Politecnico di Torino

Progettazione di veicoli aerospaziali (AA-LZ)

E2. Conceptual Design of hybrid-electric aircraft

14. TLARs & AVL

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TLARs

Common TLARs

- **BFL:** 1100 m
- **Cruise Mach:** 0.40
- **Cruise altitude:** 20000 ft
- **Maximum wingspan:** 36 m

*H = prime tre cifre della matricola**
L = ultime tre cifre della matricola

**se H<319 allora inserire H=319*

Specific TLARs

- **n° passengers**

$$30+\frac{15\ L}{999}$$

- **Range [nm]**

$$300+\frac{300(H-319)}{43}$$

- **BED [Wh/kg]**

$$400+\frac{200\ L}{999}$$

TLARs

Common TLARs

- **BFL:** 1100 m
- **Cruise Mach:** 0.40
- **Cruise altitude:** 20000 ft
- **Maximum wingspan:** 36 m

Informazioni aggiuntive:

k_c = 6.614e-08 kg/J *(power specific fuel consumption)*

Range **crociera** standard = Range missione - 144 nm
Range **crociera** diversione = 120 nm

EMPD = 16 kW/kg *(electric motor power density)*

Specific TLARs

- **n° passengers**

$$30+\frac{15\ L}{999}$$

- **Range [nm]**

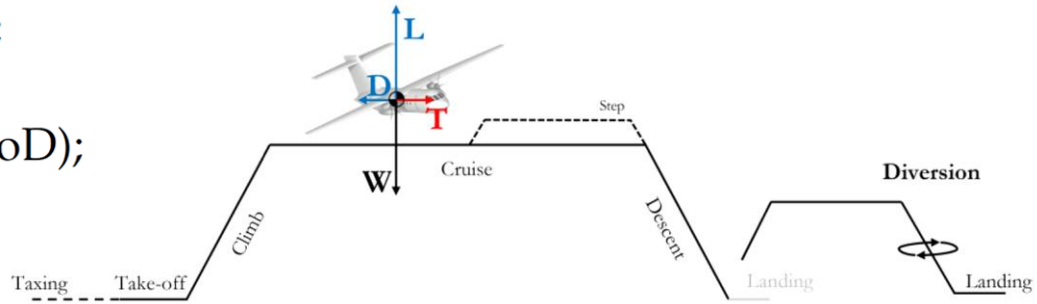
$$300+\frac{300(H-319)}{43}$$

- **BED [Wh/kg]**

$$400+\frac{200\ L}{999}$$

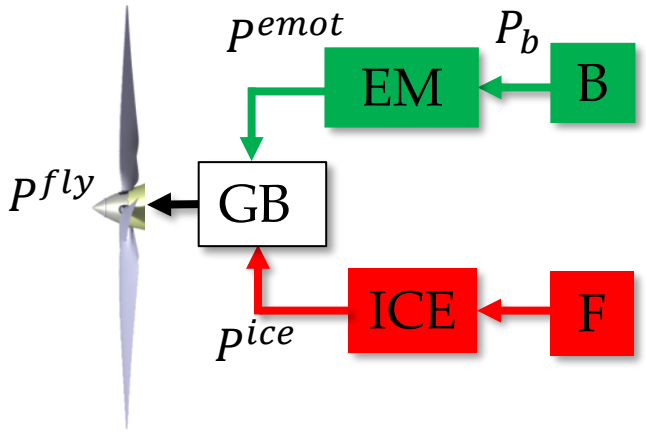
Analisi di missione: programmi di volo

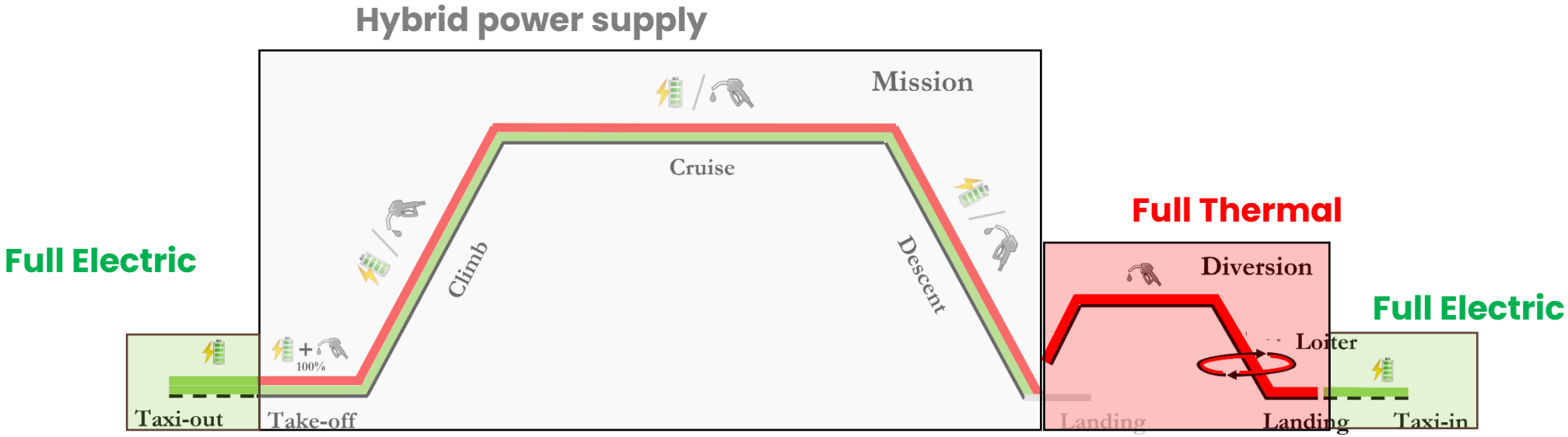
- Taxi-out: ground manoeuvring with constant power supply for 240 s;
- Take-off: full-power supply for 45 s;
- Climb: constant indicated air speed (IAS) and rate of climb (RoC);
- Cruise: constant speed and altitude;
- Descent: constant indicated air speed (IAS) and rate of descent (RoD);
- Loiter: 30 min of level flight at maximum L/D;
- Approach: constant RoD;
- Landing: neglected;
- Taxi-in: ground manoeuvring with constant power supply for 240 s.



