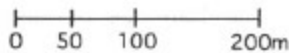
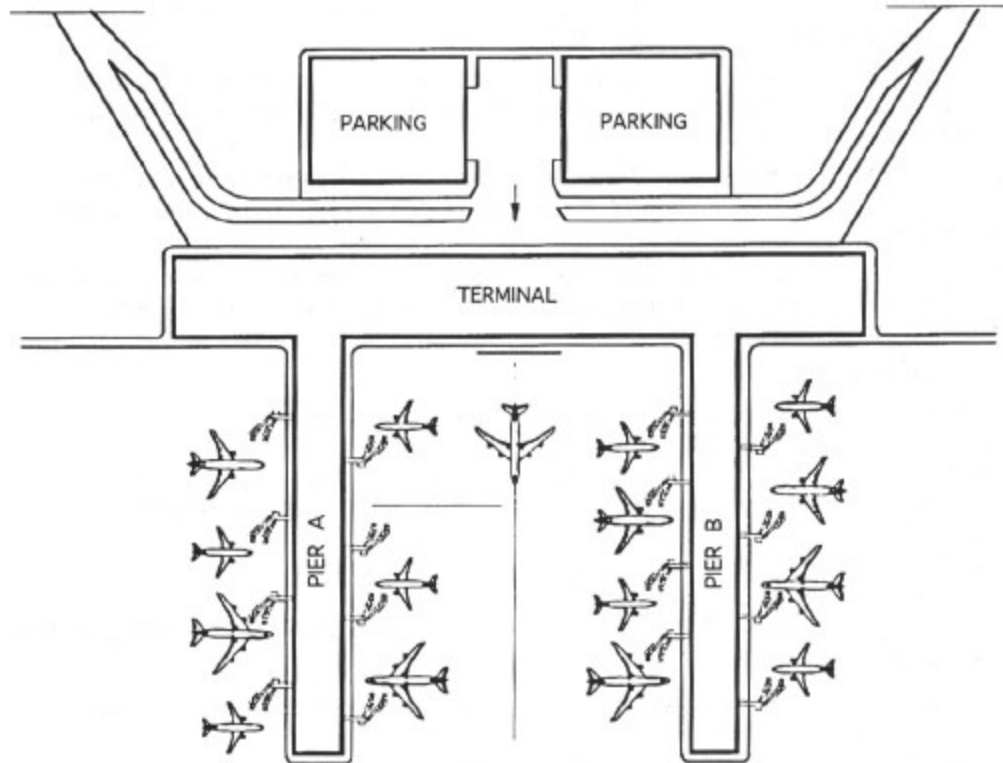


Terminal lineare semi-centralizzato



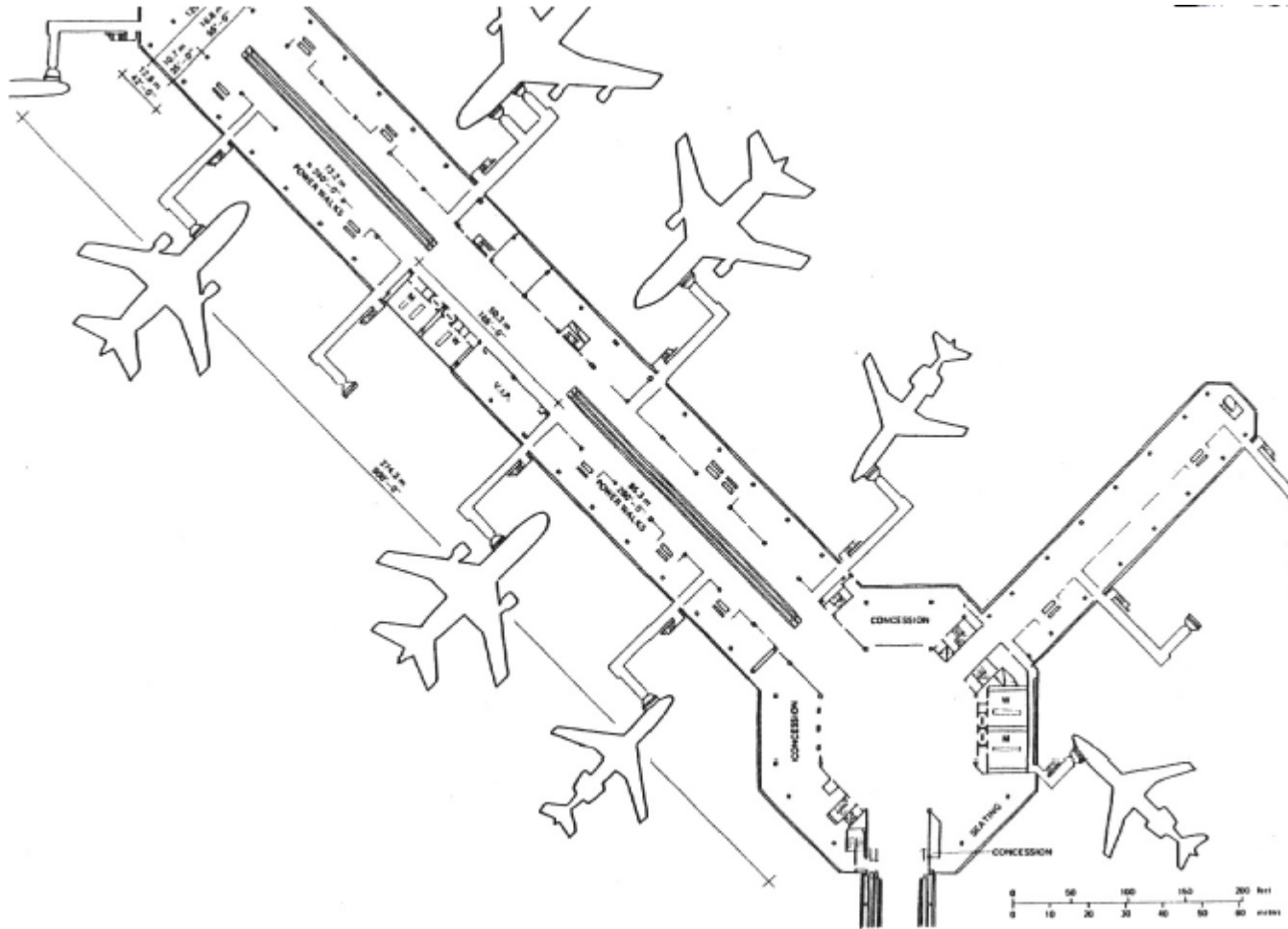
Source: IATA Airport Development Reference Manual

Terminal centralizzato con moli (1)

