Università di Napoli Federico II

ADAG RESEARCH GROUP www.dpa.unina.it\adag

AIRCRAFT DESIGN RESEARCH AND EDUCATION AT UNIVERSITY OF NAPLES

F. Nicolosi

fabrnico@unina.it

Dipartimento di Ingegneria Aerospaziale (DIAS)
www.dias.unina.it

University of Naples “Federico II“, Naples, Italy

LAYOUT

- RESEARCH ACTIVITIES (Topics)
- TOOLS FOR AIRCRAFT DESIGN
- AIRCRAFT DESIGN IN NAPLES (History and Link with Companies)
- A RECENT EXAMPLE : DESIGN OF A LIGHT TWIN ENGINE AIRCRAFT

University of Naples "Federico II"

Dipartimento Ingegneria AeroSpaziale

Dep. of Aerospace Engineering (DIAS)

- About 40 Professors and Researchers
- About 6-8 Post-Doc
- About 30 PHD students
- Research and teaching activities in :
  - Aerodynamics
  - Aerospace structures
  - Flight Mechanics and Aircraft Design
  - Aerospace Systems (Space Eng.)
  - Propulsion

- ABOUT 2 Millions of € /year of research contracts (from EC and from companies)

=> About 40 Engineers/year employed

University of Naples "Federico II"
Dep. of Aerospace Engineering (DIAS)

Dipartimento Ingegneria Aero Spaziale

ADAG (Aircraft Design and Aeroflightdynamic Group) Research Group

- 4 Professors
- 2 Post-Doc
- 3 PHD students
- About 10 Engineers

ADAG
Aircraft
Design &
AeroFlightDynamic
Group

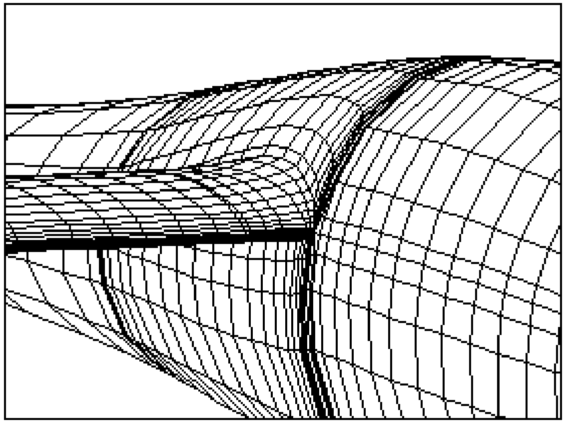
ADAG RESEARCH ACTIVITIES (1)

Light Aircraft Design - RPV Design

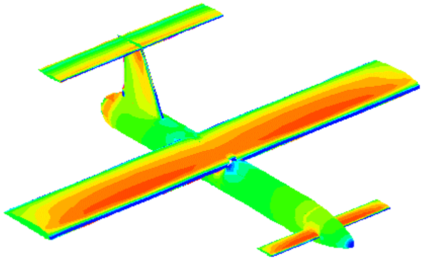
G97

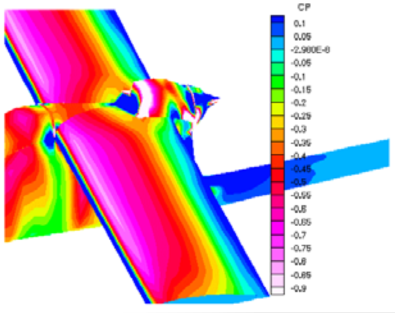
P92-P96

TLS RPV



Wing-fuselage junction design (collaboration with TU Delft, Prof. Boermans)





EASY-FLY , STOL Ultralight in composite

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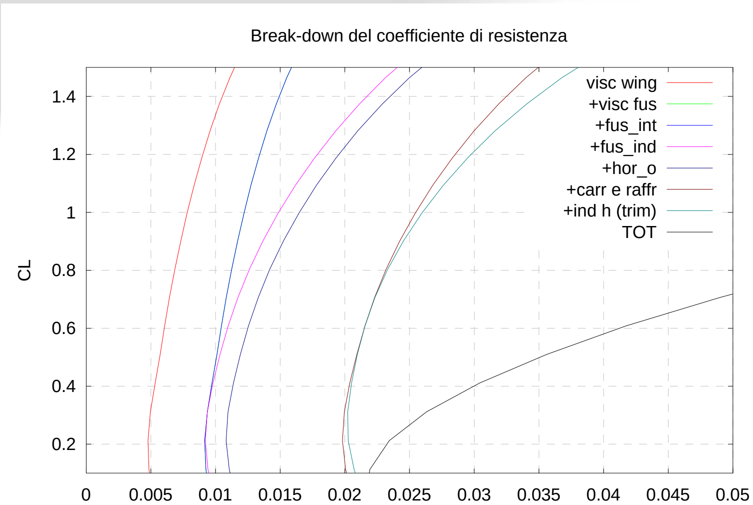
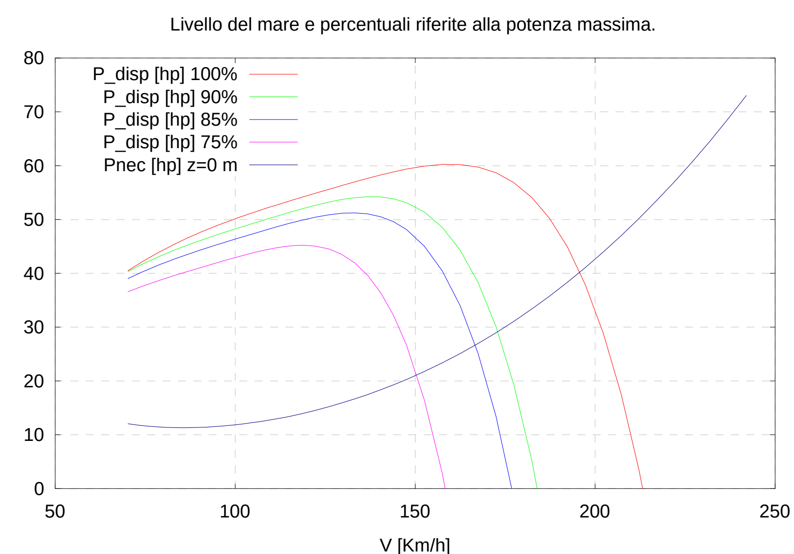
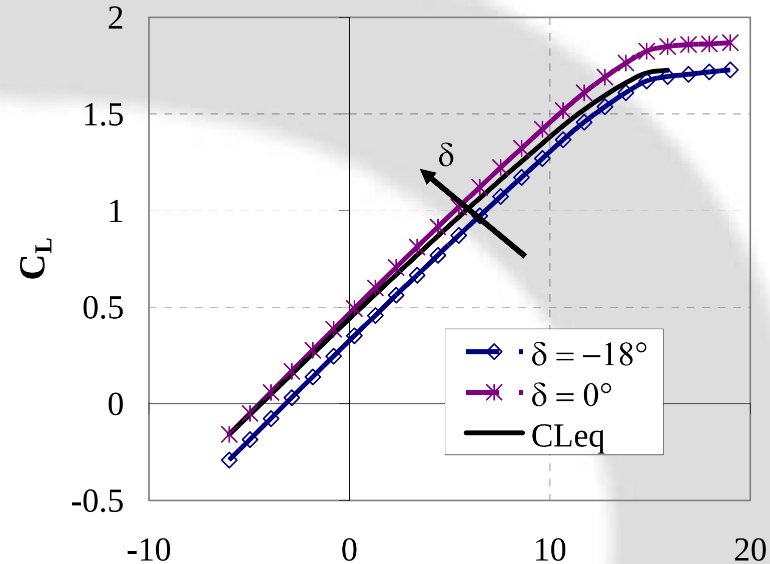
ADAG RESEARCH ACTIVITIES (1)

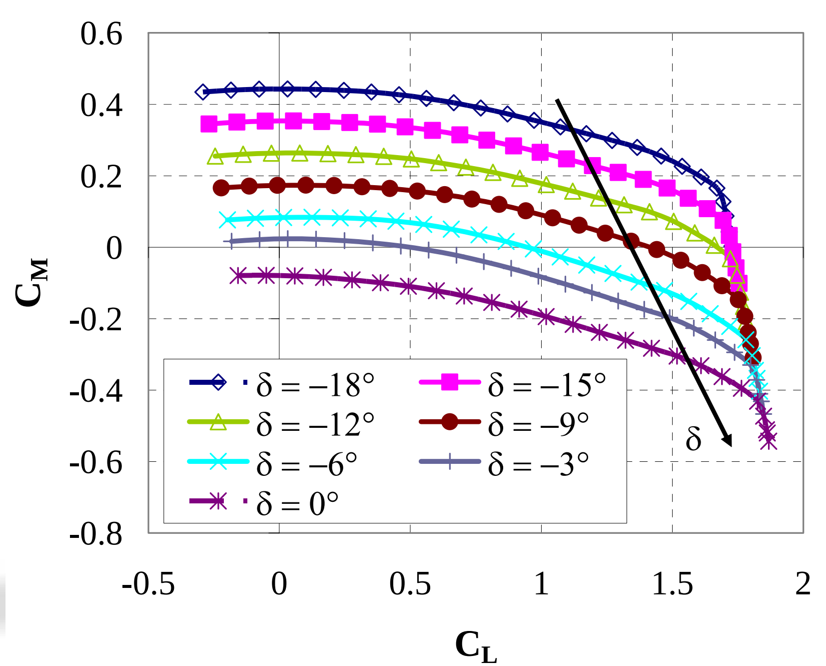
Aircraft Design TOOLS

AEREO CODE





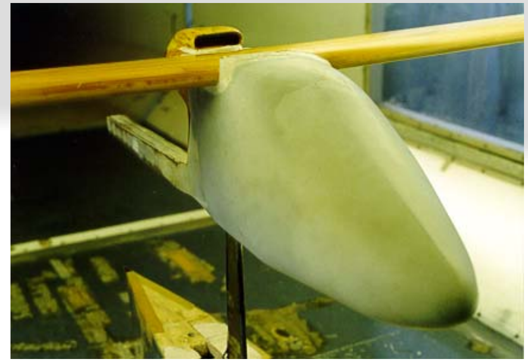


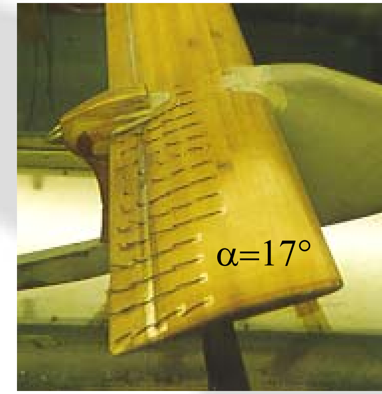


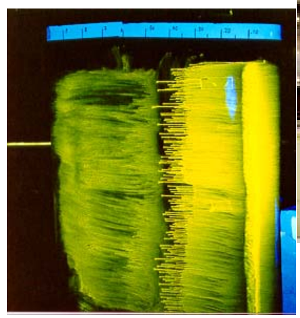
ADAG RESEARCH ACTIVITIES (2)

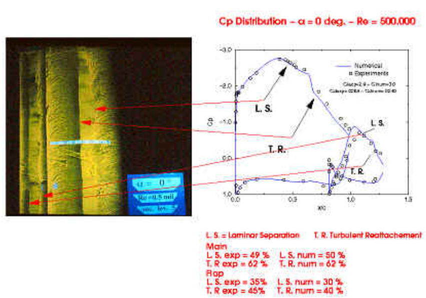
Wind-Tunnel Tests

- 2-D Airfoil Tests
- 3-D aircraft model
- 3-D semi-model





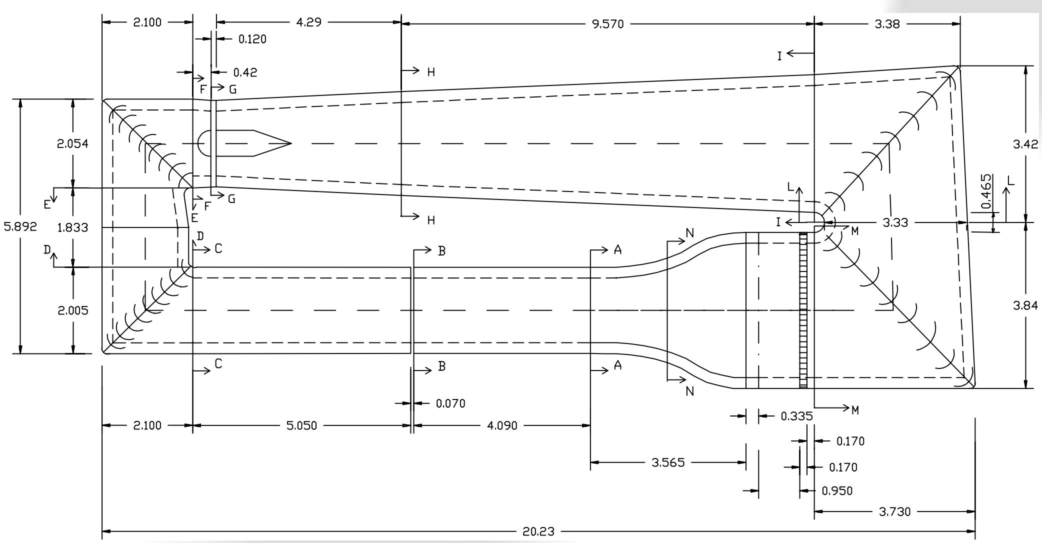




WIND-TUNNEL TESTS

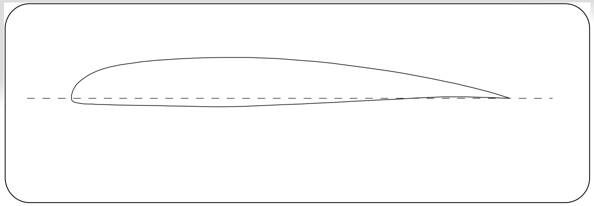
- **MAIN LOW-SPEED DPA WIND TUNNEL**

Test section dimensions	**2.0 m x 1.4 m**
Maximum speed	**150 Km/h**
Turbulence level	**0.1%**