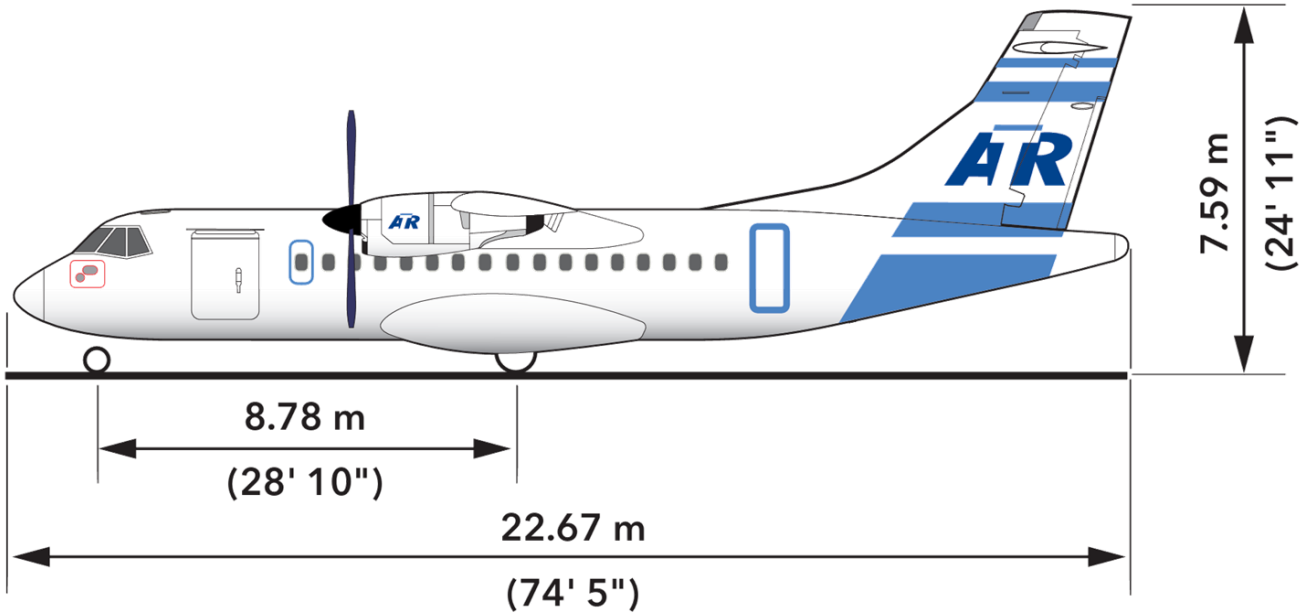
	Mission		Diversion	
Climb	IAS = 170 kt	RoC = 900 ft/min	IAS = 150 kt	RoC = 600 ft/min
Cruise	Mach = 0.4	h = 6100 m	Mach = 0.27	h = 3050 m
Descent	IAS = 220 kt	RoD = −1100ft/min	IAS = 150 kt	RoD = −1100ft/min