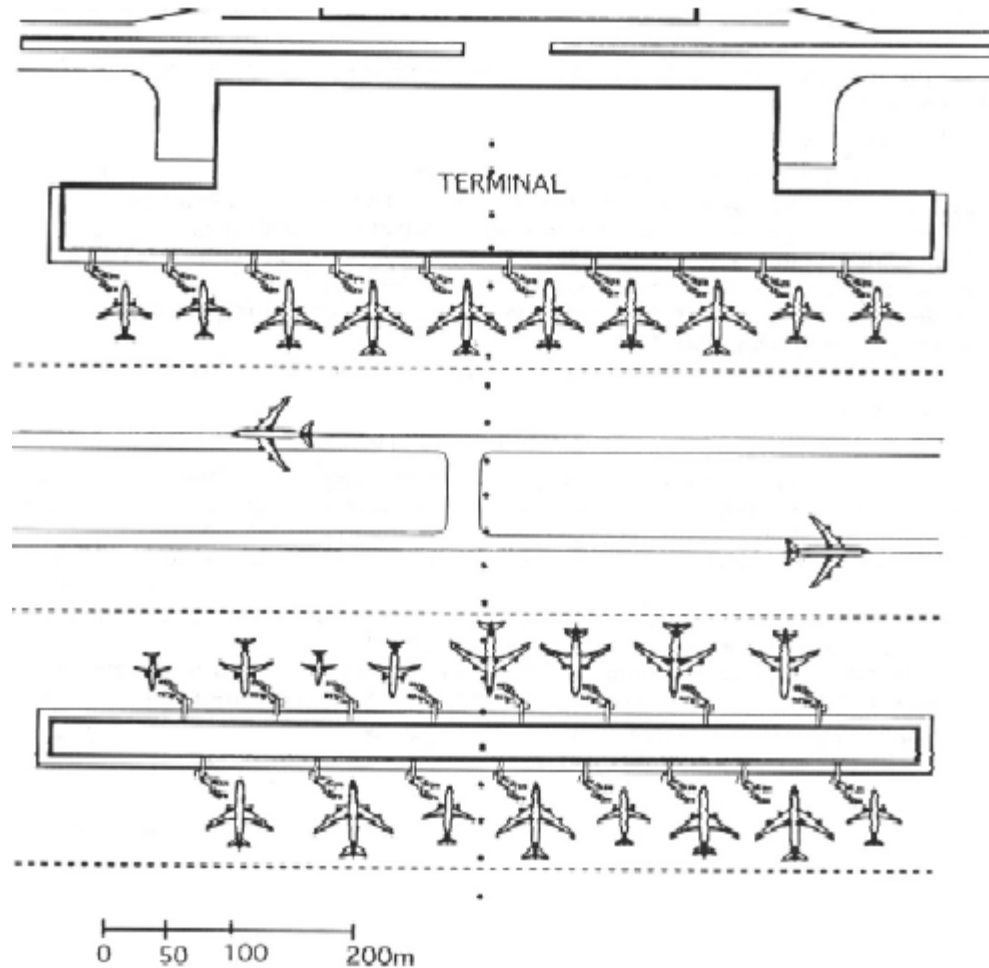


Source: IATA Airport Development Reference Manual

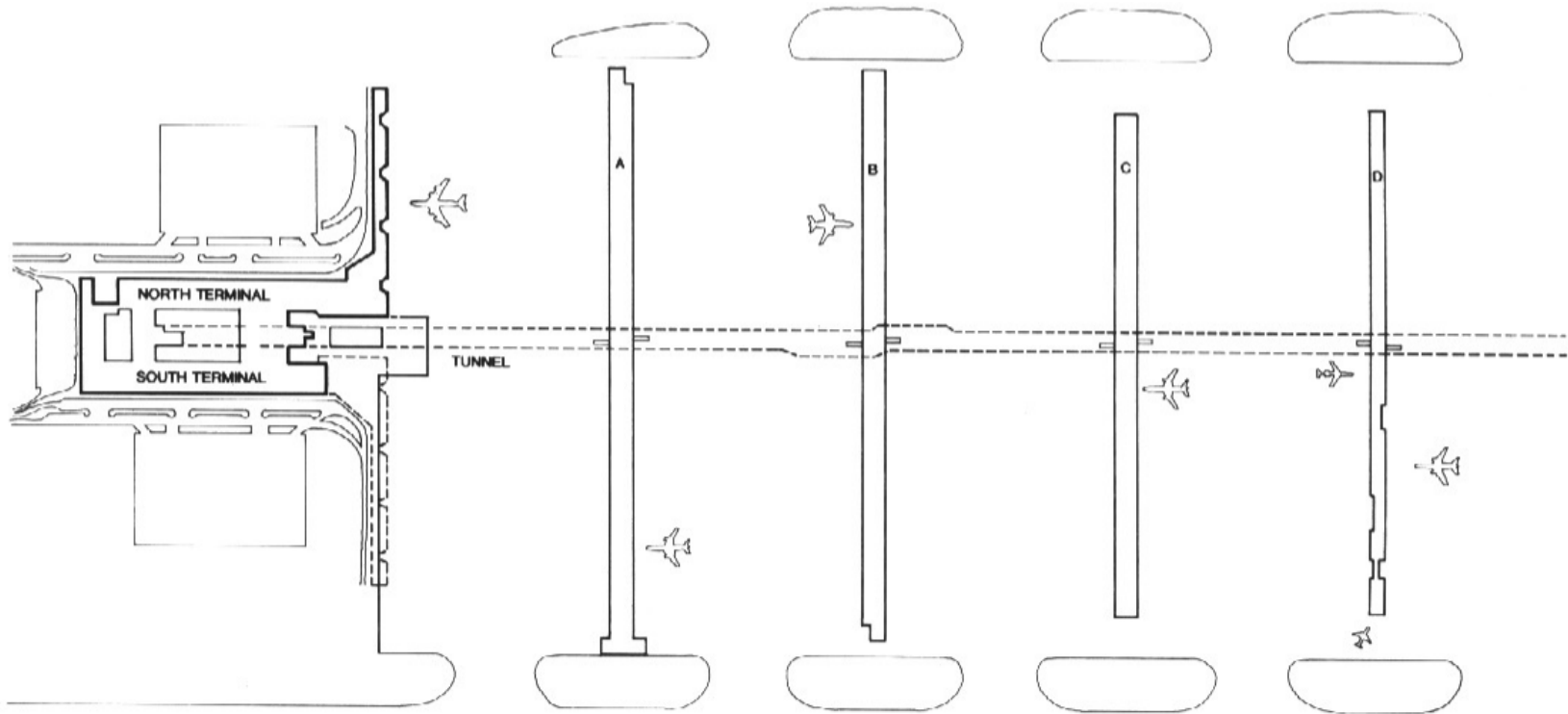
Terminal centralizzato con moli (2)