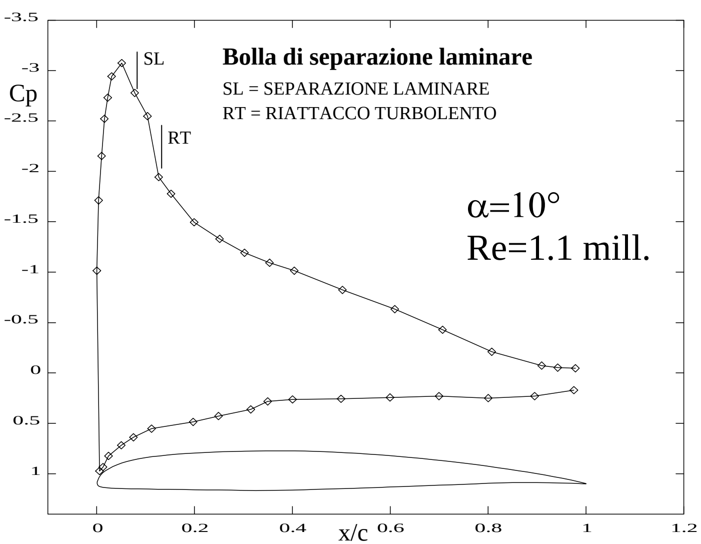
WIND-TUNNEL TESTS

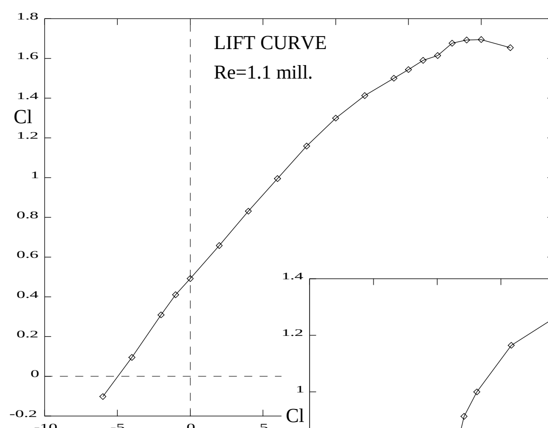
AIRFOIL TESTS

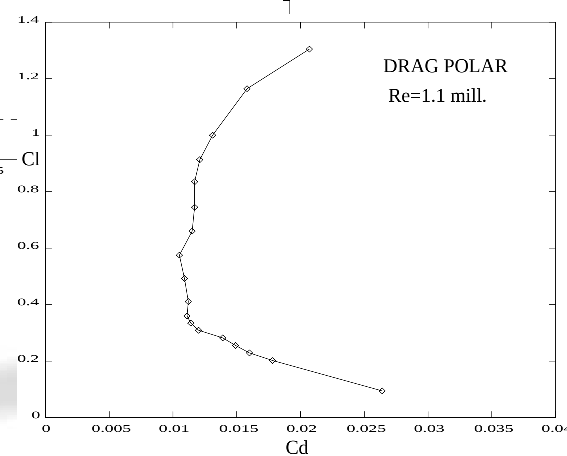


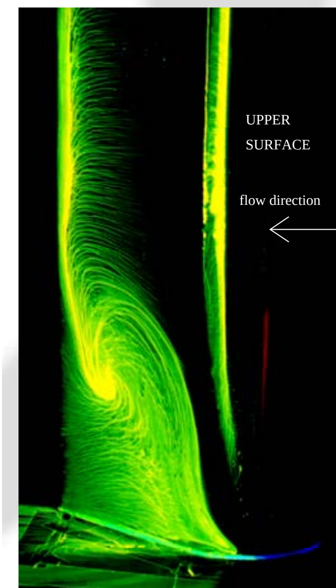
More than 20 airfoil tested since 1990

- **NACA, SM701, internally developed airfoils**
- **Multi-component airfoil tests**







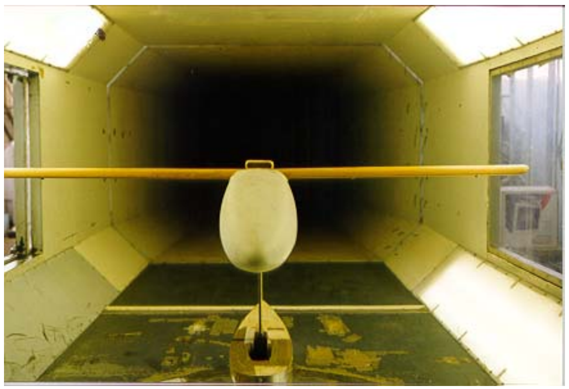


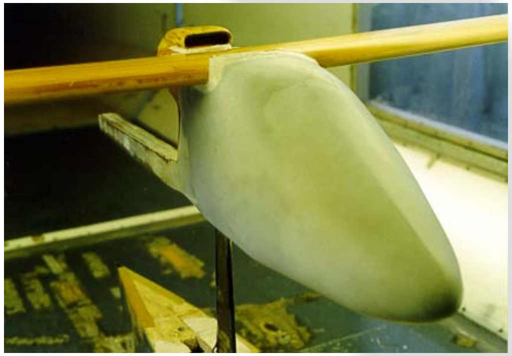
WIND-TUNNEL TESTS

AIRCRAFT 3D MODEL WIND-TUNNEL TESTS

- Scale of about 1:5 for a light aircraft (Re ~ 0.5 mil.)

➢ More than 20 aircraft (mainly G.A., light and ULM) tested in the last 15 years





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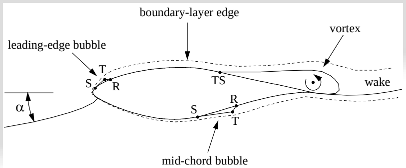
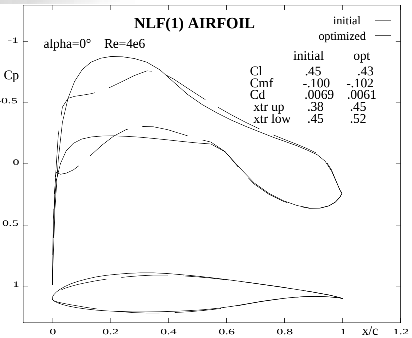
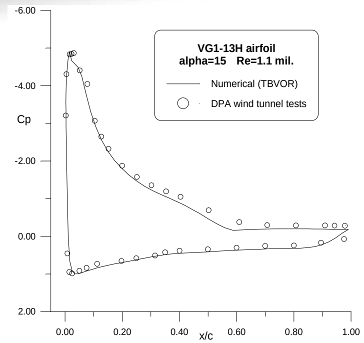
ADAG RESEARCH ACTIVITIES (3)

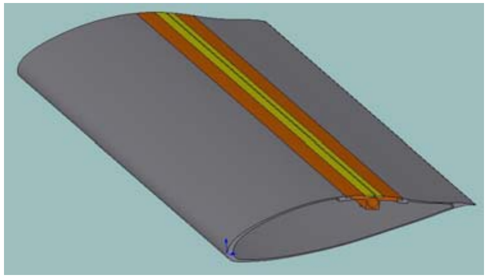
Aerodynamic Design / Analysis (num. & experim)

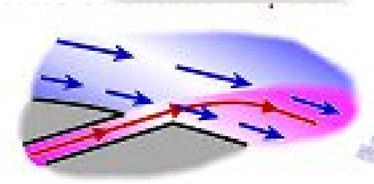




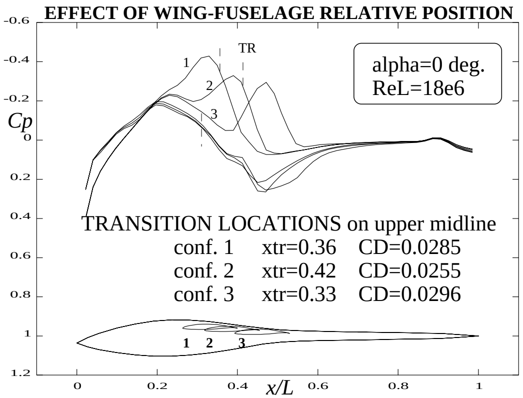


Airfoil analysis, design and optimization

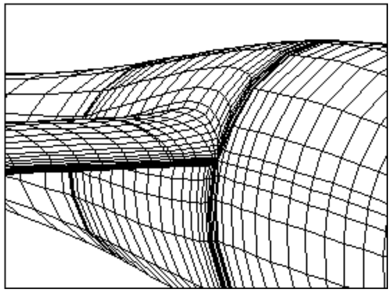




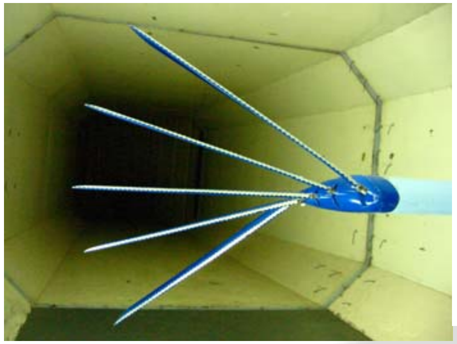
Aircraft efficiency emprovement through b.l. unsteady blowing(num. & exp.)

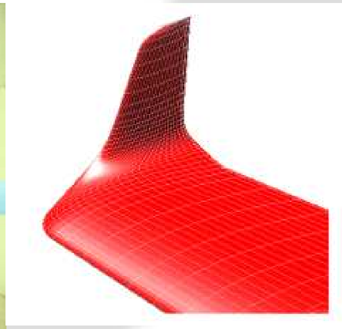


Fuselage analysis and design



Wing-fuselage junction





Wing-tip and winglet design

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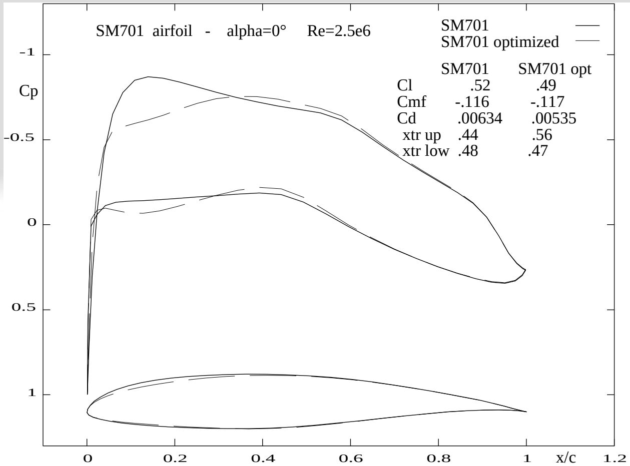
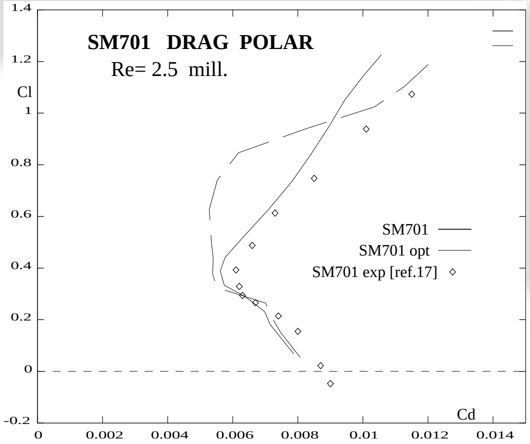
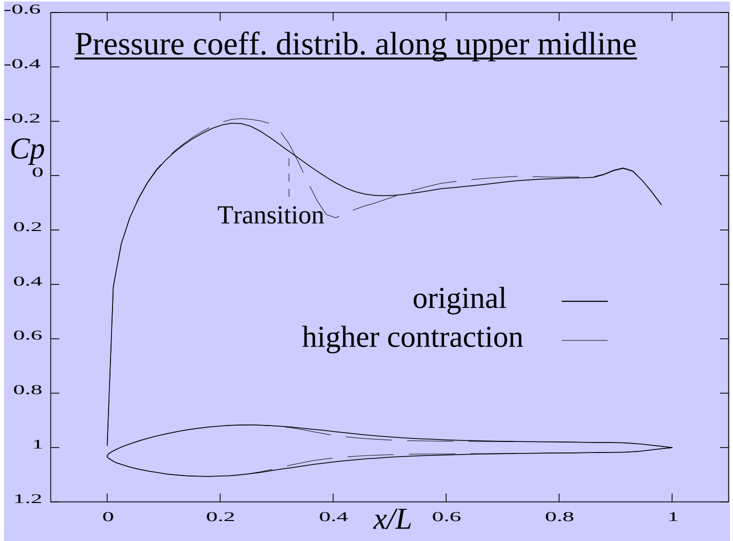
AERODYNAMIC DESIGN