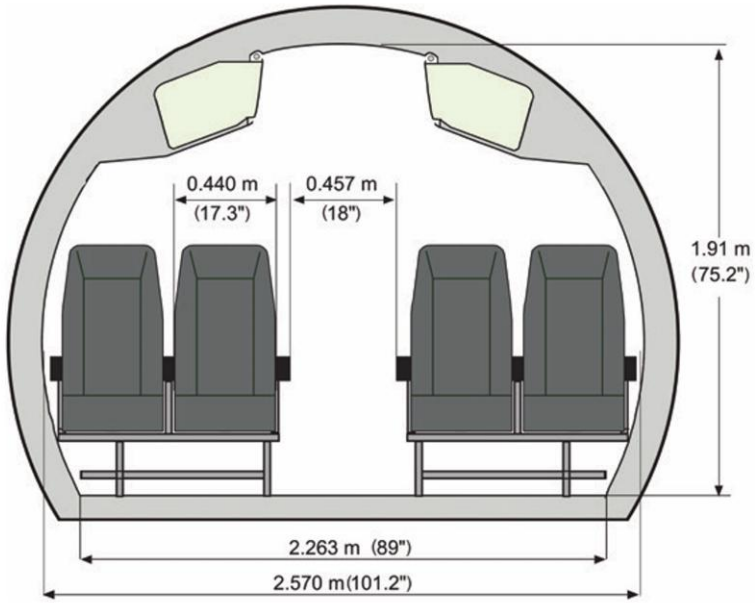
Overview


P^{emot}
P_b
EM
B
P^{fly}
GB
ICE
F
P^{ice}

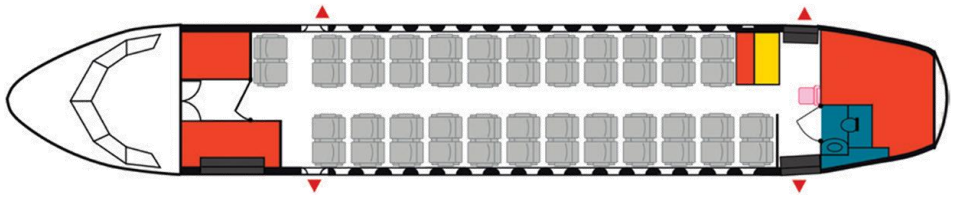

Hybrid power supply
Mission
Cruise
Climb
Descent
Full Electric
Full Thermal
Full Electric
Diversion
Loiter
100%
Taxi-out
Take-off
Landing
Landing
Taxi-in

TLARs: fuselage update





48 pax at 30″ pitch



Attendant seat Galley Toilet Baggage Emergency Exits

Parametric HE design

Design Variables Medium-Range Conventional Aircraft:

$\mathbf{(W/S)_{vect}}$ = [500 … … 700] kg/m²

$\mathbf{M_{vect}}$ = [0.76 … … 0.82]

$\mathbf{(t/c)_{vect}}$ = [0.10 … … 0.14]

$\mathbf{AR_{vect}}$ = [7 … … 11]

$\boldsymbol{\lambda_{vect}}$ = [0.25 … … 0.35]

$\boldsymbol{\Lambda_{vect}}$ = [20 … … 35] deg

Parametric HE design

Design Variables Regional Hybrid-Electric Aircraft:

$(W/S)_{vect}$ = [500 … … 700] kg/m²

M_{vect} = [0.76 … … 0.82]

$(t/c)_{vect}$ [… … 0.14]

AR_{vect} [… … 11]

λ_{vect} = [0.25 … … 0.35]

Λ_{vect} = [20 … … 35] deg

X

New set of DVs!

Parametric HE design

Design Variables Regional Hybrid-Electric Aircraft (**example**):

$\mathbf{(w/s)_{vect}}$ = [250 300 350] kg/m^2

$\mathbf{H_{P\ vect}}$ = [0.1 0.2 0.3 0.4]

$\mathbf{\Phi^{ice}_{cl\ vect}}$ = [0.10 0.30 0.50]

$\mathbf{\Phi^{ice}_{cr\ vect}}$ = [0.10 0.20 0.30 0.40 0.50]

$\mathbf{\Phi^{ice}_{de\ vect}}$ = [0.10 0.30]

New set of DVs!

Parametric HE design

Design Variables Regional Hybrid-Electric Aircraft:

$\mathbf{(w/s)_{vect}}$ = [250 300 350] kg/m²

$\mathbf{H_{P\ vect}}$ = [0.1 0.2 0.3 0.4]

$\mathbf{\Phi^{ice}_{cl\ vect}}$ = [0.10 0.30 0.50]

$\mathbf{\Phi^{ice}_{cr\ vect}}$ = [0.10 0.20 0.30 0.40 0.50]

$\mathbf{\Phi^{ice}_{de\ vect}}$ = [0.10 0.30]

New set of DVs!

Parametric HE design

Summary of the set of configurations designed

Geometry						Weights						Performance						FoMs					
x_1	x_2	x_3	…	…	x_n	w_1	w_2	w_3	…	…	w_n	y_1	y_2	y_3	…	…	y_n	f_1	f_2	f_3	…	…	f_n
x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	[illegible]	[illegible]	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	[illegible]	[illegible]	[illegible]	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
…	…	…	…	…	…	…	…	…	…	…	…	…	…	[illegible]	[illegible]	[illegible]	[illegible]	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	…	…	…	…	…	…	…	…	…	…
x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
x.xx	x.xx	x.xx	x.xx	x.xx	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
x.xx	x.xx	x.xx	x.xx	x.xx	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
x.xx	x.xx	x.xx	x.xx	x.xx	[illegible]	[illegible]	[illegible]	[illegible]	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
…	…	…	…	…	[illegible]	[illegible]	[illegible]	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	[illegible]	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx

Configuration selected!!
How to read results..?