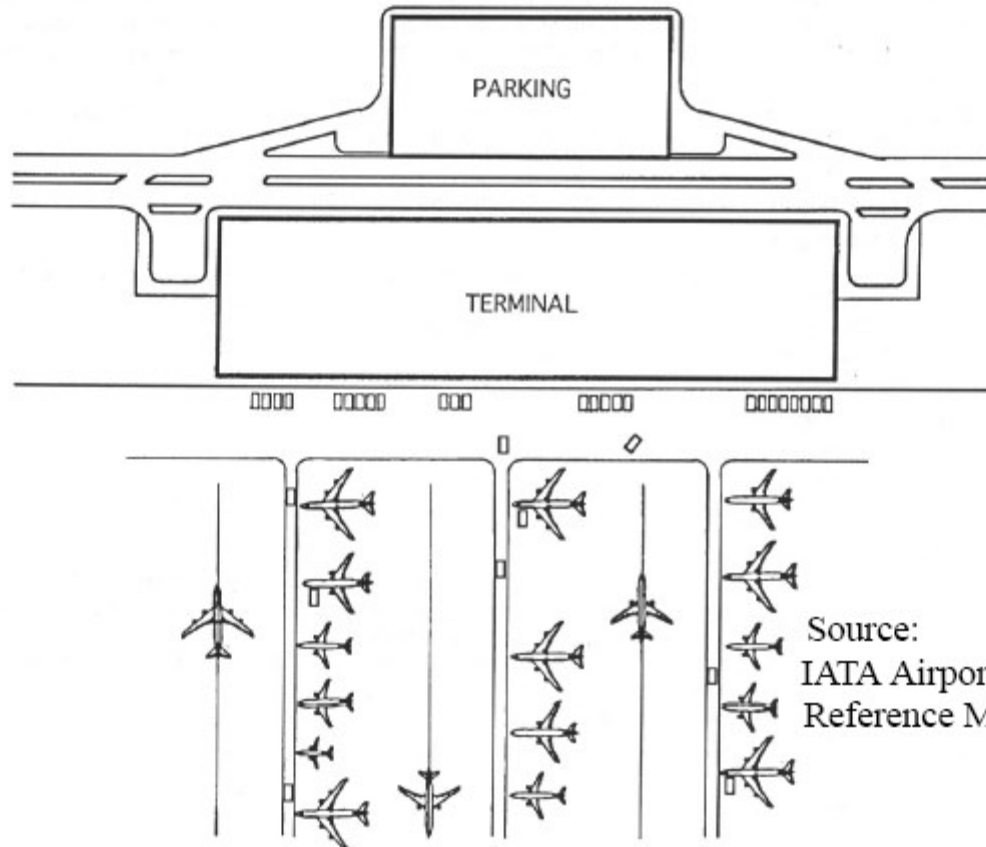
Terminal a satellite (1)



Terminal a satellite (2)

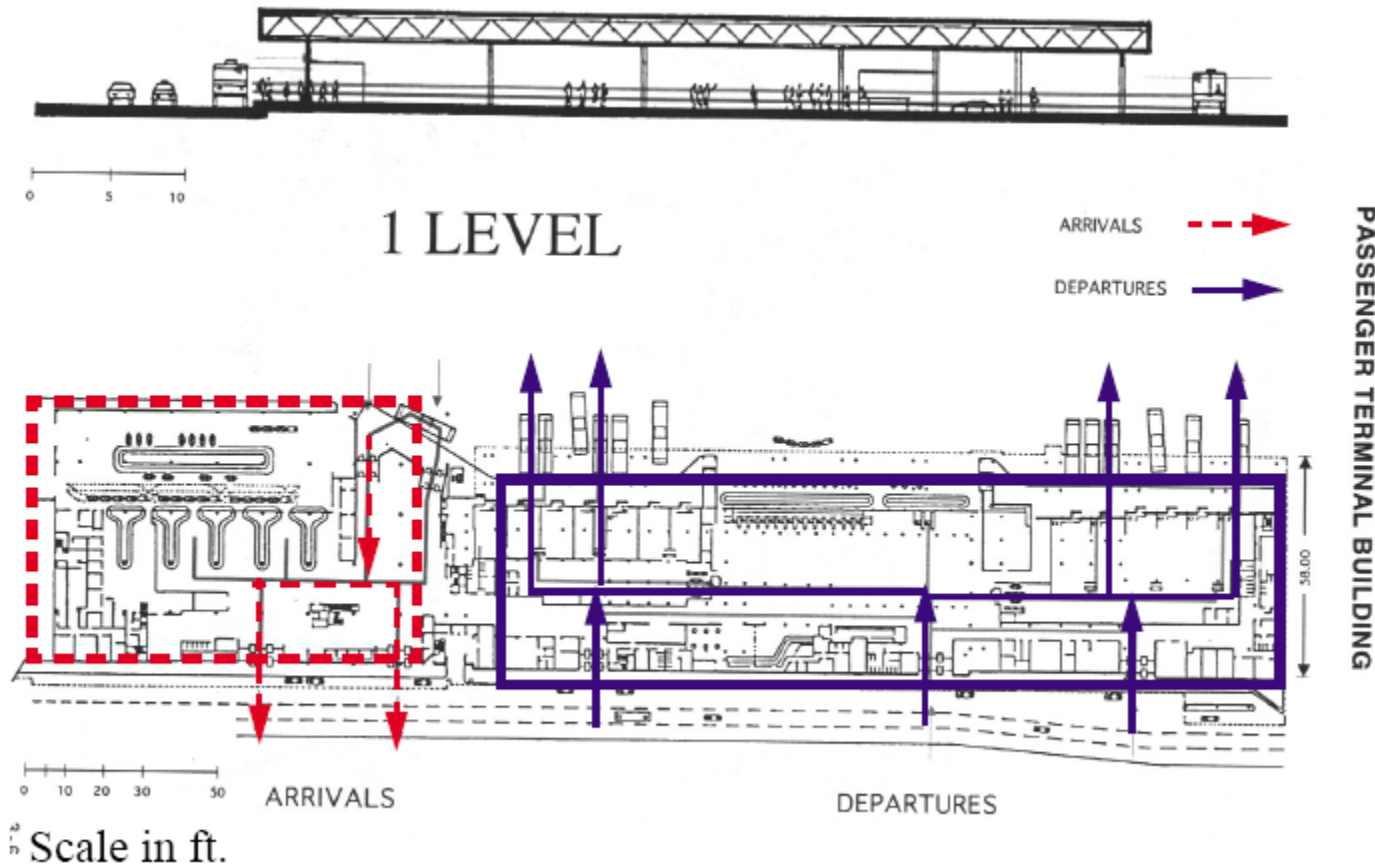


Transporter con terminal centrale



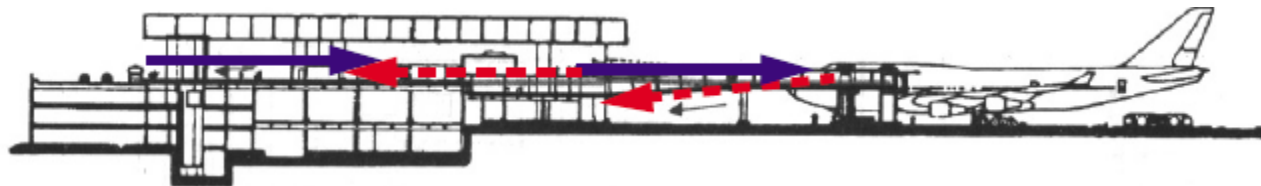
Source:
IATA Airport Development
Reference Manual