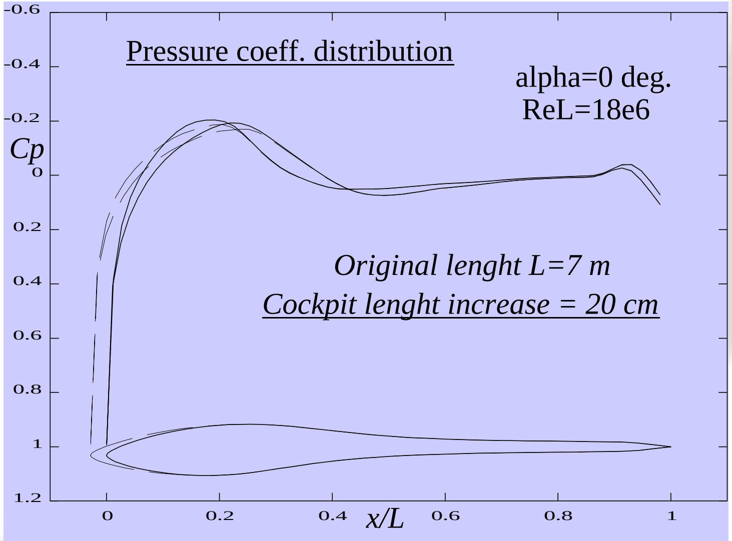
AIRFOIL DESIGN AND OPTIMIZATION





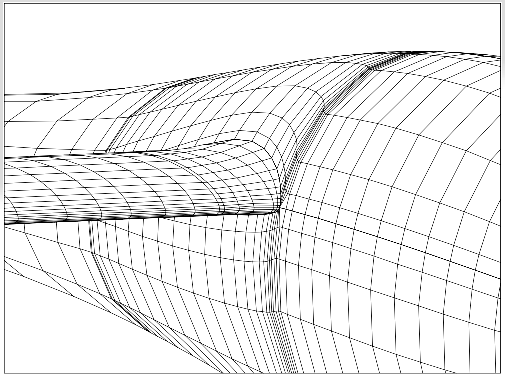
FUSELAGES AND LOW DRAG BODIES DESIGN



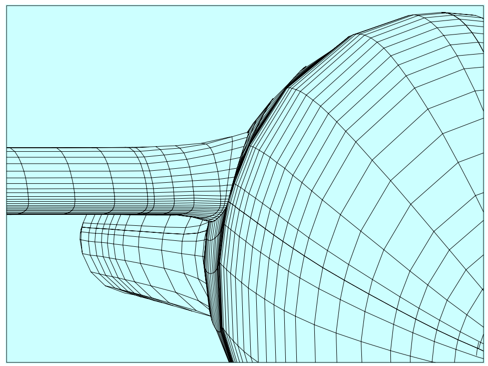


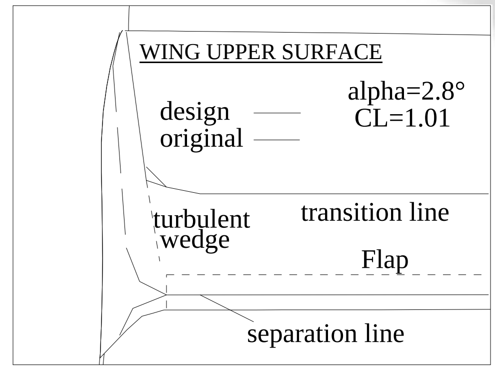
AERODYNAMIC DESIGN

WING-FUSELAGE JUNCTION DESIGN

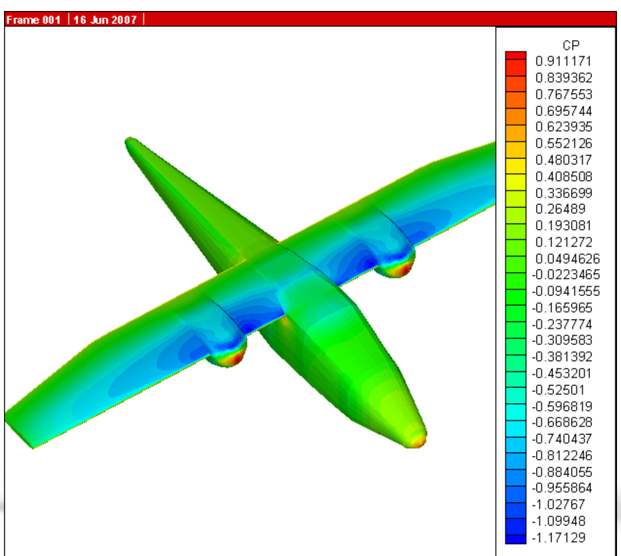


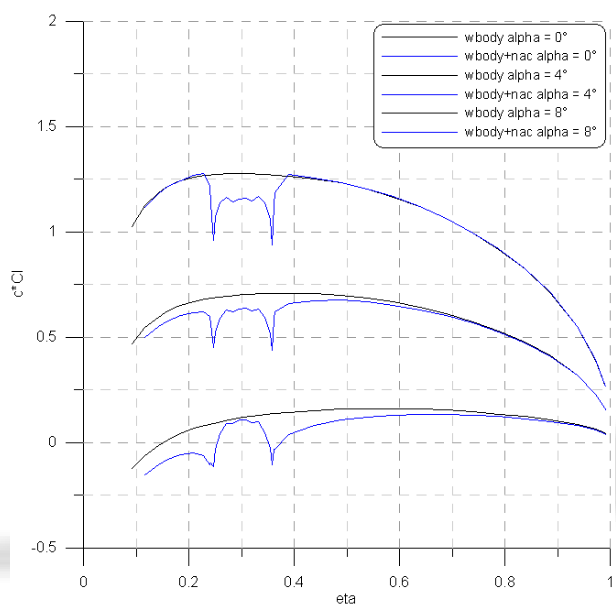
Design of wing-fuselage junction for Antares Sailplane (@ TU Delft with Prof. L. Boermans)

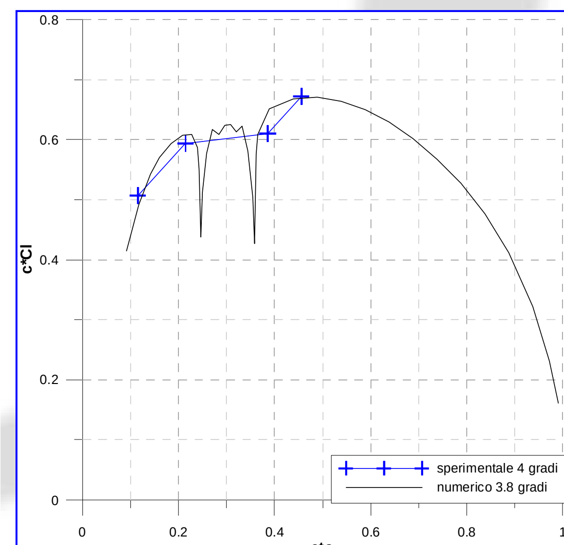




FUSELAGE AND NACELLE INFLUENCE ON WING SPAN-LOADING







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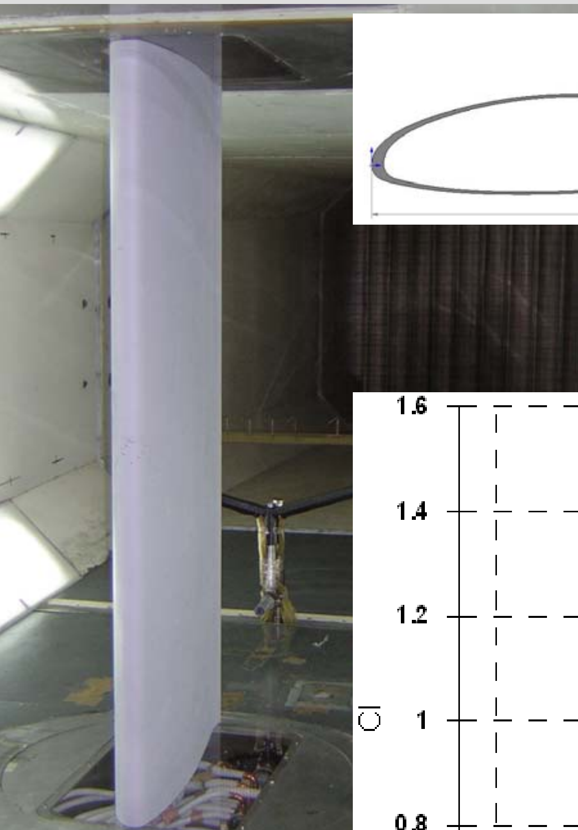
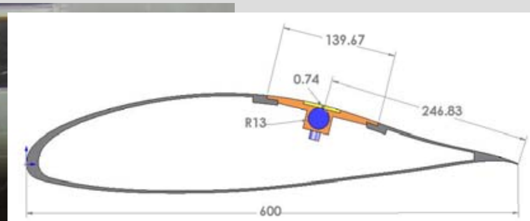
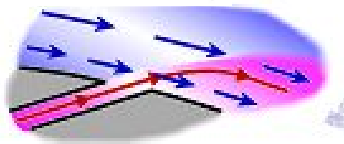
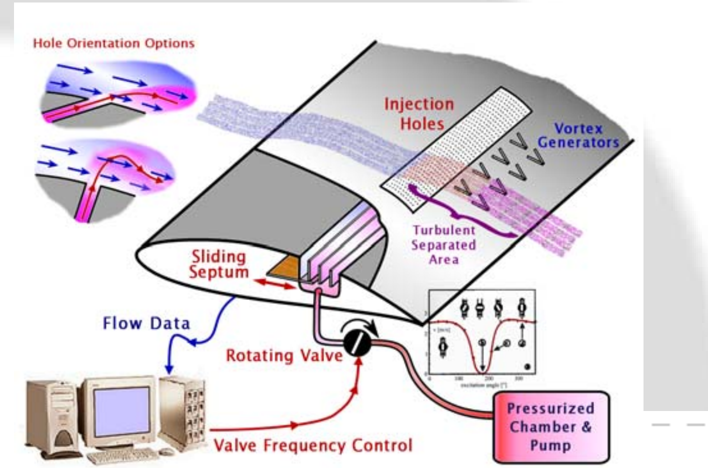
NUMERICAL & APPLIED AERODYNAMICS

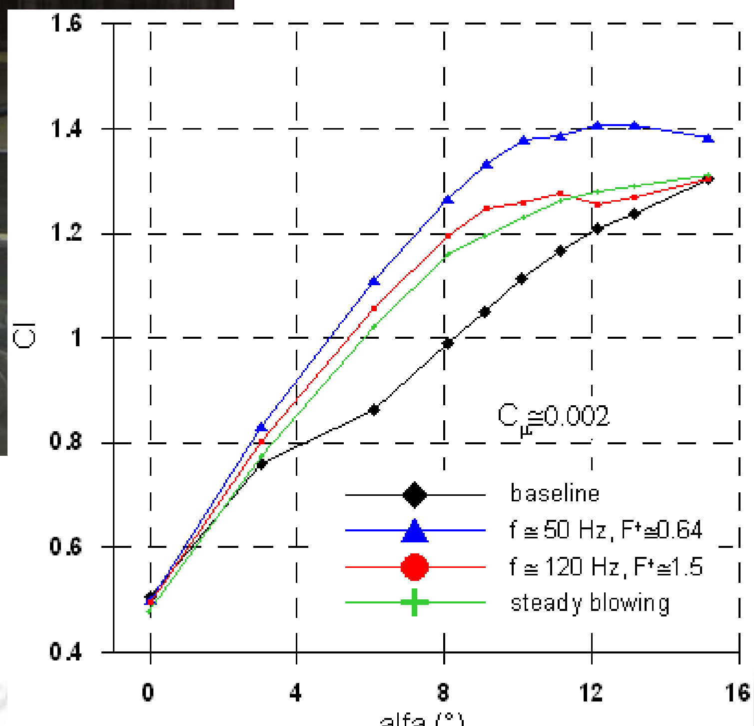
Turbulent flow control with unsteady blowing (wind-tunnel tests)

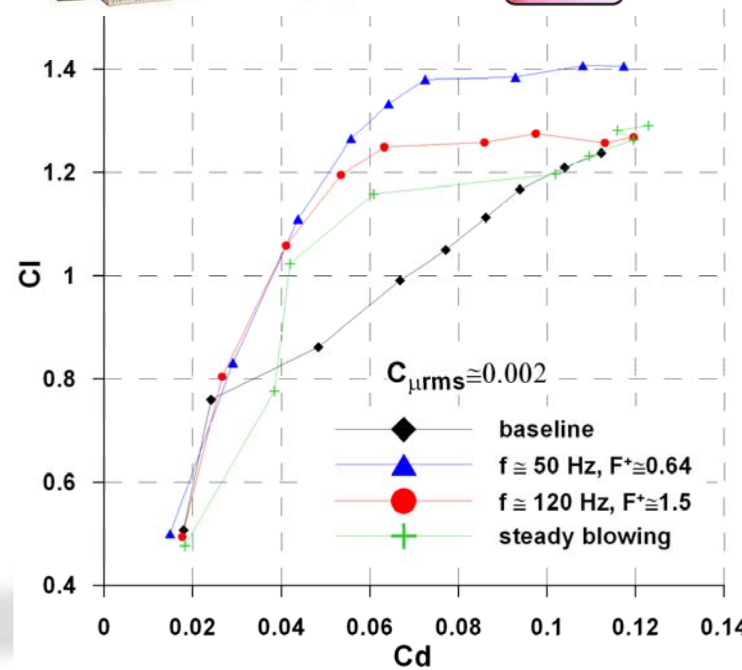






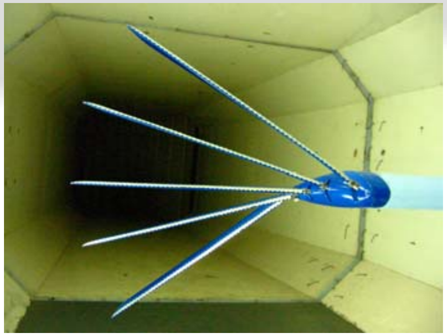


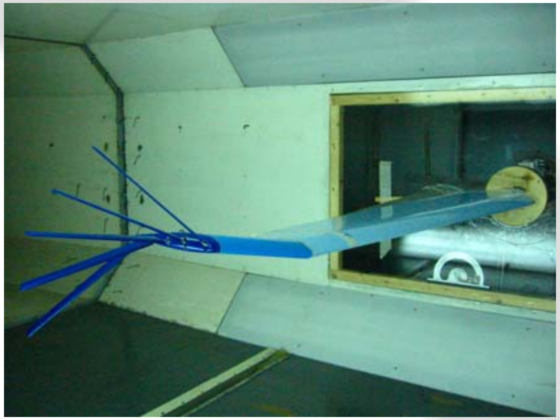


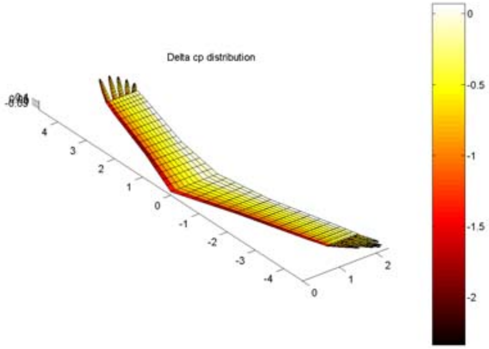


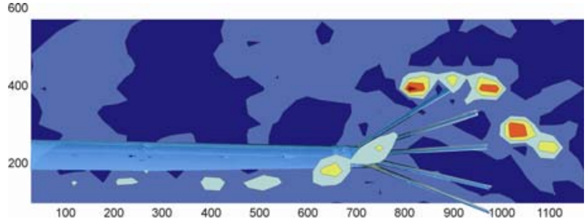
NUMERICAL & APPLIED AERODYNAMICS

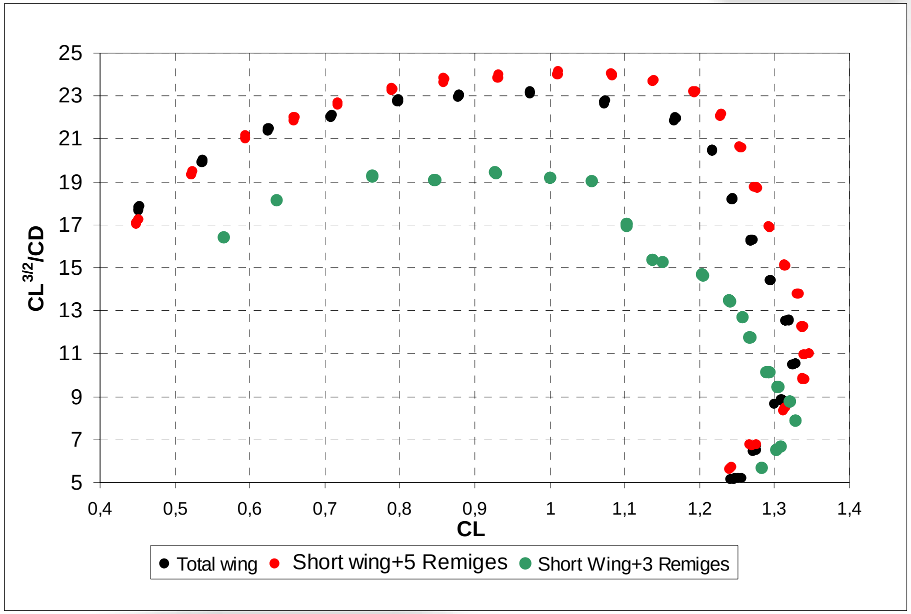
Induced drag reduction with multiple winglets