Part III: AVL (live demo)

Upgrade aerodynamic evaluations

A focus on potential aerodynamic solvers

Live demo: An example of utilization of Vortex Lattice Method AVL

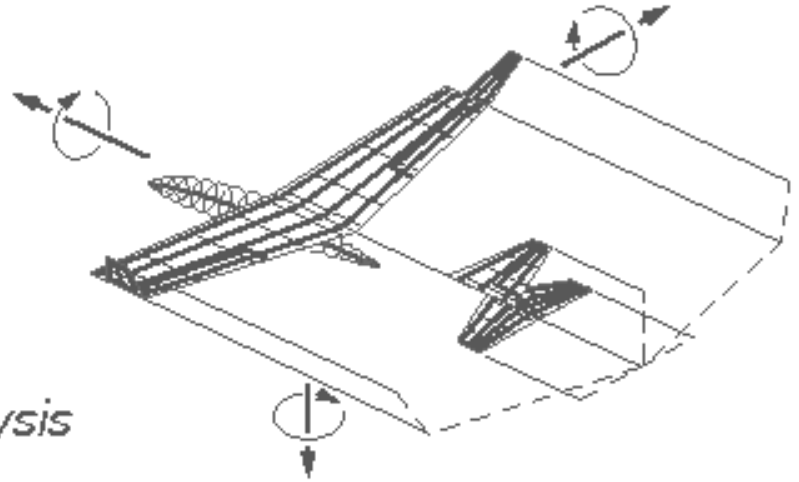
AVL

Aerodynamic Analysis

Trim Calculation

Dynamic Stability Analysis

Aircraft Configuration Development



https://web.mit.edu/drela/Public/web/avl/

Input file

General parameters and settings

```
!*************************************
!AVL dataset for NOME FILE
!*************************************
velivolo.avl     ! Titolo
!-------------------------------------------------------------
!-------------------------------------------------------------
0                ! Mach   {n° di mach del flusso imperturbato}
!-------------------------------------------------------------
!-------------------------------------------------------------
0 0 0            ! IYsym   IZsym   Zsym  {simmetria}
!-------------------------------------------------------------
!-------------------------------------------------------------
7.20e+01 3.50e+00 2.80e+01    ! Sref    Cref    Bref
#
11.50  0 2.35 ! Xref    Yref    Zref  {Polo momenti}
!-------------------------------------------------------------
!-------------------------------------------------------------
```

Input file

General lifting surface definition

```
#*****************************************
#*****************************************
#      DEFINIZIONE ALA [1]
#*****************************************
#*****************************************
SURFACE       ! comando di creazione nuova superficie
ala           ! nome univoco della surface
8 2           ! n° pannelli in corda    tipo di distribuzione
YDUPLICATE    ! comando 'specchio' rispetto ad y
0             ! coordinata y per YDUPLICATE
#
ANGLE        ! comando angolo di calettamento SURFACE
0             ! valore del calettamento
```

Input file

General lifting surface definition

```
#*****************************************
#*****************************************
#       DEFINIZIONE ALA [1]
#*****************************************
#*****************************************
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```
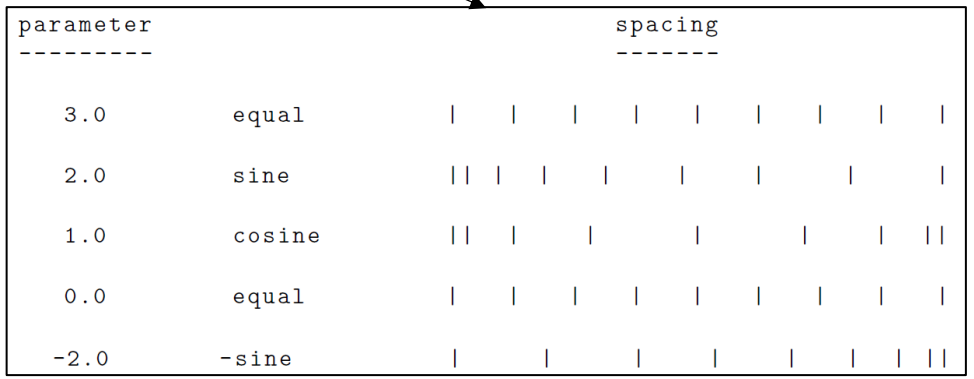
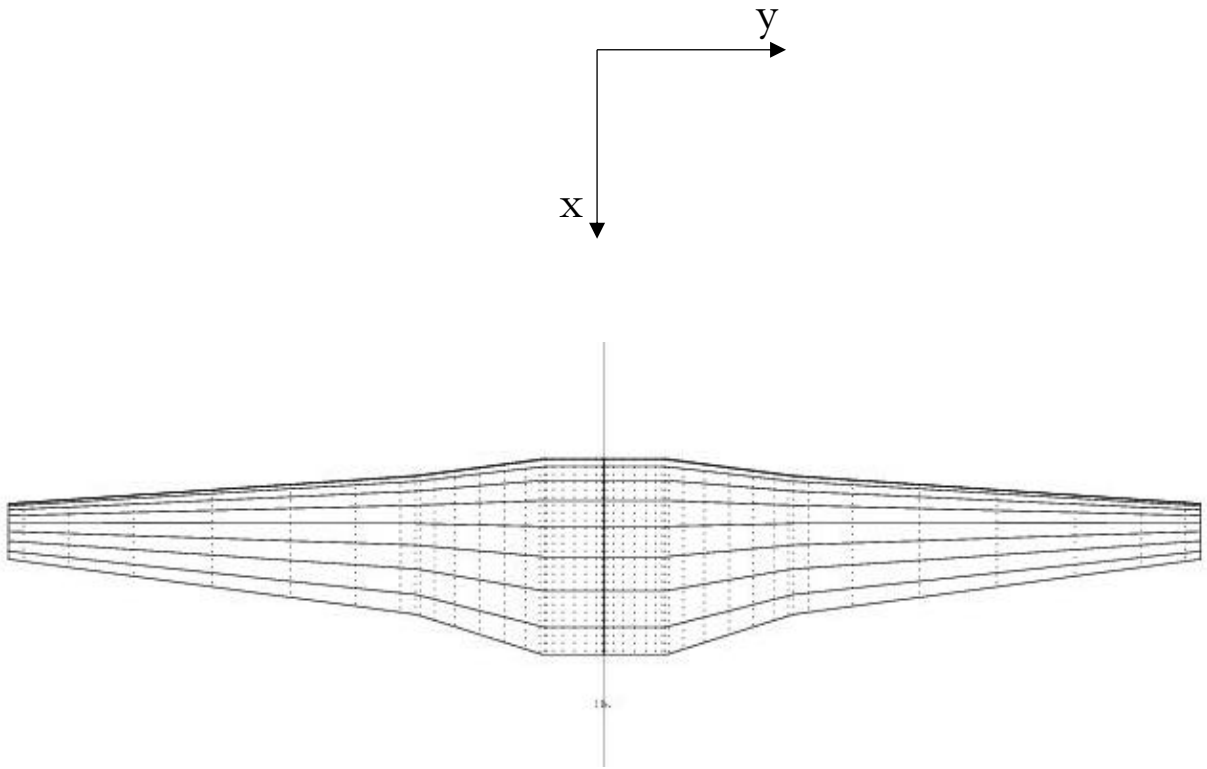



Input file

Definition of the sections of the lifting surfaces