Terminal ad un piano



Source: IATA Airport Development Reference Manual

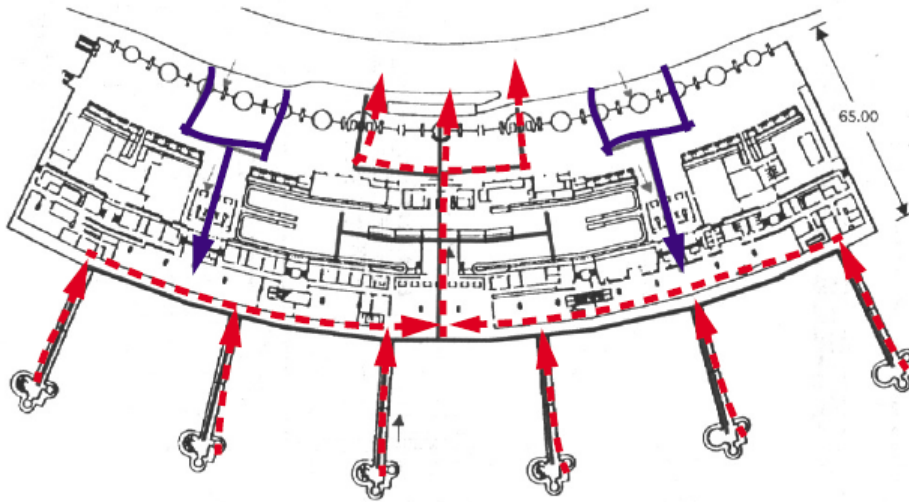
Terminal ad un piano e mezzo



0 10 25 50

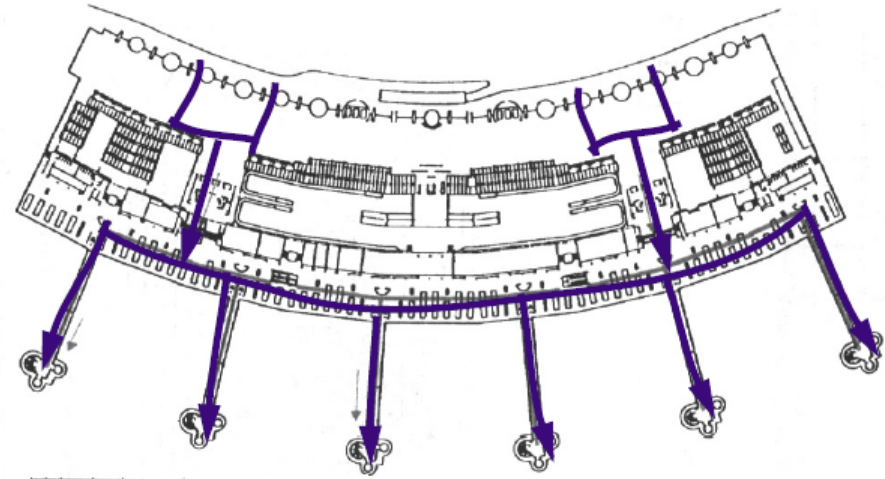
ARRIVALS 

DEPARTURES 




65.00

Arriving Passenger Flows 
Departing Passenger Flows 



0 10 30 50

Scale in ft.

Departing Passenger Flows 

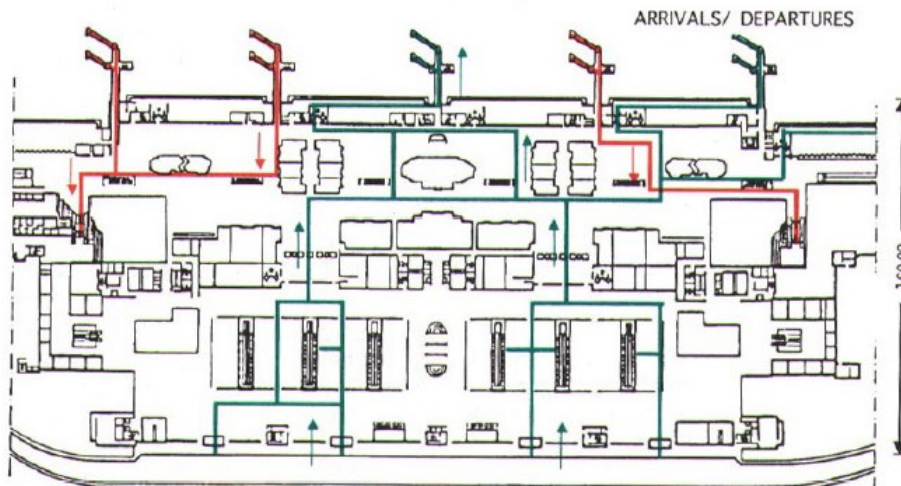
Terminal a due piani



0 10 25 50

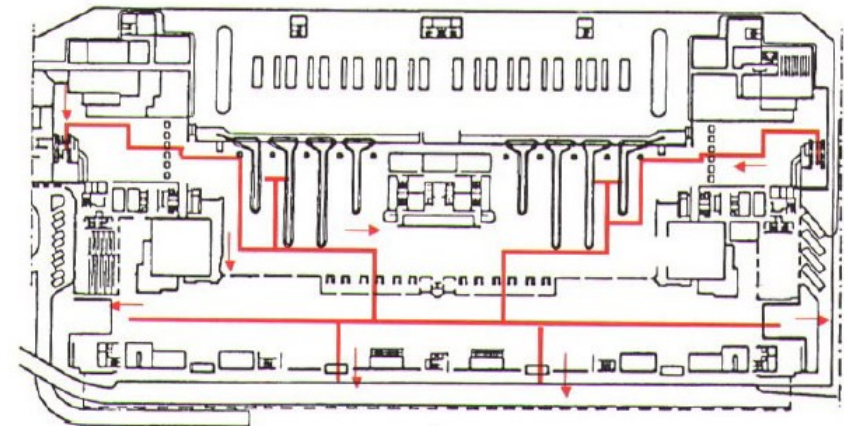
Scale in ft.

ARRIVALS ———
DEPARTURES ———



0 20 50

Departing Passenger Flows ———→
Arriving Passenger Flows ———→



0 20 50

ARRIVALS
Arriving Passenger Flows ———→

Numero di Stalli

$$N = \left(\sum_i m_i \cdot \frac{T_i}{60 \cdot u} \right) \cdot C + \alpha$$

u = fattore di utilizzazione (0 – 1)

N = numero stalli necessari

m_i = % di aerei del gruppo i che opera sull'aeroporto

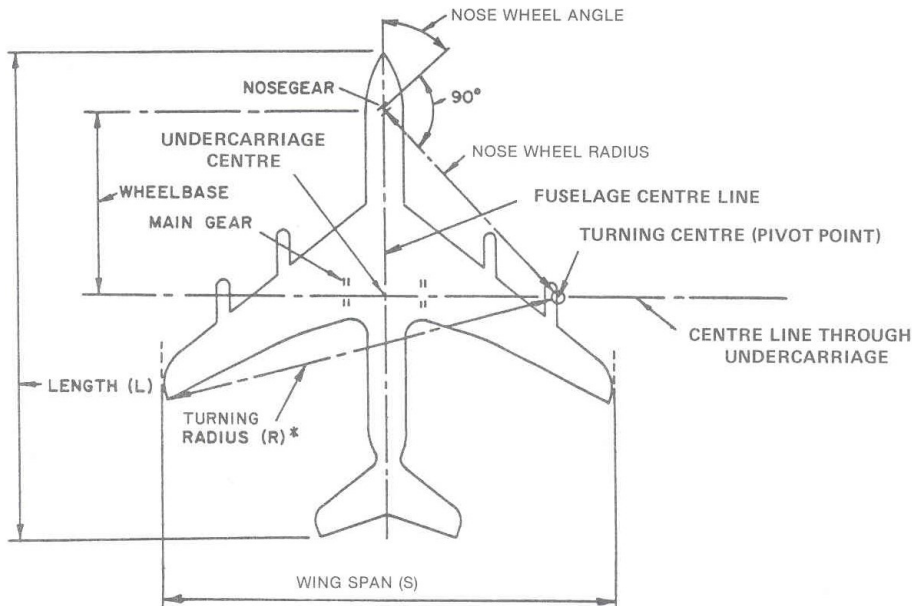
T_i = tempo di servizio del gate per l'aereo di tipo i