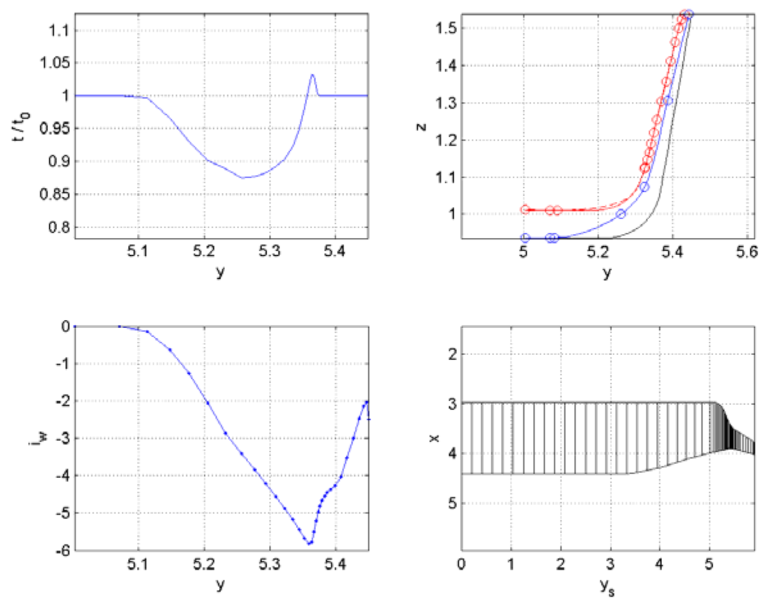


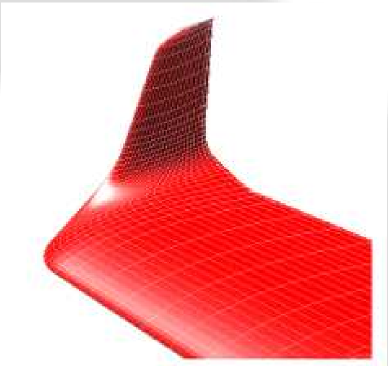


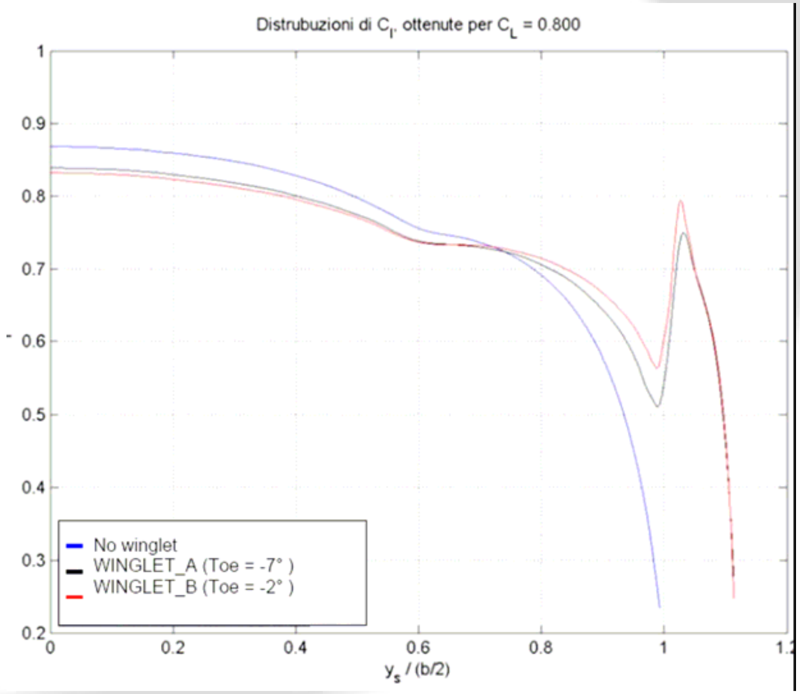


NUMERICAL & APPLIED AERODYNAMICS

Light aircraft and General aviation winglet design







ADAG RESEARCH ACTIVITIES (4)

Flight tests – Flight Mechanics - Flight Dynamics

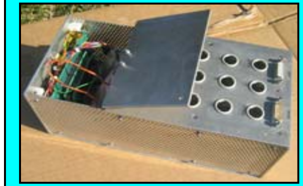
Flight tests:

- Light Aircraft Flight test certification (JAR VLA)
- Performances flight meas. - AFM
- Parametric Identification

Potentiometer

Inertial platform

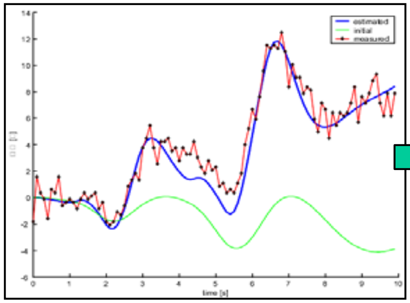
Stick force



Acquisition and control system

AIR Data Boom

Ground Control Station



Parametric aerod deriv. Estimation. Flight qualities.

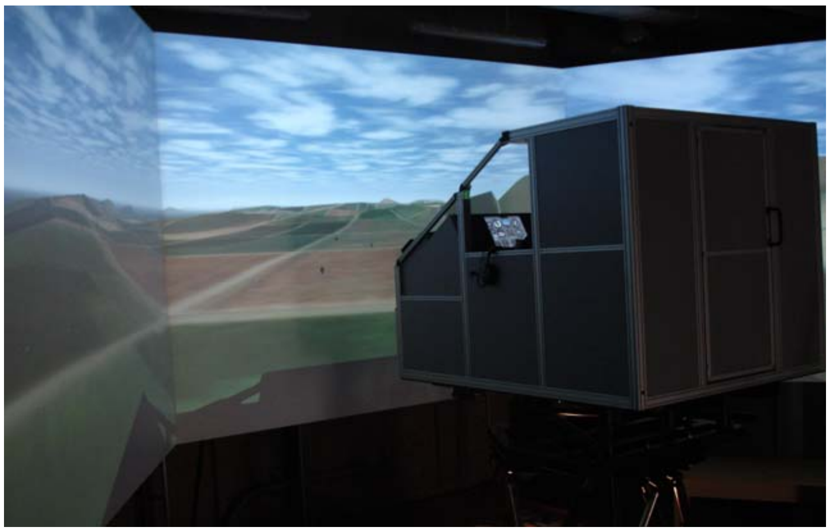
6-DOF flight simulator

ADAG RESEARCH ACTIVITIES (4)

Flight simulator

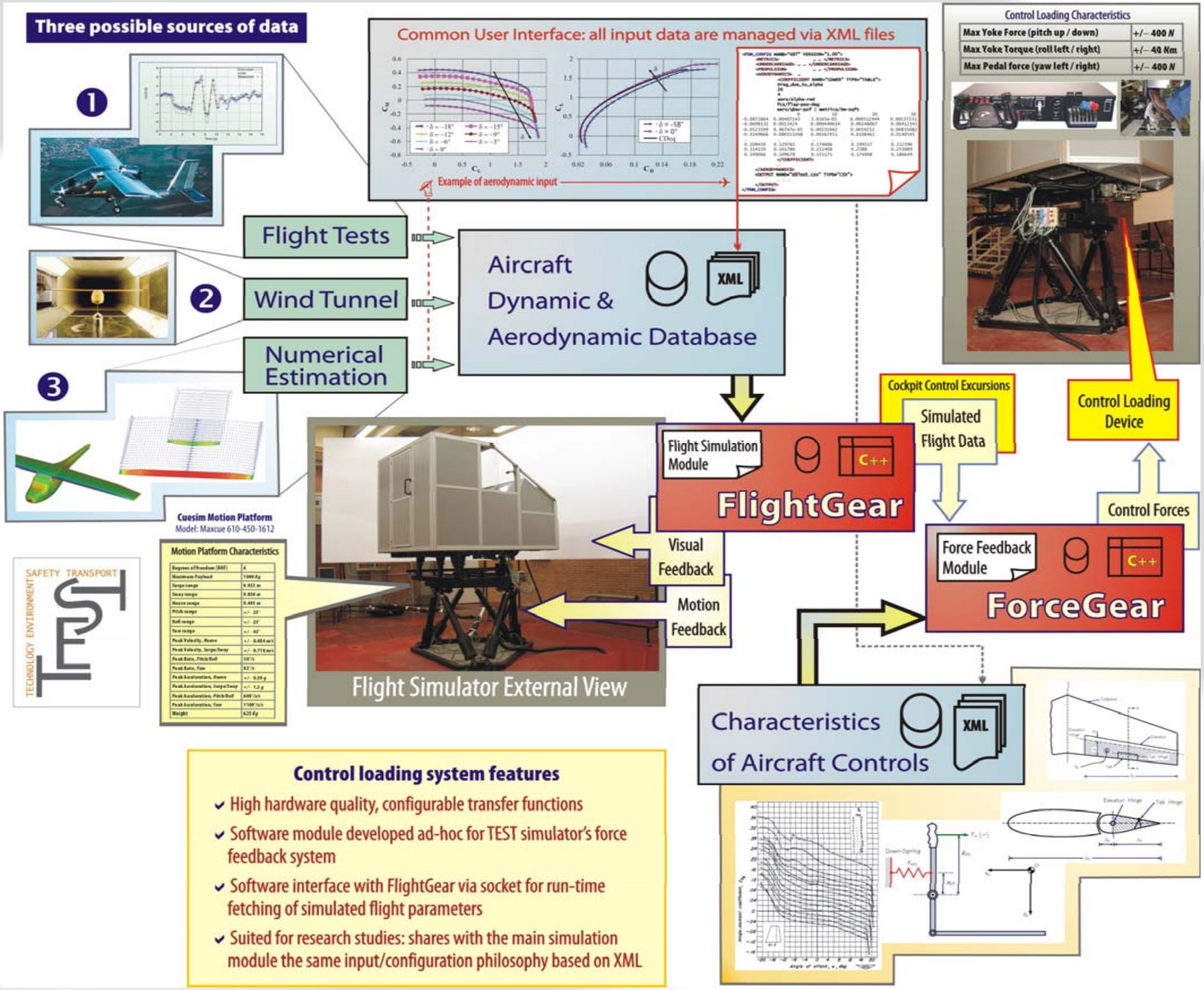
- The Department together with TEST (Company) has recently acquired a 6 DOF Flight Simulator

- Stick force reproduction



Cockpit Layout

HOW ALL DISCIPLINES ARE INTEGRATED….

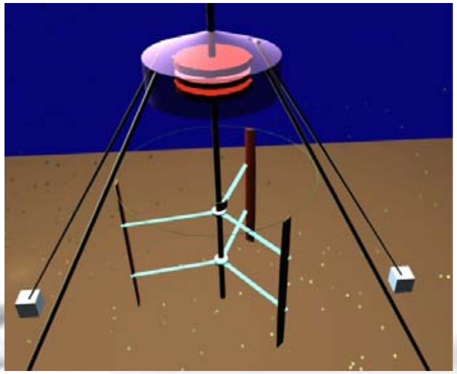


RENEWABLE ENERGIES RESEARCH ACTIVITIES

Design, building and testing of horizontal and vertical axis wind and water turbines

Nov. 2006 we founded a SPIN-OFF Company EOLPOWER Srl

EOL-H5 5 KW Wind Generator (Production has started in 2009)



KOBOLD Turbine
To exploit tidal currents

Internationally patented

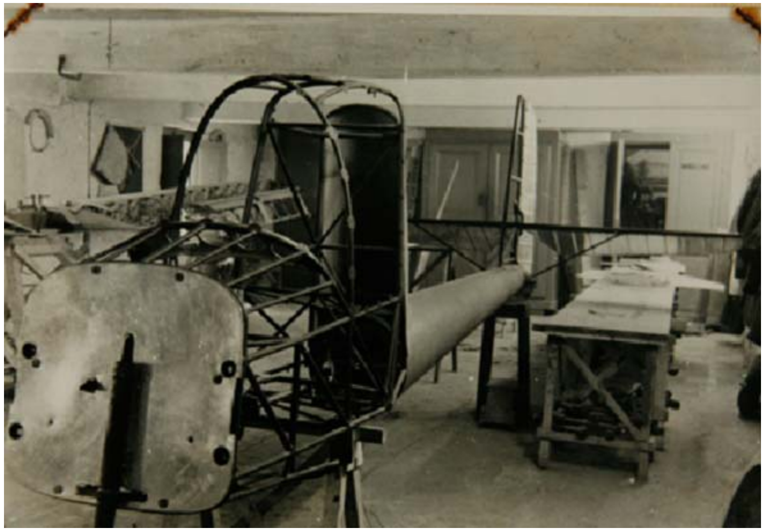
AIRCRAFT DESIGN @ University of Naples
… started in early times….

1926 Prof. Gen. Umberto Nobile

Bundesarchiv, Bild 102-05736
Foto: o.Ang. | April 1928

AIRCRAFT DESIGN @ University of Naples … in the 50's

- **Prof. L. Pascale**



PARTENAVIA Company

AIRCRAFT DESIGN @ University of Naples
PARTENAVIA company aircrafts

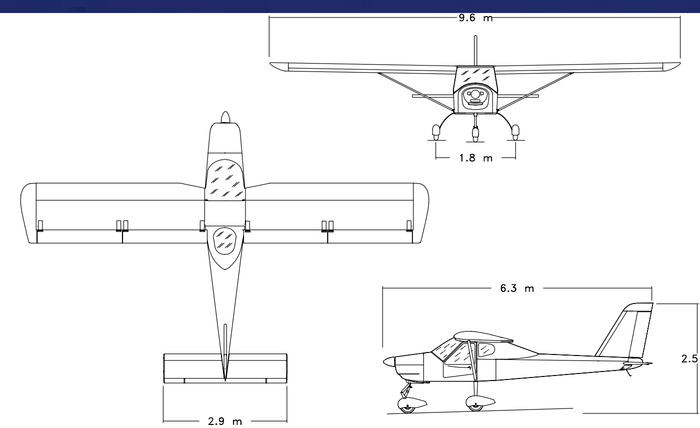

P48-B Astore

P.48 Astore
P.52 Tigrotto
P.53 Aeroscooter
P.55 Tornado
P.57 Fachiro
P.59 Jolly
P.64 Fachiro III
P.64B Oscar
P.66B Oscar
P.66C Charlie
P.66D Delta
P.66T Charlie
P.68
P.70 Alpha
P.86 Mosquito

AIRCRAFT DESIGN @ University of Naples
… in the 90's

TECNAM P92 and P96
(Prof. L. Pascale)

G97 Spotter (1997-1999)
Prof. V. Giordano



AIRCRAFT DESIGN @ University of Naples

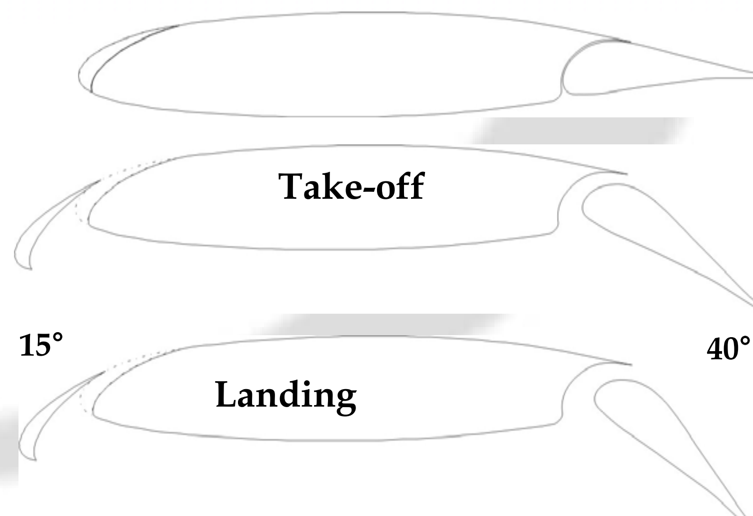
… in the new century …

EASY-FLY (2003-2006)

<u>**EASY-FLY**</u>

New STOL ULM in composite material

ADAG – Group



AIRCRAFT DESIGN @ University of Naples

… in the new century …

Many new tecnam ULM and..