```
!-------------------------------------------------------------
SECTION      ! comando di creazione nuova sezione
# Xle      Yle      Zle       Chord    Ainc Nspanwise Space
9.12e+00    0     3.125    4.71e+00     0       8        1
AFILE        ! comando di assegnazione coordinate profilo
43018.dat    ! nome file dat coordinate profilo
!-------------------------------------------------------------
!-------------------------------------------------------------
SECTION
# Xle      Yle      Zle       Chord    Ainc Nspanwise Space
9.12e+00 1.44e+00 3.125e+00 4.71e+00  3.90     8        1
AFILE
43018.dat
!-------------------------------------------------------------
!-------------------------------------------------------------
SECTION
# Xle      Yle      Zle       Chord    Ainc Nspanwise Space
9.53e+00 4.53e+00 3.125e+00 3.32e+00   3.9     8        1
AFILE
43018.dat
!-------------------------------------------------------------
!-------------------------------------------------------------
SECTION
# Xle      Yle      Zle       Chord    Ainc Nspanwise Space
1.02e+01 1.43e+01 3.125e+00 1.33e+00  9e-01    8        1
AFILE
43018.dat
!-------------------------------------------------------------
```



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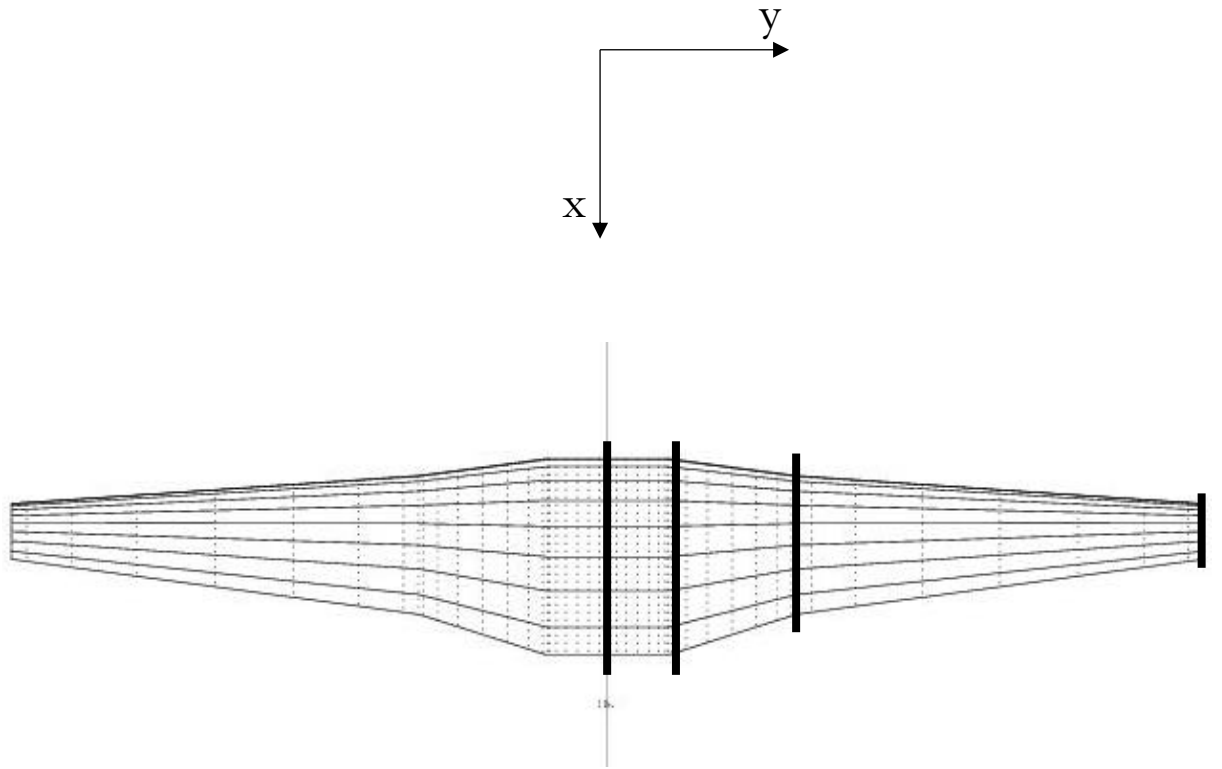

Input file

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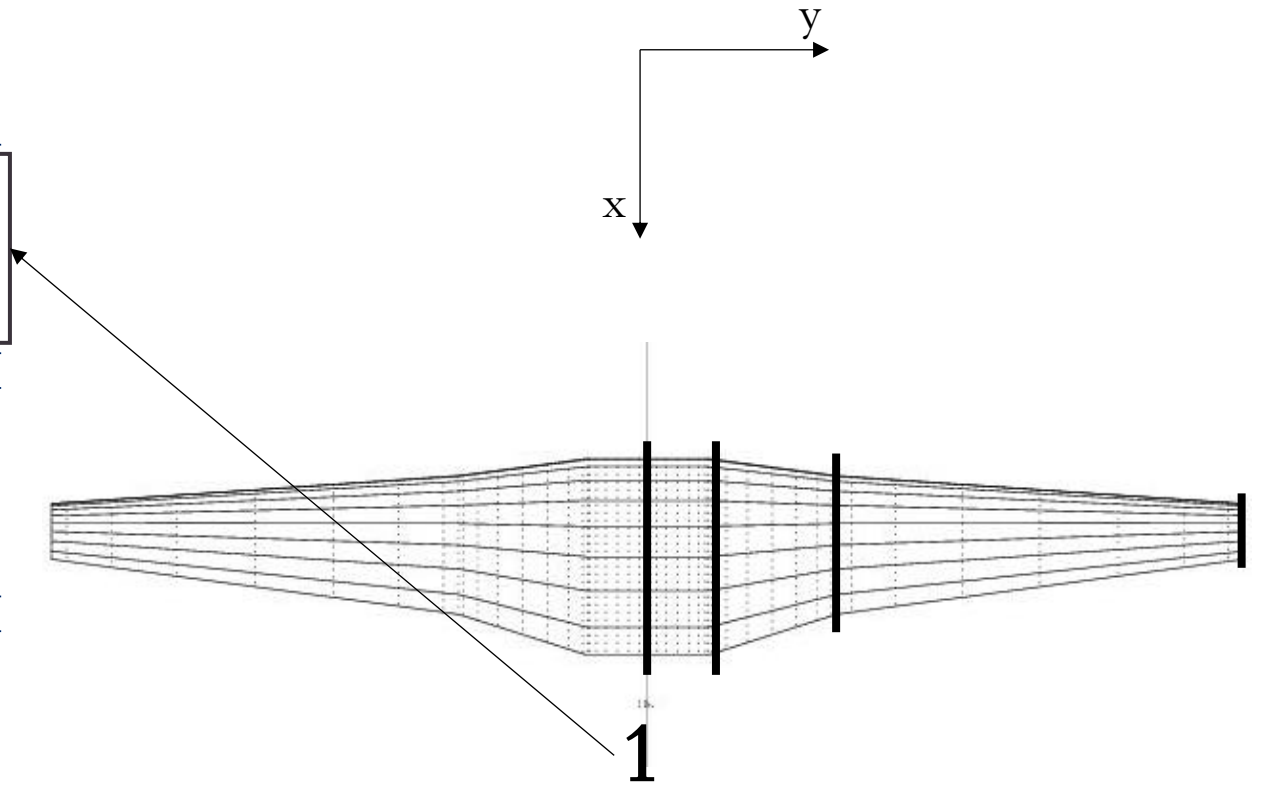

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AFILE
43018.dat
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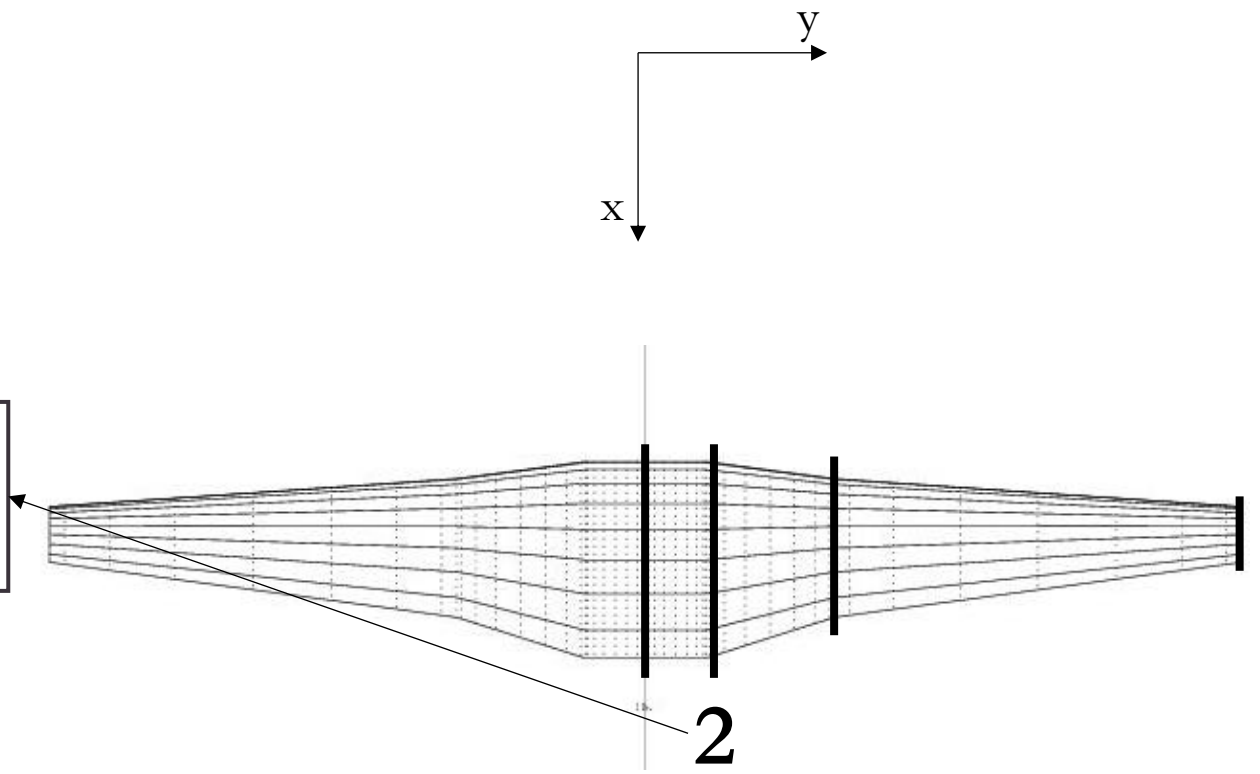