C = domanda richiesta all'aeroporto (Aerei/ora)

α = riserva

| Aircraft | Through flight | Domestic | | International Turnaround flight | Group | Aircraft |
|------------------------|----------------|-------------------|-------------------|------------------------------------|-------|---------------------------------|
| | | Turnaround flight | Turnaround flight | | | |
| B-737, DC-9, F-28 | 25 | 45 | — | — | S | F-28, B-737 |
| B-707, B-757 | 45 | 50 | 60 | 60 | M | B-707-320, A-300, L-1011, DC-10 |
| A300, DC-10, L-1011 | 45-60 | 60 | 120 | 120 | L | B-747 SP, B-747 |
| B-747 | — | 60 | 120-180 | 120-180 | LL | B-747 II (future aircraft) |

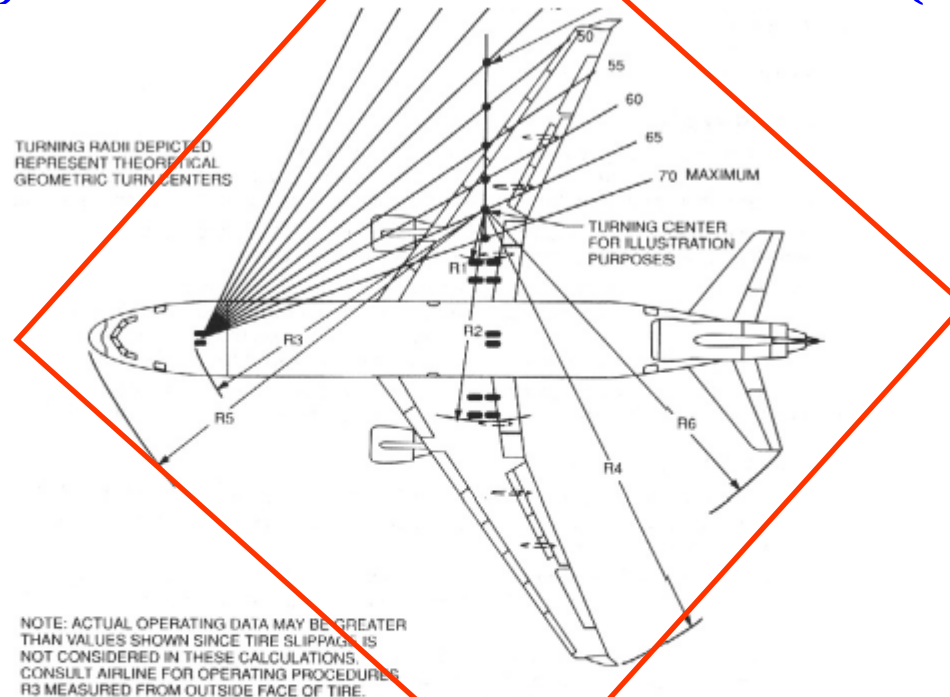
Ingombri statici e dinamici (1)



| Aircraft type | Length (m) | Wing span (m) | Nose wheel angle | Turning radius (m) |
|----------------------|------------|---------------|------------------|--------------------|
| A300B-B2 | 46.70 | 44.80 | 50° | 38.80 ^a |
| B727-100 | 40.59 | 32.92 | 75° | 21.90 ^c |
| B727-200 | 46.68 | 32.92 | 75° | 25.00 ^c |
| B737-100 | 28.65 | 28.35 | 70° | 18.40 ^a |
| B737-200 | 30.58 | 28.35 | 70° | 18.70 ^a |
| B747 | 70.40 | 59.64 | 60° | 60.20 ^a |
| B747-400 | 70.67 | 64.90 | | |
| B757 | 47.32 | 37.95 | 60° | 27.90 ^a |
| B767 | 48.51 | 47.63 | 60° | 36.00 ^a |
| BAC 111-400 | 28.50 | 27.00 | 65° | 21.30 ^a |
| Caravelle | 36.70 | 34.30 | 45° | 29.00 ^a |
| Concorde | 62.10 | 25.50 | 50° | 30.10 ^c |
| DC8-40/50 | 45.95 | 43.41 | 70° | 29.20 ^a |
| DC8-61/63 | 57.12 | 43.41/45.2 | 70° | 32.70 ^c |
| DC9-10/20 | 31.82 | 27.25/28.5 | 75° | 17.80 ^c |
| DC9-30 | 36.36 | 28.44 | 75° | 20.40 ^c |
| DC9-40 | 38.28 | 28.44 | 75° | 21.40 ^c |
| DC9-50 | 40.72 | 28.45 | 75° | 22.50 ^c |
| DC9-80 | 45.02 | 32.85 | 75° | 25.10 ^b |
| DC10-10 | 55.55 | 47.35 | 65° | 35.60 ^a |
| DC10-30 | 55.35 | 50.39 | 65° | 37.30 ^a |
| DC10-40 | 55.54 | 50.39 | 65° | 36.00 ^a |
| L1011 | 54.15 | 47.34 | 60° | 35.59 ^a |
| Vickers Viscount 800 | 26.10 | 28.60 | 50° | 21.60 ^a |

a To wing tip
b To nose
c To tail

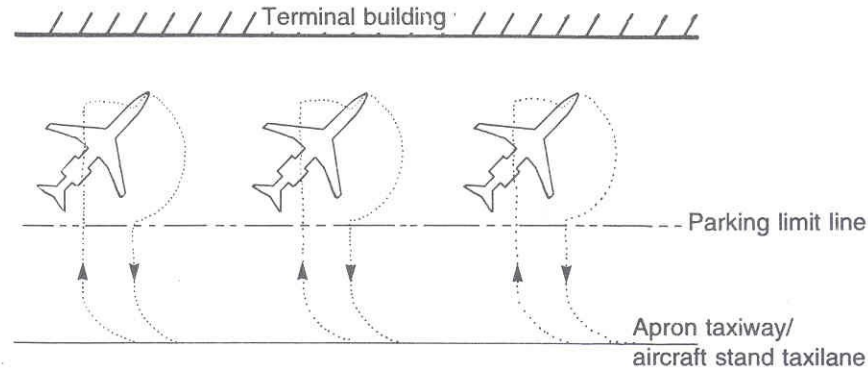
Ingombri statici e dinamici (2)