<u>TECNAM</u>
P2006T
(Prof. Pascale)

Many experiences in collaboration with Tecnam on design of many ULM

P92 Echo (1992)

P92J (1995) (Cert. VLA)

P92 Sea-Sky

P92JS

P92 2000 RG

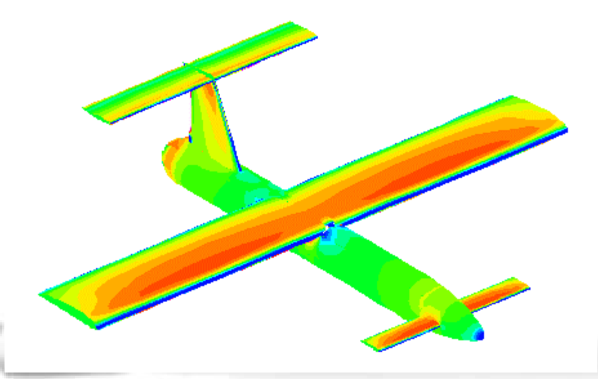
P96 Golf (1996)

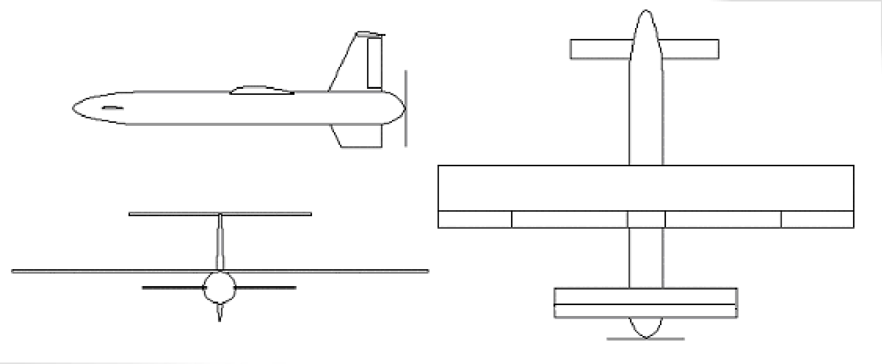
P2002 Sierra (2002)

ADAG - AIRCRAFT DESIGN RPV ACTIVITY

• UAV and RADIO-CONTROLLED (RPV) MODEL DESIGN

- Study an unmanned aircraft for observation-reconnaissance (UAV)
- Analysis of canard influences on aircraft aerodynamics, static and dynamic flying characteristics (the model can fly with and without canard)
- Complete and accurate flight instrumentation for flight parameter measurement and model maneuver analysis





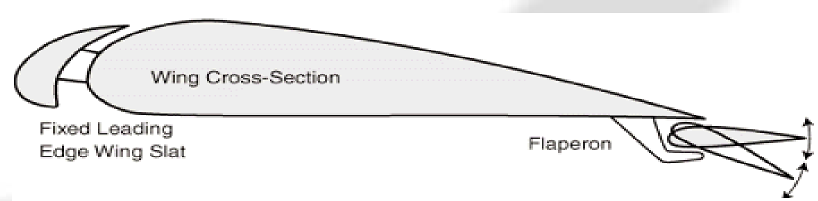
EASY FLY PROJECT

Conventional STOL light aircraft are characterized by a very "DIRTY" configuration


Savannah

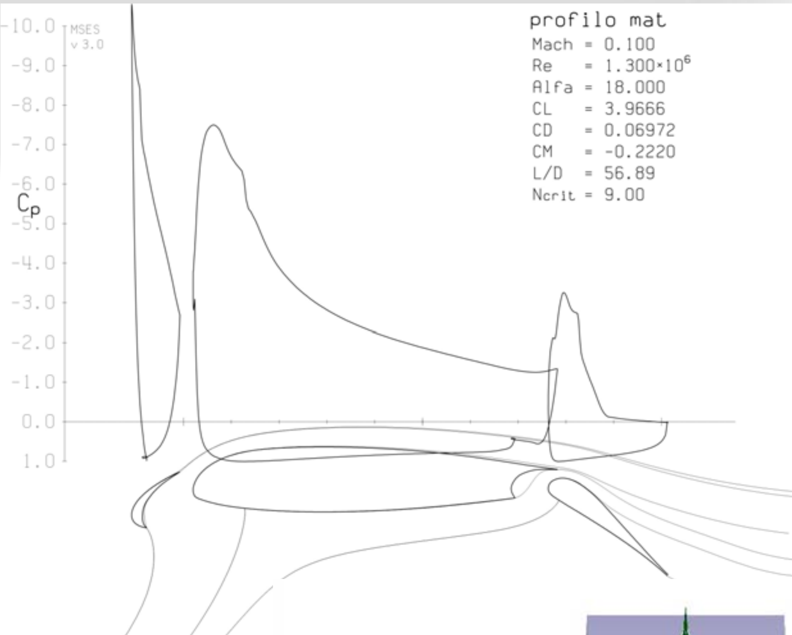

YUMA (foldable wing)

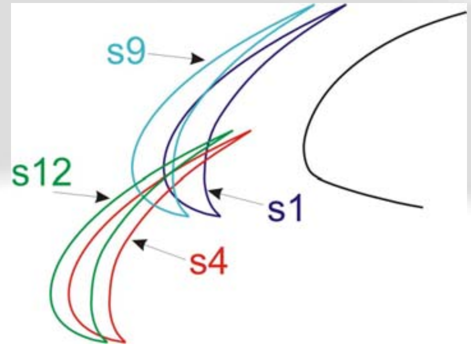

Zenair CH 701

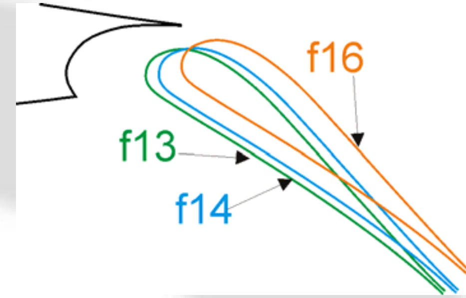


EASY-FLY

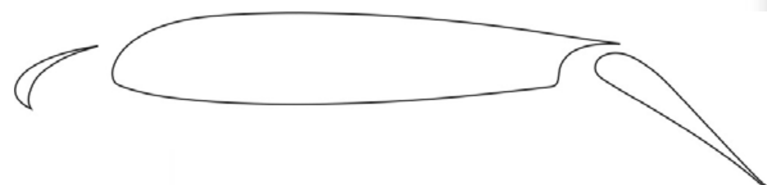
MAIN RESEARCH ACTIVITIES
- 2D and 3-D HIGH LIFT SYSTEM DESIGN

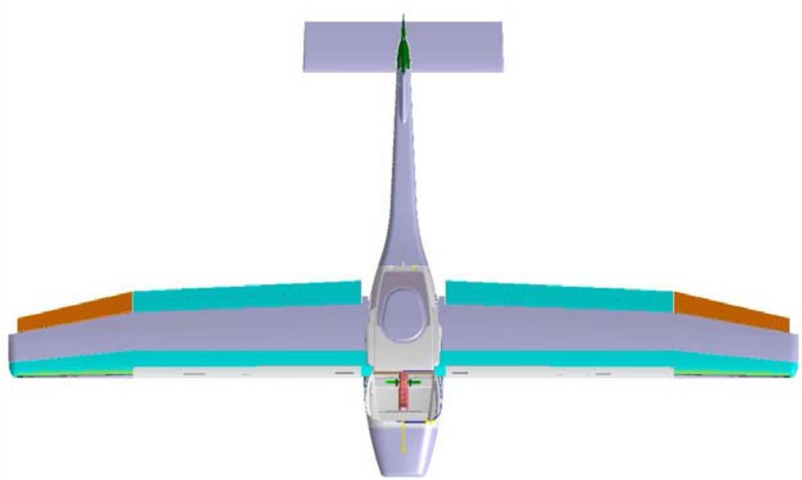






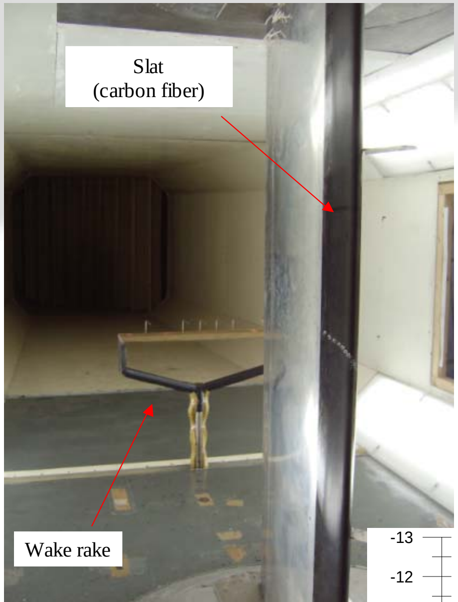
	OVERLAP				
GAP		3	1.9	1	0
	1.7	1.32	4.01	4.03	3.97
	1.8	3.83	3.95	3.99	3.93
	1.88	3.87	4	4.02	3.87
	2	3.79	4	3.98	3.88

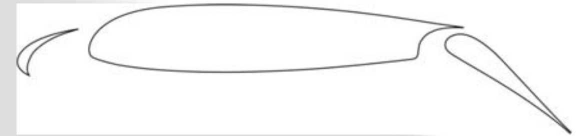


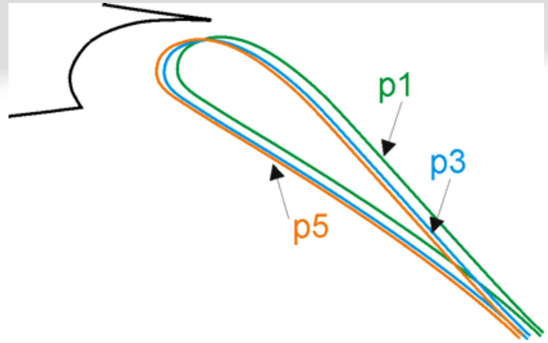


EASY-FLY

- 2D and 3-D HIGH LIFT SYSTEM WT TESTS

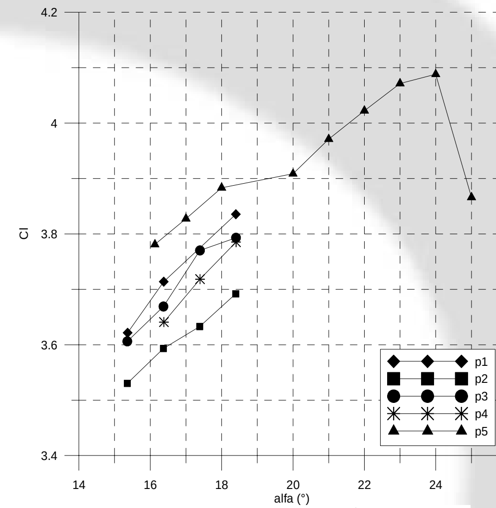


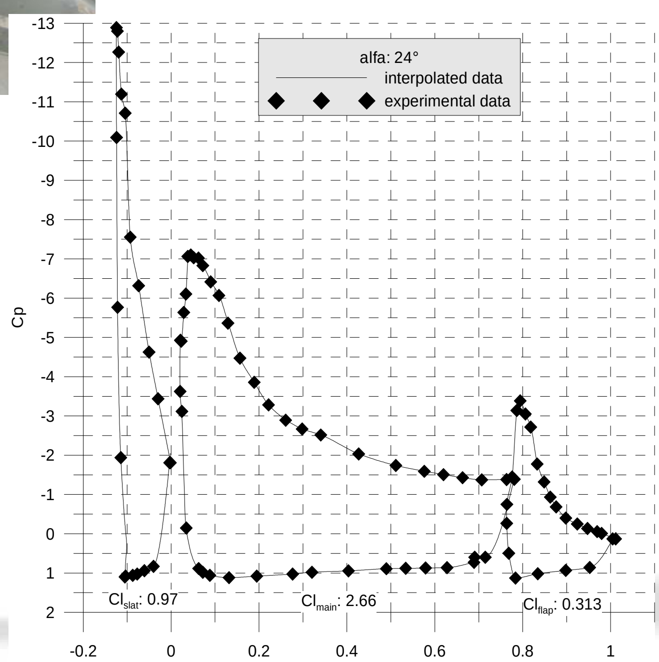


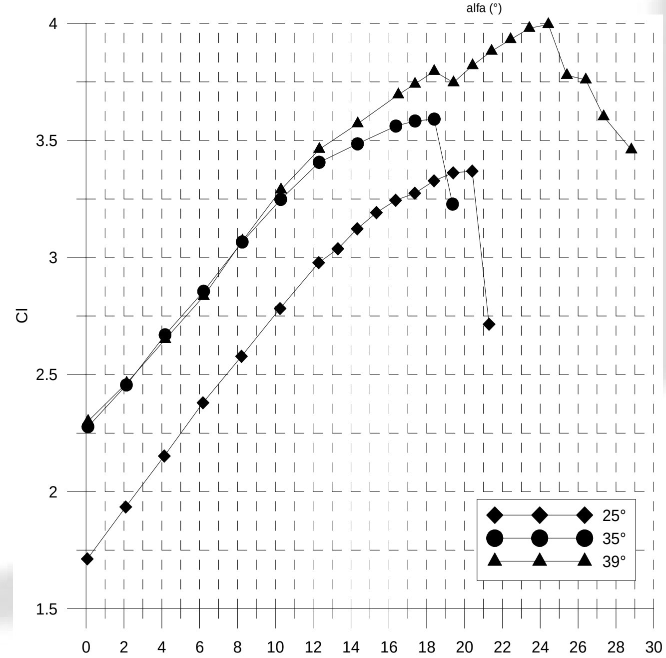


Test Reynolds = 1.3 mil.