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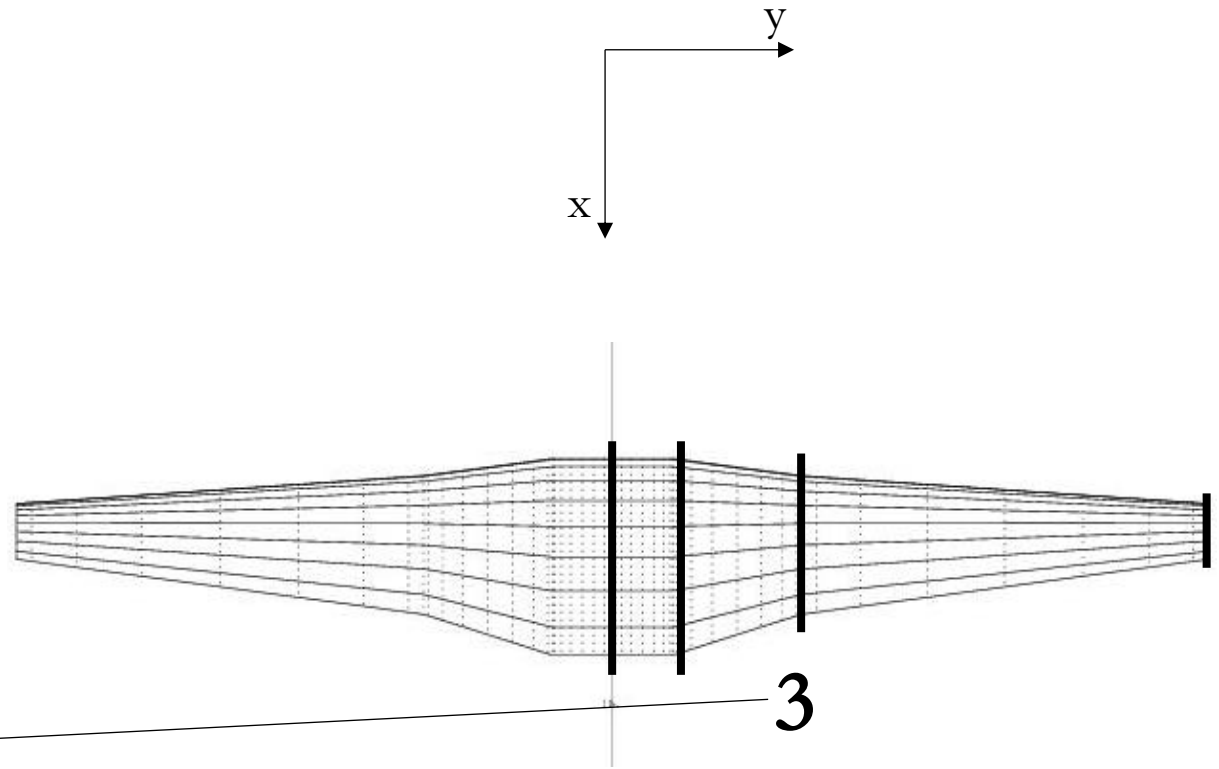

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AFILE
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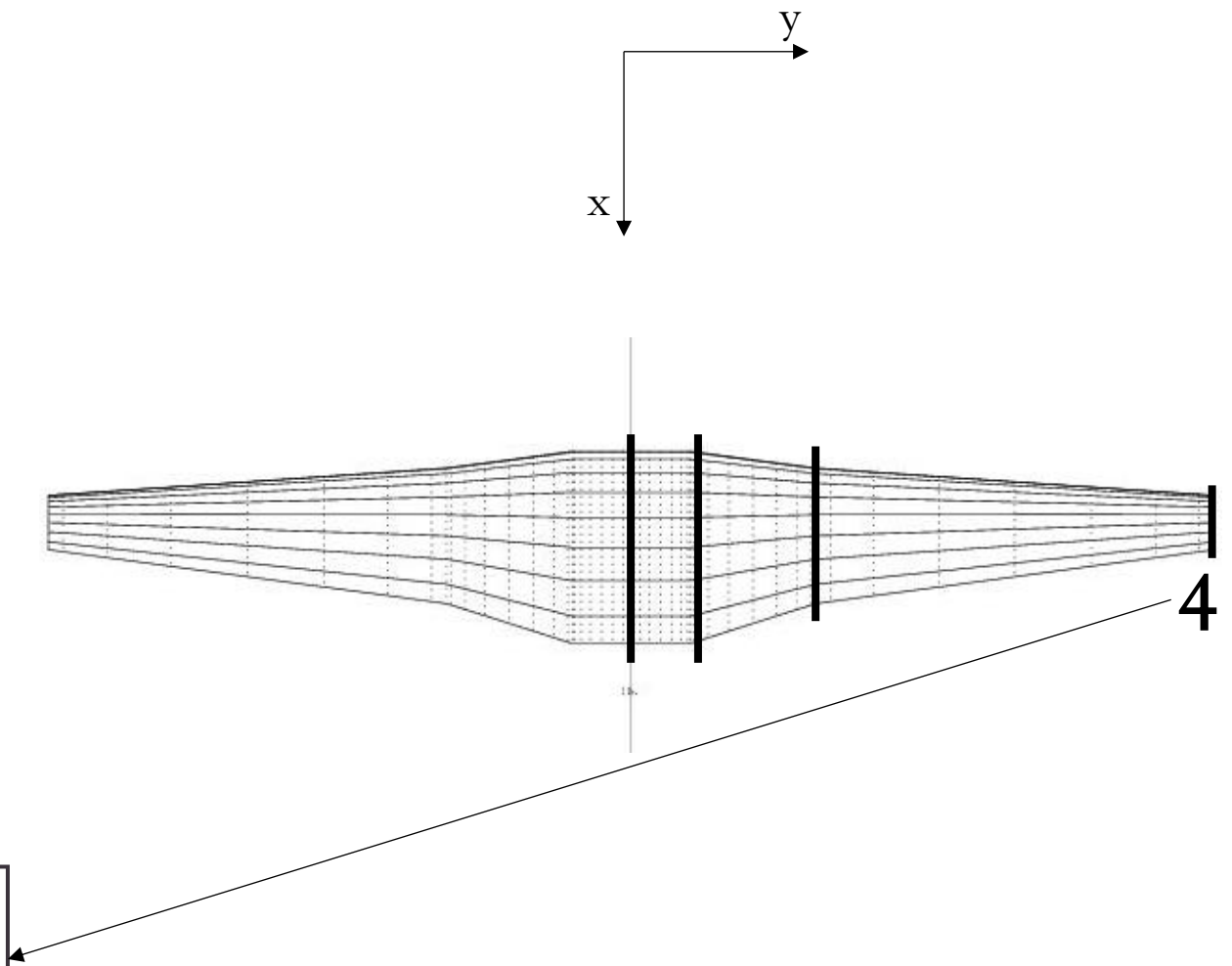

Basic controls

Load: loads input file

Oper: set operating case

G: plot geometry

A: set alpha

D_n: set n-deflection

X: execute operating case

post-processing

O: options

ST: stability derivatives

T: plot Trefftz plane

End