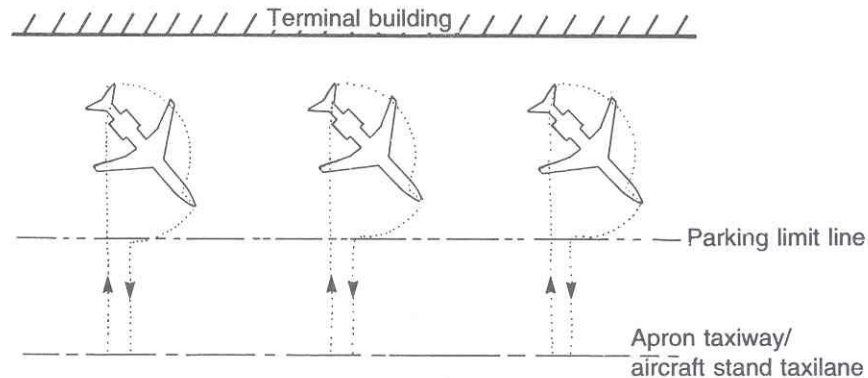
| STEERING ANGLE (DEG) | R-1 | | R-2 | | R-3 | | R-4 | | R-5 | | R-6 | |
|----------------------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|------|
| | FT | m | FT | m | FT | m | FT | m | FT | m | FT | m |
| 25 | 153.7 | 46.8 | 194.9 | 59.4 | 194.0 | 59.1 | 222.8 | 80.0 | 205.7 | 62.7 | 220.2 | 67.1 |
| 30 | 120.2 | 36.6 | 161.4 | 49.2 | 164.3 | 50.1 | 229.5 | 69.9 | 178.2 | 54.0 | 189.5 | 57.8 |
| 35 | 95.5 | 29.1 | 136.7 | 41.7 | 143.5 | 43.7 | 205.2 | 62.5 | 159.4 | 48.6 | 167.7 | 51.2 |
| 40 | 76.3 | 23.2 | 117.5 | 35.8 | 120.2 | 39.1 | 186.4 | 56.8 | 145.9 | 44.5 | 151.3 | 46.1 |
| 45 | 60.7 | 18.5 | 101.9 | 31.1 | 116.8 | 35.6 | 171.2 | 52.2 | 136.1 | 41.5 | 136.5 | 42.2 |
| 50 | 47.6 | 14.5 | 88.8 | 27.1 | 107.8 | 32.9 | 158.5 | 48.3 | 128.7 | 39.2 | 128.3 | 39.1 |
| 55 | 36.3 | 11.1 | 77.5 | 23.6 | 100.9 | 30.8 | 147.6 | 45.0 | 123.1 | 37.5 | 119.9 | 36.6 |
| 60 | 26.3 | 8.0 | 67.6 | 20.6 | 95.6 | 29.1 | 138.0 | 42.0 | 118.8 | 36.2 | 112.9 | 34.4 |
| 65 | 17.3 | 5.3 | 58.5 | 17.8 | 91.4 | 27.9 | 129.4 | 39.4 | 115.8 | 35.2 | 107.0 | 32.6 |

Configurazione dei parcheggi (1)

a) Taxi-in/taxi-out
(angled nose-in parking)

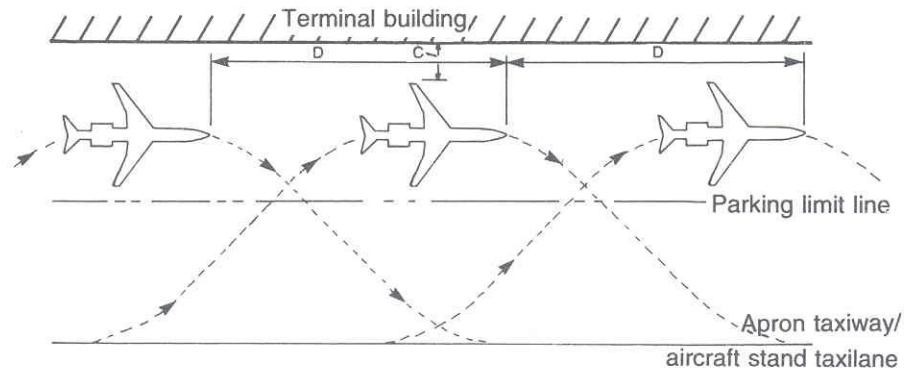


b) Taxi-in/taxi-out
(angled nose-out parking)

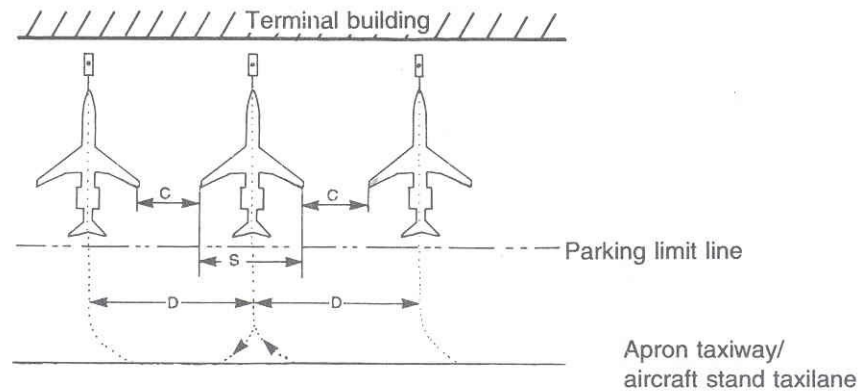


Configurazione dei parcheggi (2)

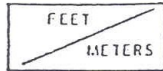
c) Taxi-in/taxi-out
(parallel parking)



d) Taxi-in/push-out

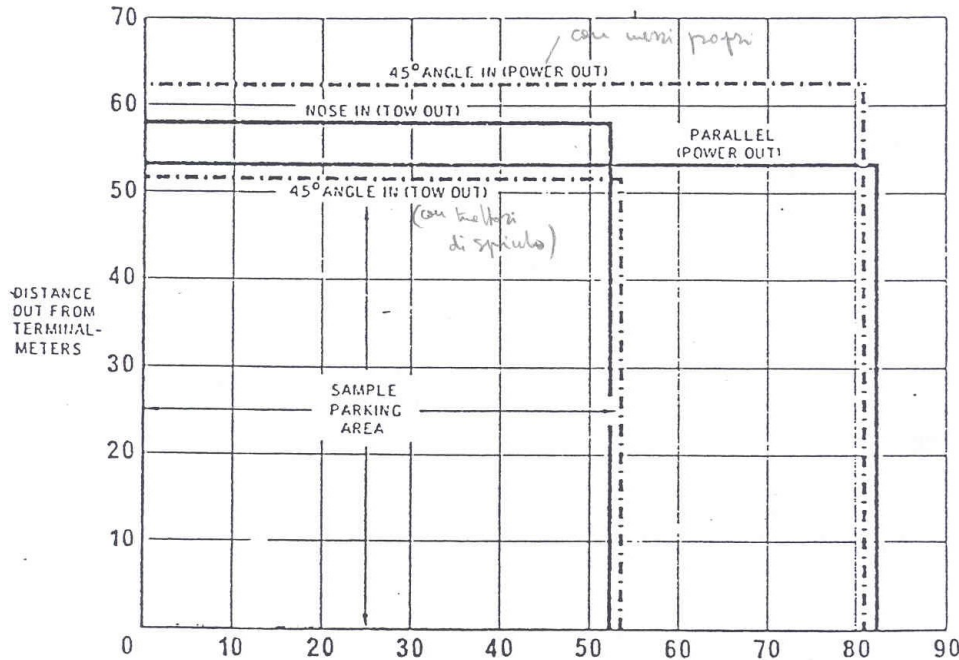


Dimensioni degli stalli e manovre (1)



| EFFECTIVE TURN ANGLE | X | Y | A | R3 | R4 | R5 | R6 |
|----------------------|-------|-------|--------|-------|--------|-------|--------|
| 63° 64' | 1.35 | 33.11 | 122.26 | 69.71 | 109.27 | 89.29 | 111.15 |
| | 18.70 | 10.09 | 37.26 | 21.25 | 33.31 | 27.21 | 33.88 |