Cl_max=4.0 !





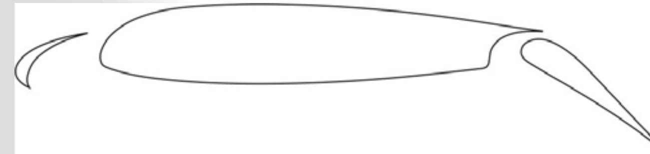


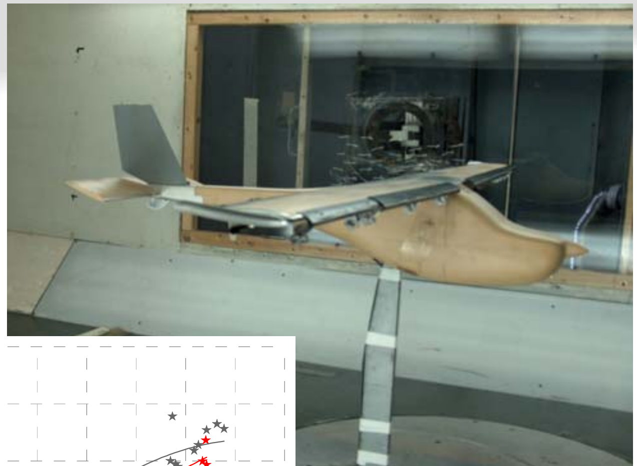
EASY-FLY

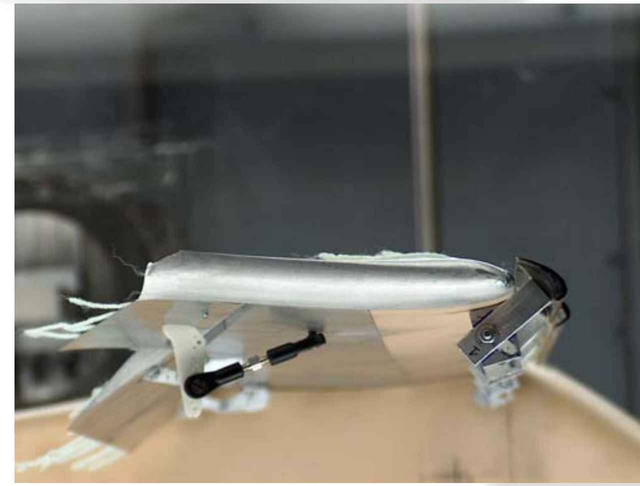
- 2D and 3-D HIGH LIFT SYSTEM WT TESTS

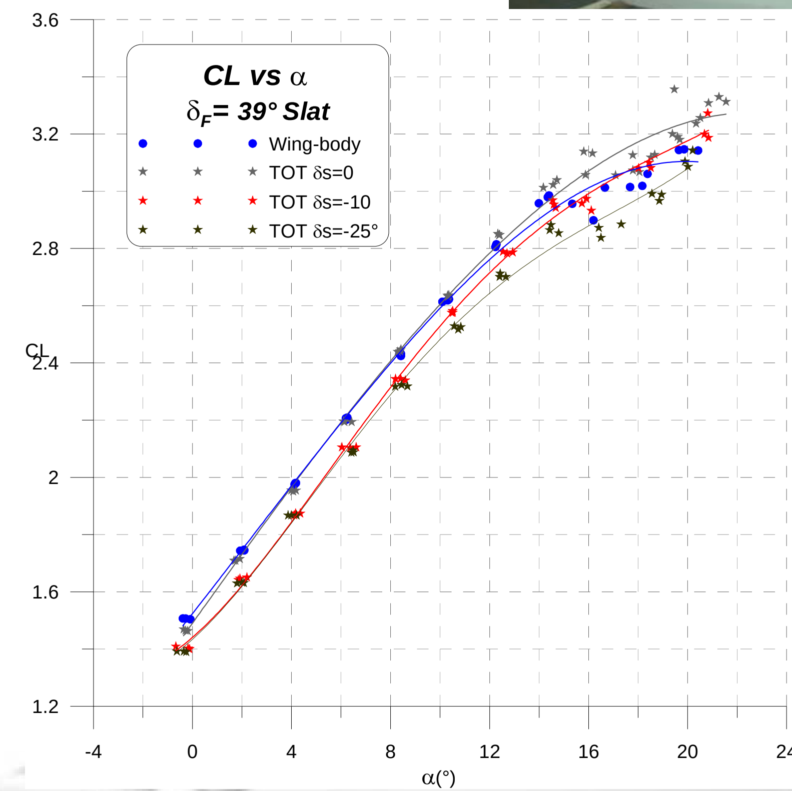
Test Reynolds = 0.6 mil.

CL_max=3.1 !

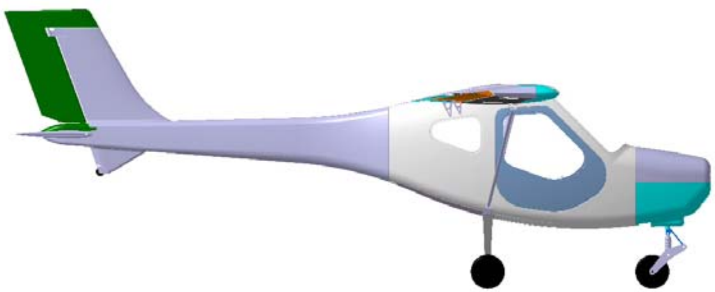


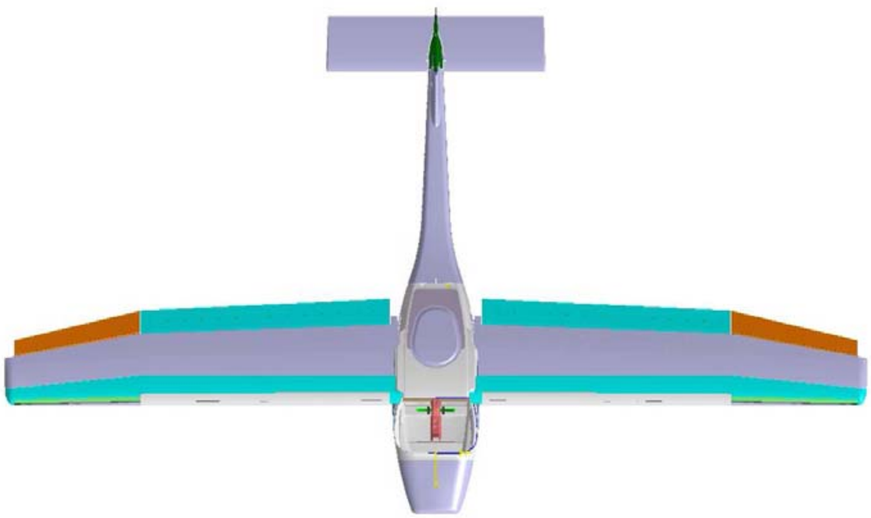






EASY-FLY





Università di Napoli Federico II

www.dpa.unina.it\adag

DESIGN AND AERODYNAMIC ANALYSIS AND OPTIMIZATION OF A LIGHT TWIN ENGINE AIRCRAFT

L. Pascale F. Nicolosi

P2006T AIRCRAFT

Since 2006 *Tecnam* has started his intention to enter the market with a new CS 23 certified 4 seat aircraft.

• In the last years, starting from the United States, the General Aviation has been revitalized, due to the necessity to decongest the classical skyway system and to use thousands of small airport in the country (AGATE , SATS).

MARKET ANALYSIS AND P2006 AIRCRAFT DESIGN ASPECTS

- The fast economical growth of developing countries (like in Africa, south-America and in south-east of Asia) that do not have developed transportation systems has pushed the use and the diffusion of light aircraft in those areas.

- In example in some remote area of south Africa the transport through light aircraft can be the only solution, taking into account the absence of asphalt roads and the low acquisition and maintenance costs of these kind of machines.

P2006T design aspects

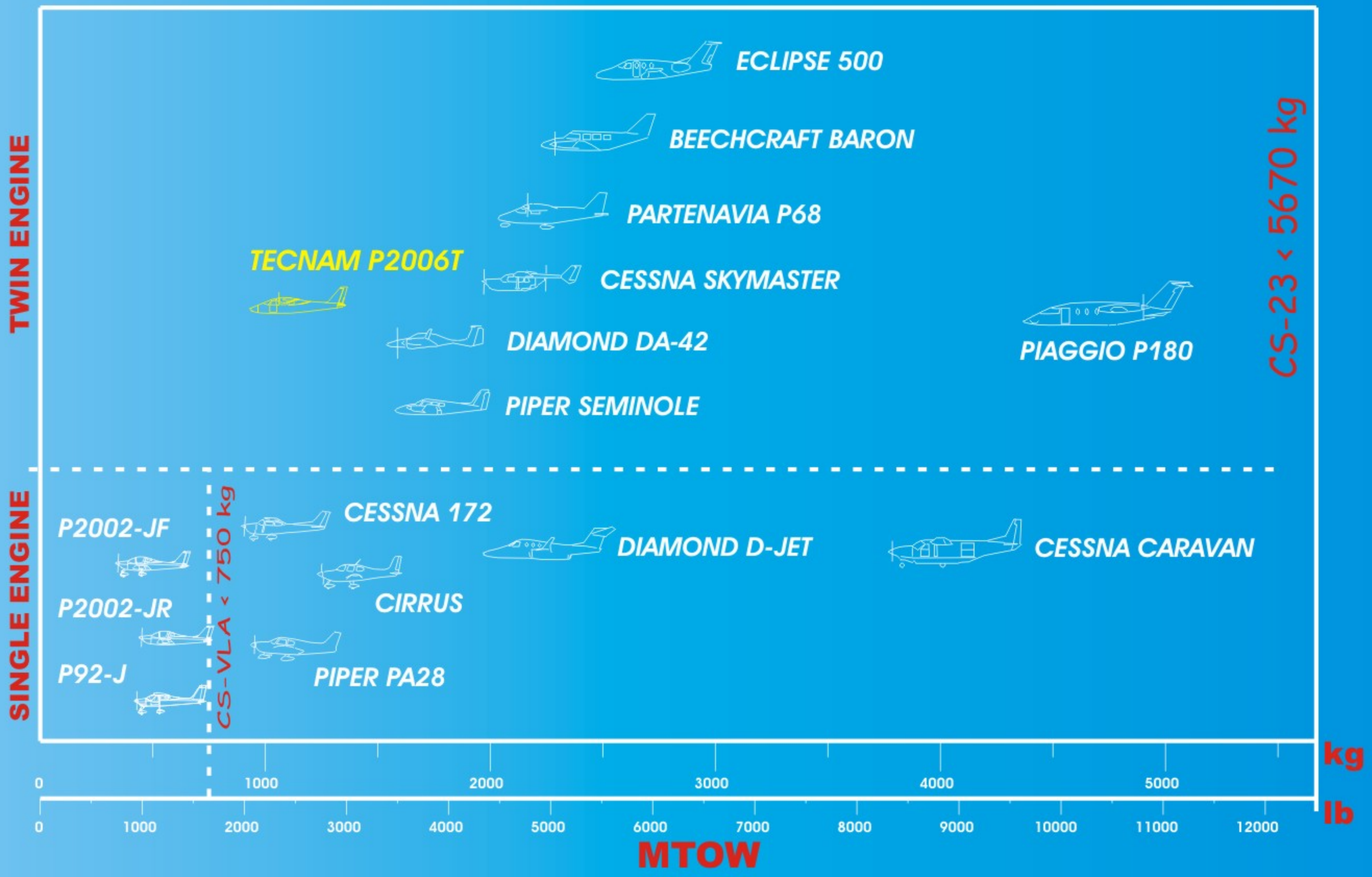
- USE: Tourist, Flight school, Monitoring (i.e. Police)

- Rotax 912S (100 hp) used in ULM and VLA
- Simple construction (Light and not expensive)
- Use of automotive gasoline (instead of AVGAS) (Rotax 912)
- Short TO and Landing (not prepared)
- 4 seats – twin engines – light (to fly with two Rotax, 100hp each).

- Twin engine with the weight of a single-engine

- Similar performances but with lower operative costs compared to single engine 4-seats aircraft.

P2006T


ECLIPSE 500
BEECHCRAFT BARON
PARTENAVIA P68
TECNAM P2006T
CESSNA SKYMASTER
DIAMOND DA-42
PIAGGIO P180
PIPER SEMINOLE
TWIN ENGINE
CS-23 < 5670 kg
SINGLE ENGINE
P2002-JF
P2002-JR
P92-J
CS-VLA < 750 kg
CESSNA 172
CIRRUS
PIPER PA28
DIAMOND D-JET
CESSNA CARAVAN
0
1000
2000
3000
4000
5000
kg
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
lb
MTOW

ROTAX 912 S (100 hp)

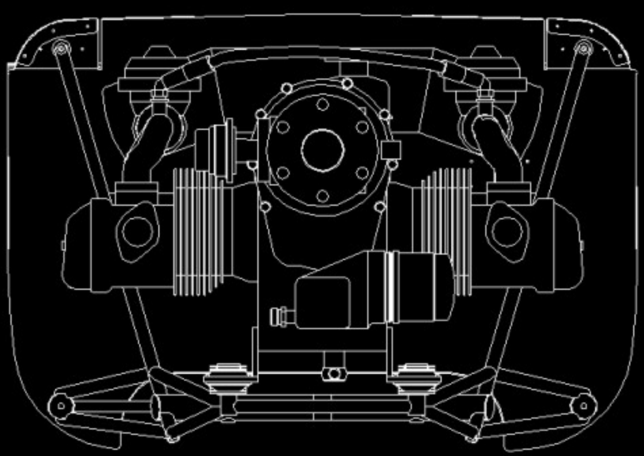
- Certified
- Use of automotive fuel

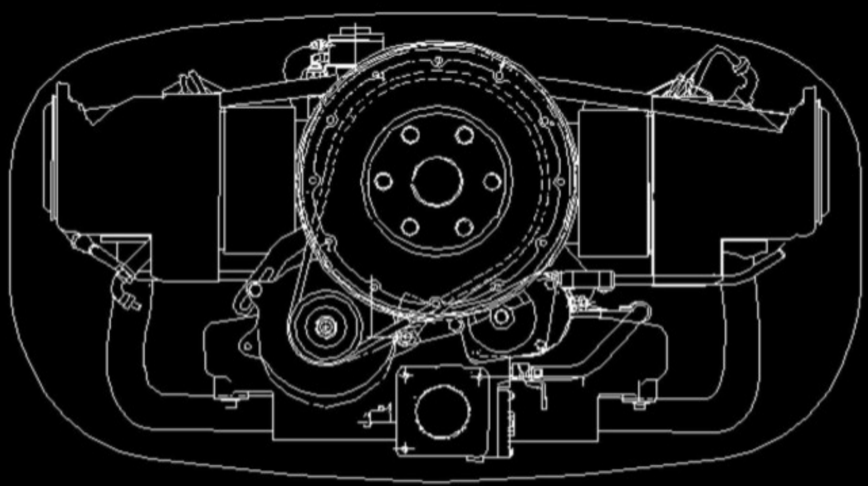
Advantages:

- ➢ Lower frontal area (small and streamlined nacelle)
- ➢ Lower weight to power ratio
- ➢ Lower specific consumption
- ➢ Lower rpm for the propeller (efficiency and noise)
- ➢ Water cooling (stable temp.)

ROTAX vs Lycoming

	ROTAX 912S	Lycoming IO-360
Peso (a secco, senza accessori)	59 kg	149 kg
Potenza max	100 hp @2390	200 hp @2700
Area frontale	0.322 m^2	0.428 m^2
Larghezza massima	575 mm	867 mm
Consumo (75%)	19 l/hr	46 l/hr



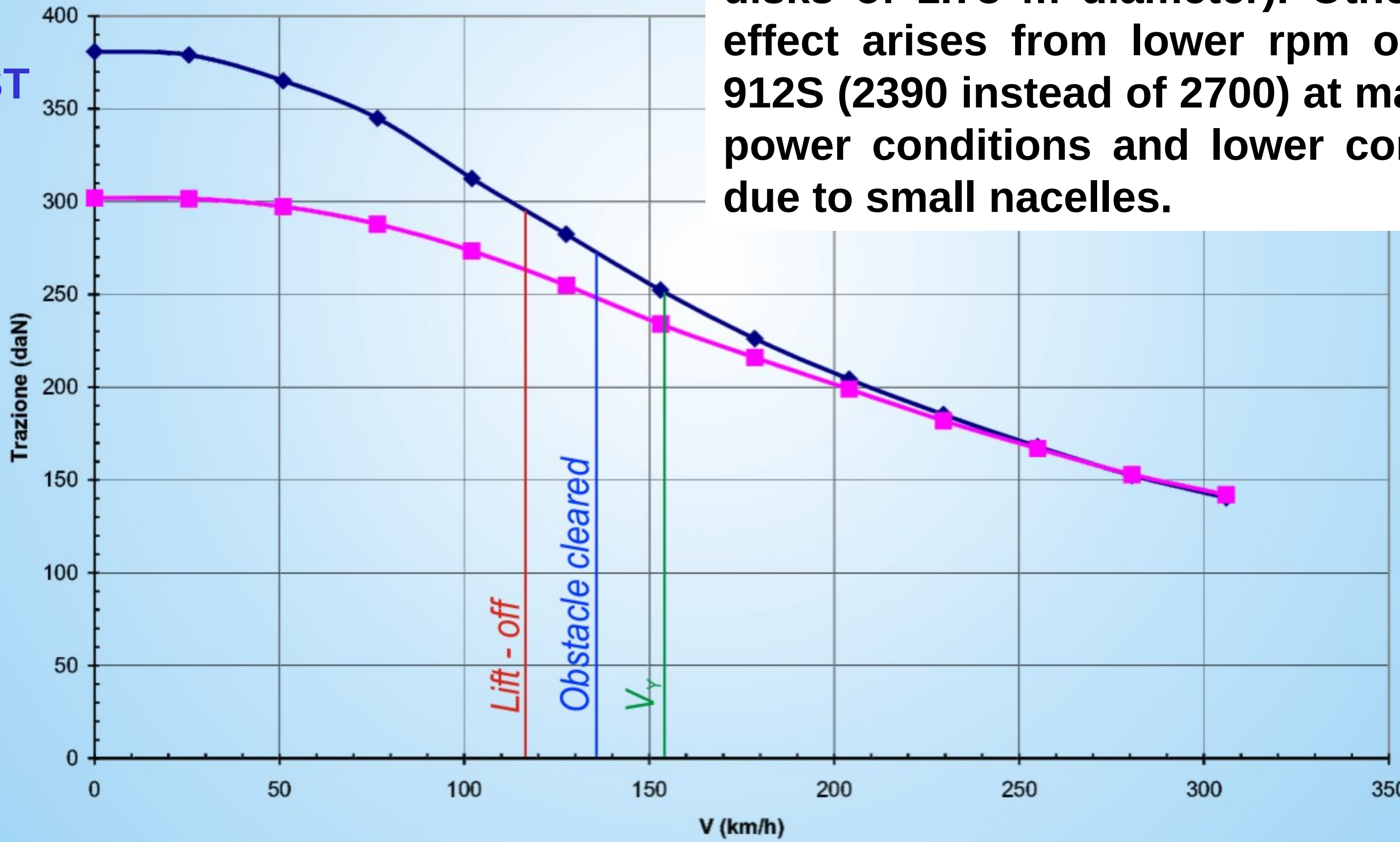


Comparison 2 Rotax vs 1 Lycoming

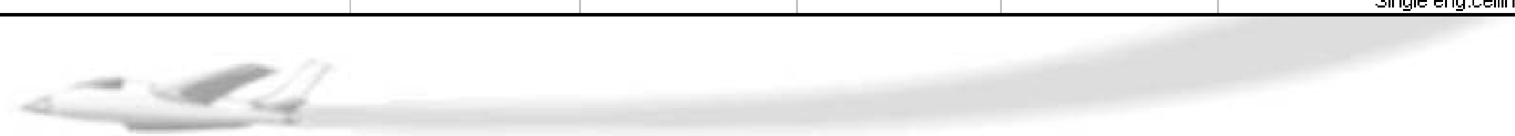
2 Rotax 912S 100hp + elica Ø1.78m
vs
1 Lycoming 200hp + elica Ø1.88m

The higher thrust of Rotax912S is mainly due to the fact that the same engine power is distributed on much larger propeller disk area(area of two disks of 1.78 m diameter). Other small effect arises from lower rpm of Rotax 912S (2390 instead of 2700) at maximum power conditions and lower correction due to small nacelles.

THRUST



MODEL	Cessna 172R	Cessna 182T	Piper PA28-181	Cirrus	Diamond	EADS Socata	TECNAM
Specifications	**Skyhawk**	**Skylane**	**Archer**	**SRV-G2**	**DA-40**	**TB10 Tobago**	**P2006T**
wingspan (m)	10,97	10,97	10,80	10,84	12,00	10,04	11,20
wing area (mq)	16,20	16,20	16,00	12,50	13,47	11,90	14,76
lenght (m)	8,28	8,84	7,32	7,92	8,02	7,75	8,70
height (m)	2,72	2,84	2,20	2,59	1,98	3,02	2,90
cabin width (m)	1,00	1,07	1,06	1,24	1,14	1,08	1,20
cabin lenght (m)	3,60	3,40	2,49	3,30	n.a.	2,53	2,60
landing gear type	fixed, tricycle	fixed, tricycle	fixed, tricycle	fixed, tricycle	fixed, tricycle	fixed, tricycle	retractable, tricycle
Engine							
manufacturer	Lycoming	Lycoming	Lycoming	Continental	Lycoming	Lycoming	Rotax
model	IO-360-L2A	IO-540-AB1A5	0-360-A4M	IO-360-ES	0-360-M1A	0-360-A1AD	2x 912 S
horsepower	160 hp @ 2400 RPM	230 hp @ 2400 RPM	180 hp @ 2700 RPM	200 hp @ 2600 RPM	180 hp @ 2700 RPM	180 hp @ 2700 RPM	2x98 hp @ 2400 RPM
Propeller							
type	Fixed Pitch, 2 blade	Const. speed, 3 blade	Fixed Pitch, 2 blade	Const. speed, 2 blade	Const. speed, 2 blade	Const. speed, 2 blade	Const. speed, 2 blade
diameter (m)	1,91	2,00	n.a.	1,93	1,80	1,88	1,78
Design weight & Loading							
max. gross weight (kg)	1043	1406	1157	1360	1149	1150	1160
std. empty weight (kg)	588	860	760	929	744	730	750
useful load (kg)	455	550	397	431	405	420	410
seating capacity	4	4	4	4	4	4	4
fuel capacity (lt)	159	348	182	213	148	210	200
Wing loading (kg/mq)	64,4	86,9	72,3	108,8	85,3	96,6	78,6
Power loading (kg/hp)	6,52	6,10	6,43	6,8	6,38	6,39	5,92
Performance							
max. level speed s.l. (kts)	123	149	133	n.a.	n.a.	n.a.	150
cruise speed (kts)	122 (80%,8000 ft)	145 (80%,6000 ft)	128 (75%,7900 ft)	150 (75%)	145 (75%,6500 ft)	127 (75%,6000 ft)	145 (75% 7000 ft)
cruise speed "	116 (10000 ft)		n.a.	n.a.	134 (65%,10000ft)	109 (65%,6000 ft)	140 (65%,9000 ft)
stall speed, flaps up, pwr off (kts)	51	54	n.a	54	52	n.a.	53
stall speed, flaps down, " " "	47	49	52	n.a.	49	n.a.	48
best rate of climb (ft/m')	720	924	n.a.	900	1070	787	1350
service ceiling (ft)	13500	18100	14100	n.a.	15000	13000	16500
fuel cosump. lt/h (65%)	28	41	32	35	32	32	32
cruise range w/reserve (30') nm	580	968	487	634	n.a.	n.a.	750
takeoff, ground roll (m)	288	242	346	409	219	505	235
takeoff, total distance (50 ft) (m)	514	461	490	597	352	n.a.	460
landing ground roll (m)	168	180	280	309	146	460	180
landing distance (50 ft) (m)	395	411	427	622	314	n.a.	420
					* Single eng. R/c (s.l.), ft/m'		350
					Single eng.ceiling, ft		7500



- **It is possible to compare a twin-engine aircraft with single-engine ones.**
- **P2006T empty weight is low compared to other twin-engine. The payload is higher !**
  - **=> high structural efficiency**
  - **=> good weight/power ratio of Rotax 912**
  - **=> the two engines lower the flight loads on the wings**

- **From an operating point of view, is worth to consider that the option to use automotive fuel instead of AVGAS allows P2006 operators to dramatically reduce direct costs, making also possible to fly in regional or remote areas where AVGAS is difficult to find or prohibitively expensive.**

NOT A VERY NEW IDEA !

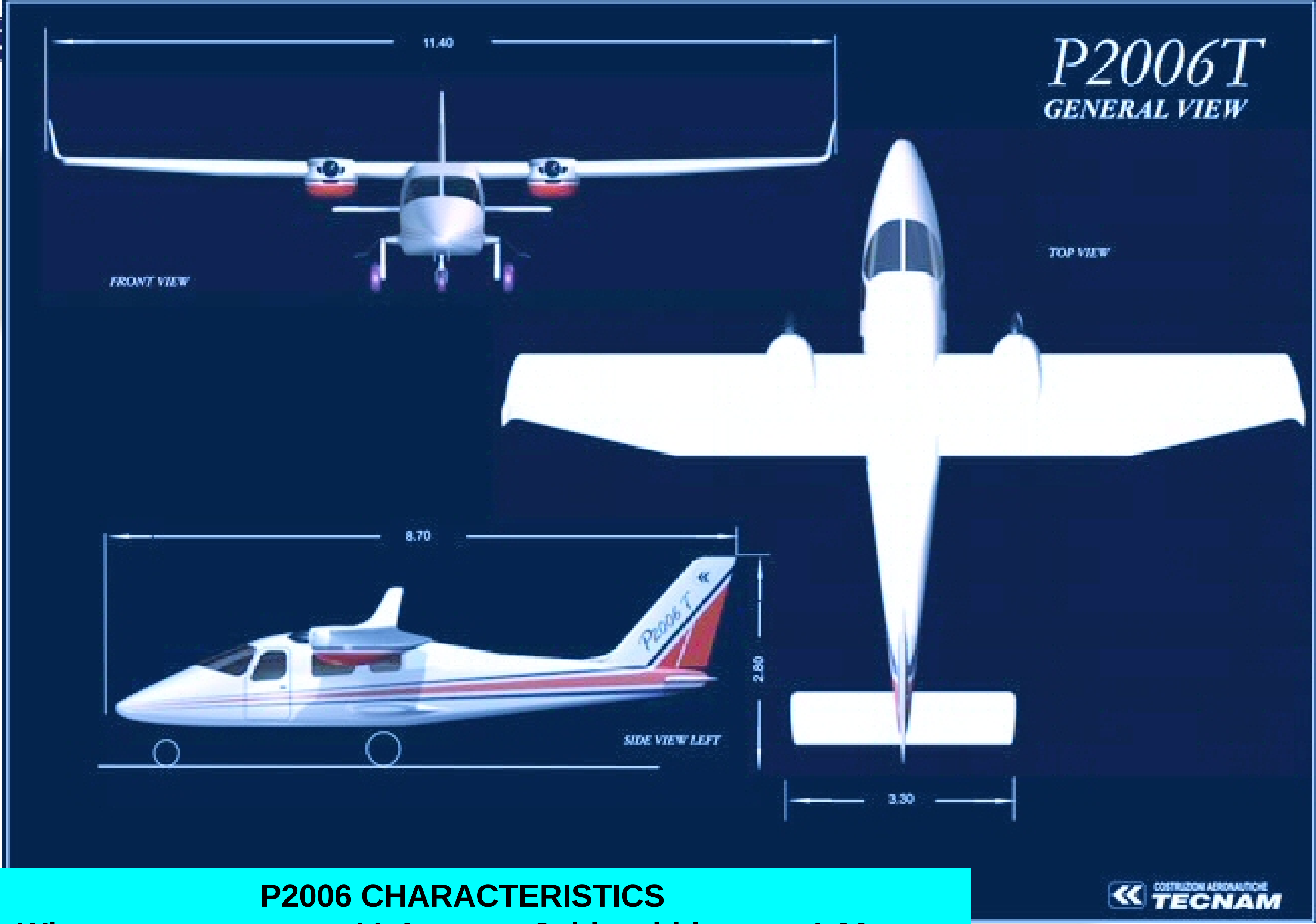
Aero 45

4-seat aircraft - Two Walter 105 hp eng
MTOW 1600 Kg.
The wing loading 88 Kg/m^2
Maximum flight speed 270 Km/h.