ed i diagrammi dei minimi spazi richiesti:
(ad es. per il AB 300)~



| Aircraft Group | Push-out (ft., in.) ^f | | Area (mq) | Taxi-out (ft., in.) | | Area (mq) |
|----------------|----------------------------------|----------------|-----------|---------------------|----------------|-----------|
| | L ^d | W ^d | | L ^d | W ^d | |
| A | | | | | | |
| FH-227 | 103,1 | 115,2 | 1206 | 148,10 | 140,2 | 2119 |
| YS-11B | 106,3 | 124,11 | 1347 | 171,0 | 149,11 | 2606 |
| BAC-111 | 123,6 | 113,6 | 1423 | 130,0 | 138,6 | 1829 |
| DC-9-10 | 134,5 | 109,5 | 1494 | 149,2 | 134,5 | 2037 |
| B | | | | | | |
| DC-9-21,30 | 149,4 | 113,4 | 1719 | 149,0 | 138,4 | 2093 |
| 727 (all) | 173,2 | 128,0 | 2252 | 194,0 | 153,0 | 3015 |
| 737 (all) | 120,0 | 113,0 | 1378 | 145,4 | 138,0 | 2037 |
| C | | | | | | |
| B-707 (all) | 172,11 | 165,9 | 2915 | 258,0 | 190,9 | 4999 |
| B-720 | 156,9 | 150,10 | 2402 | 228,0 | 175,10 | 4072 |
| DC-8-43,51 | 170,9 | 162,5 | 2817 | 211,10 | 187,5 | 4033 |
| D | | | | | | |
| DC-8-61,63 | 207,5 | 168,5 | 3549 | 252,4 | 193,5 | 4958 |
| E | | | | | | |
| L-1011 | 188,8 | 175,4 | 3361 | 263,6 | 200,4 | 5362 |
| DC-10 | 192,3 | 185,4 | 3620 | 291,0 | 210,4 | 6218 |
| F | | | | | | |
| B-747 | 241,10 | 215,8 | 5298 | 328,0 | 240,8 | 8020 |

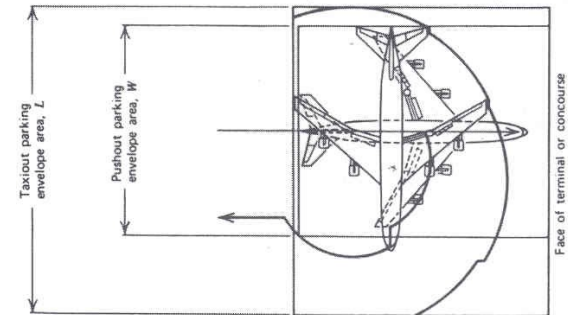
^fIncluding clearances of 20 ft wing tip to wing tip; nose to building: 30 ft, groups A and B; 20 ft, groups C and D; 10 ft, groups E and F.

^gIncluding clearances of 20 ft to other aircraft and GSE, 45 ft.

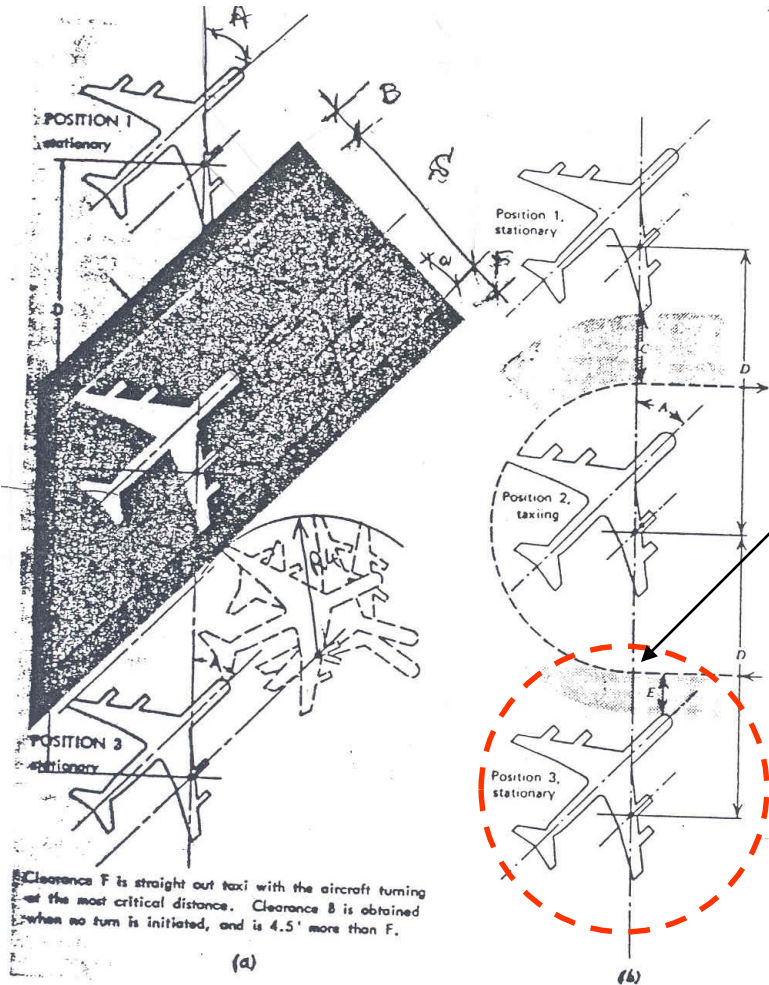
^h1 ft = 0.3048 m.

^dLength and width are based on the largest dimension in the group of aircraft.

Source: *The Apron and Terminal Building Planning Report*, prepared for the FAA by Ralph M. Parsons Company, Report FAA-RD-75-191, July 1975 (rev. March 1976); and *Planning and Design Guidelines For Airport Terminal Facilities*, FAA Advisory Circular AC 150/5360-13, April 22, 1988.



Dimensioni degli stalli e manovre (2)

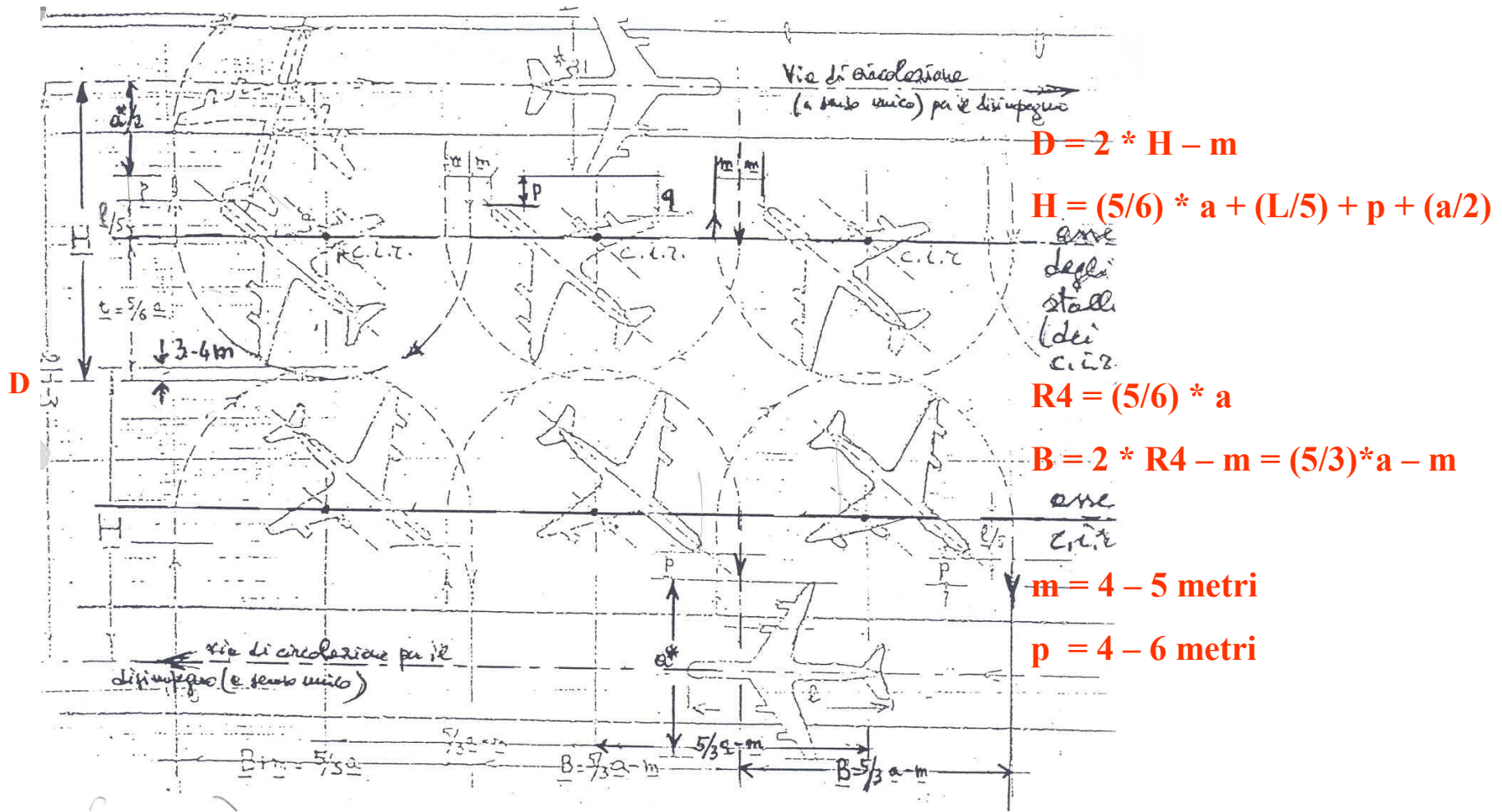


$$B = D * \text{sen}(A) - S$$

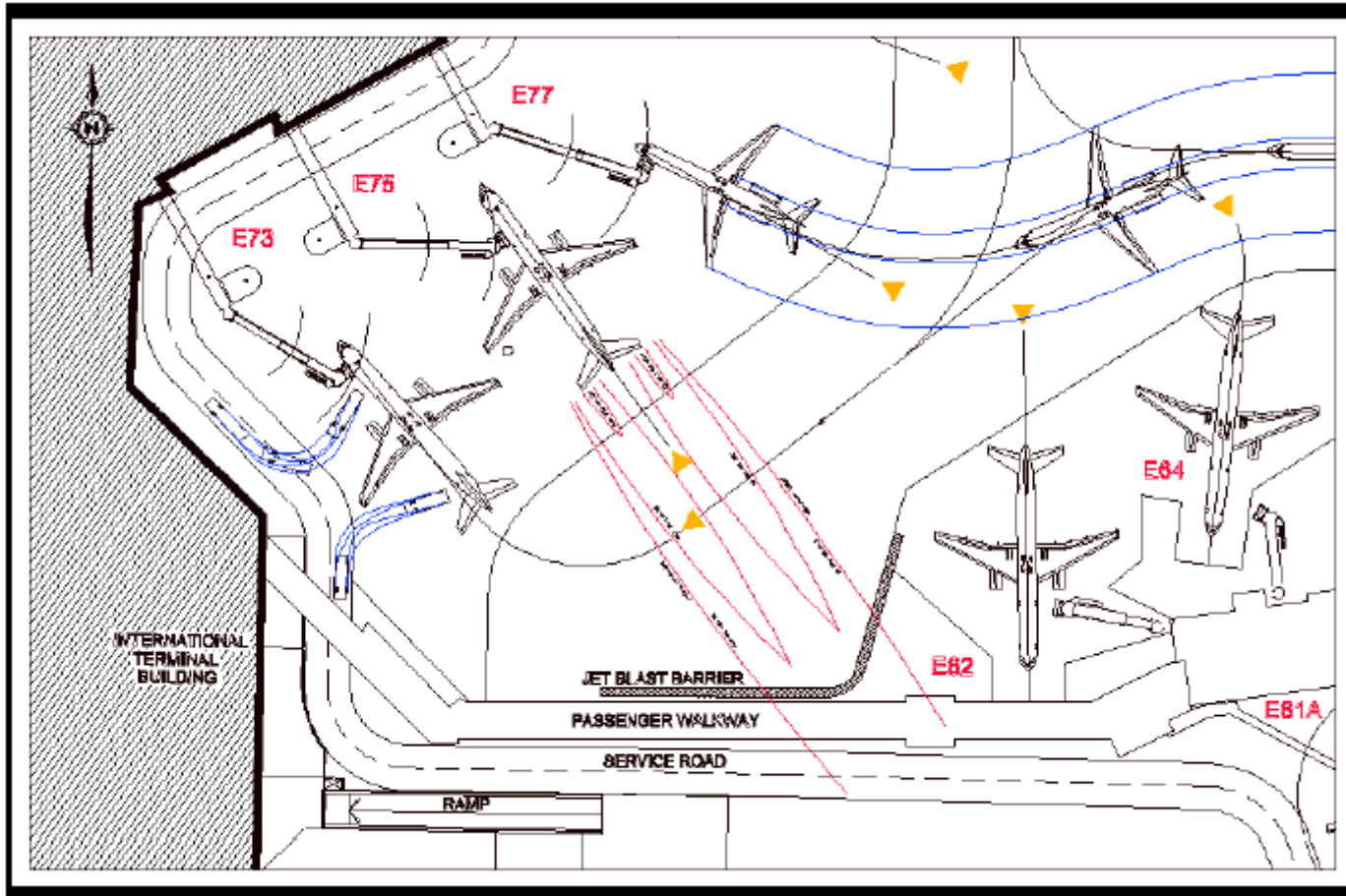
$$F = D * \text{sen}(A) - (a + R)$$

$$m = 2 * R - D$$

Dimensioni degli stalli e manovre (3)



Analisi dinamica negli apron



Approfondimenti e Riflessioni



“Un esperto è uno che conosce alcuni dei peggiori errori che può compiere nel suo campo, e sa come evitarli.”

WERNER KARL HEISENBERG



Le masse saranno sempre al di sotto della media. La maggiore età si abbasserà, la barriera del sesso cadrà, e la democrazia arriverà all'assurdo rimettendo la decisione intorno alle cose più grandi ai più incapaci. Sarà la punizione del suo principio astratto dell'uguaglianza, che dispensa l'ignorante di istruirsi, l'imbecille di giudicarsi, il bambino di essere uomo e il delinquente di correggersi. Il diritto pubblico fondato sulla uguaglianza andrà in pezzi a causa delle sue conseguenze. Perché non riconosce la disuguaglianza di valore, di merito, di esperienza, cioè la fatica individuale: culminerà nel trionfo della feccia e dell'appiattimento. L'adorazione delle apparenze si paga. »

Henri-Frédéric Amiel, “Frammenti di diario intimo”, 12 giugno 1871