P2006 CHARACTERISTICS

Wing span	11.2 m	Cabin width	1.20 m
Mean geometric chord	1.32 m	Wing Area S	14.76 m^2
Aspect ratio	8.47	Length	8.30 m

Maximum Take-off weight 1160 Kg

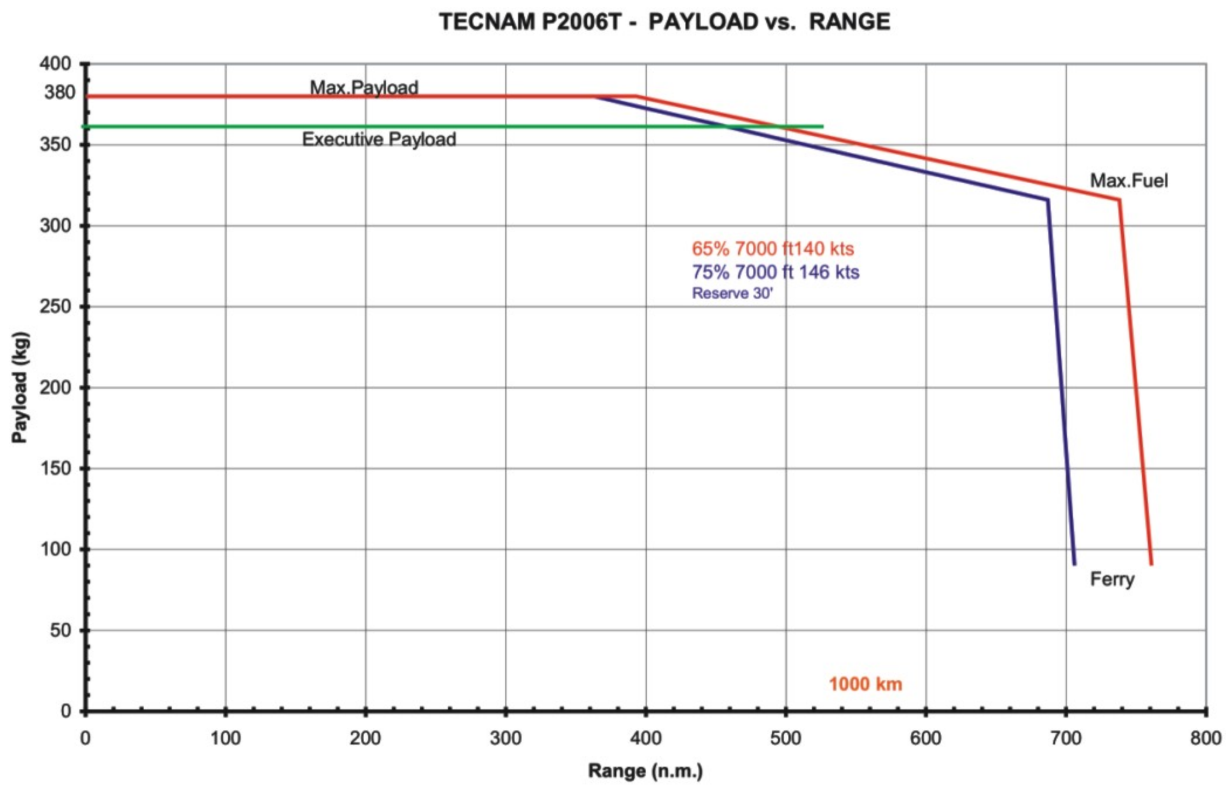


P2006 CHARACTERISTICS

Wing span	11.4 m	Cabin width	1.20 m
Mean geom. chord	1.32 m	Wing Area S	14.76 m^2
Aspect ratio	8.8	Length	8.70 m
MTOW	1180 Kg	Empty weight	760 Kg

Design Specifications

- Easy cabin access and cabin comfort
- Spacious luggage compartment,
- Reduced take-off run (<1500 ft) and take-off from not prepared runways
- Cruise flight speed of about 140 Kts at flight altitude of 7000-8000 ft
- Range higher than 500 nm
- Installation of an AFCS (Automatic Flight Control System).

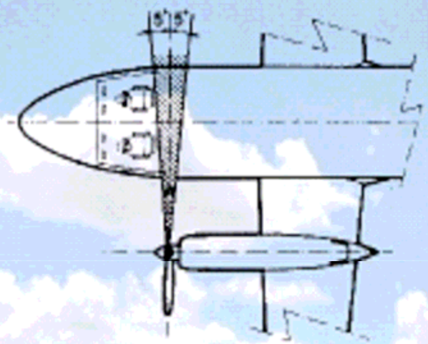


Twin-engine possible configurations

✓ *Push pull*

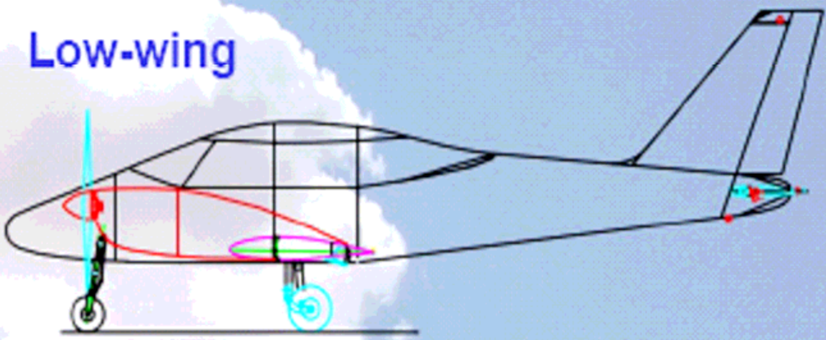
✓ *Pusher propeller*

Certification CS23

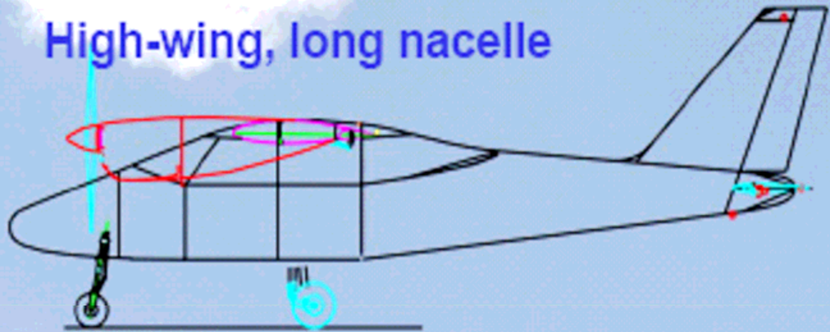


TECNAM P2006 possible solutions

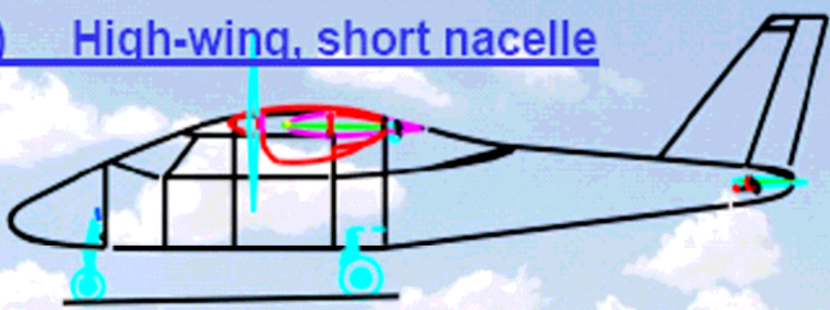
(A) Low-wing

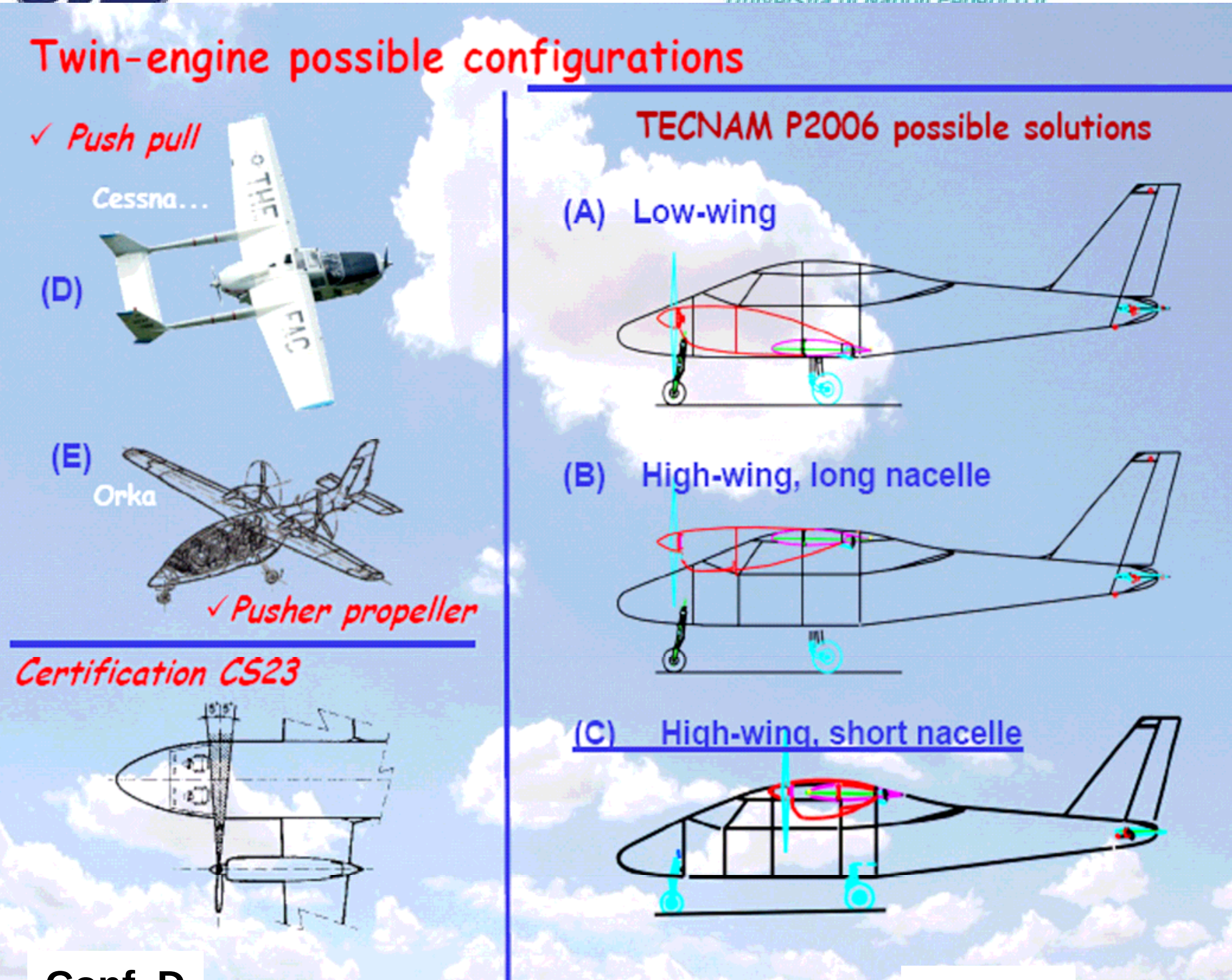


(B) High-wing, long nacelle



(C) High-wing, short nacelle





A e B

+ Wing pos => opt CG travel
- Long nacelle
  => High Tors Inertial loads on the wing
- A , nacelle not stream.
- (prop clearance)

Negative aspects A

- Cabin access
- Higher landing gear (=> Higher weight)
- Possible ingestion (not prepared runways)

Conf. C

+ Cabin access
+ Short & stream nacelle
+ Aerodynamic (par area)
+ Empty weight
- CG travel

Conf. D

+ Yaw Mom (Vtail area)
- Structural diff and high costs of twin boom
- rear engine cooling
- parassite area

Conf. E

- rear engine cooling
- interr flap on the wing
- acoustical problems (propeller behind the wing)

Chosen Configuration

Advantages

- EASY ACCESS
- LOW NACELLE DRAG, STRUCTURALLY SIMPLE, LOW WEIGHT
- HIGH *SPAN EFFICIENCY FACTOR* WITHOUT COMPLEX FAIRING
- GOOD GROUND VISIBILITY
- LOW EFFECT OF PROPELLERS ON LONG. STABILITY
- PROPELLERS NOT EXPOSED DURING TAKE-OFF

Disadvantages

- CG TRAVEL
- REFUELING and ENGINE SERVICING
- FUSELAGE PODS FOR THE 2 MAIN LANDING GEARS
- HIGHER WEIGHT FOR THE MAIN LAND-GEAR STRUCTURE

WING DESIGN

⇒**Wing span b=11.20 m**

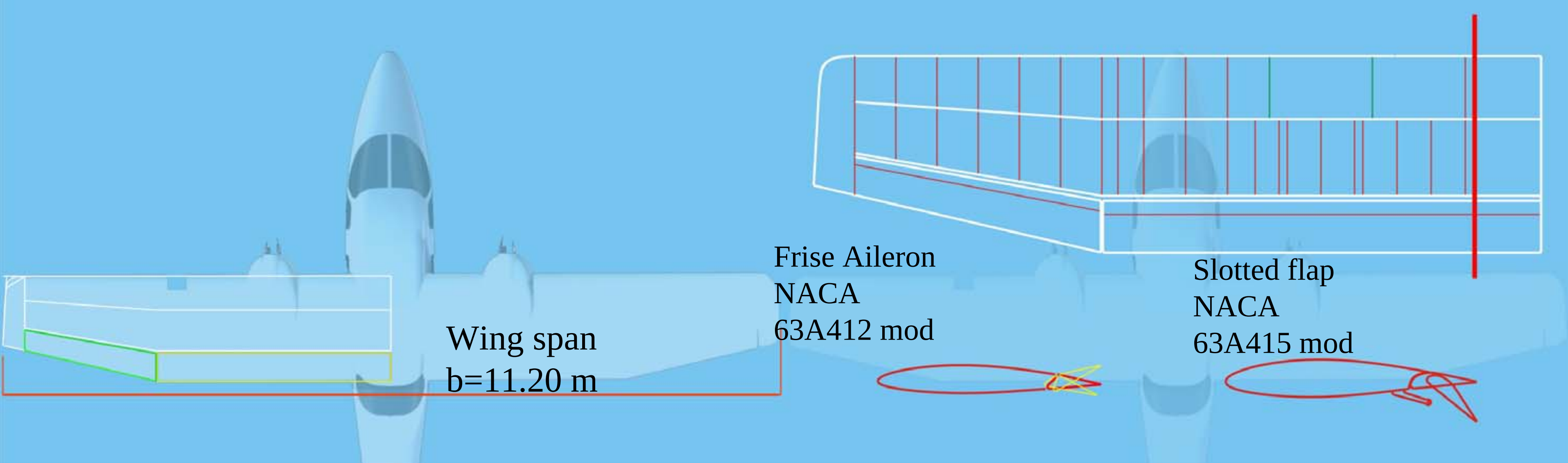
<u>CHOSEN PLANFORM</u>

⇒ **MAC shift toward aircraft nose**

⇒ **RECTANGULAR FLAP (light and lower-cost flap)**

⇒ **QUITE GOOD induced drag factor.**

⇒ **GOOD and SAFE STALL PATH**

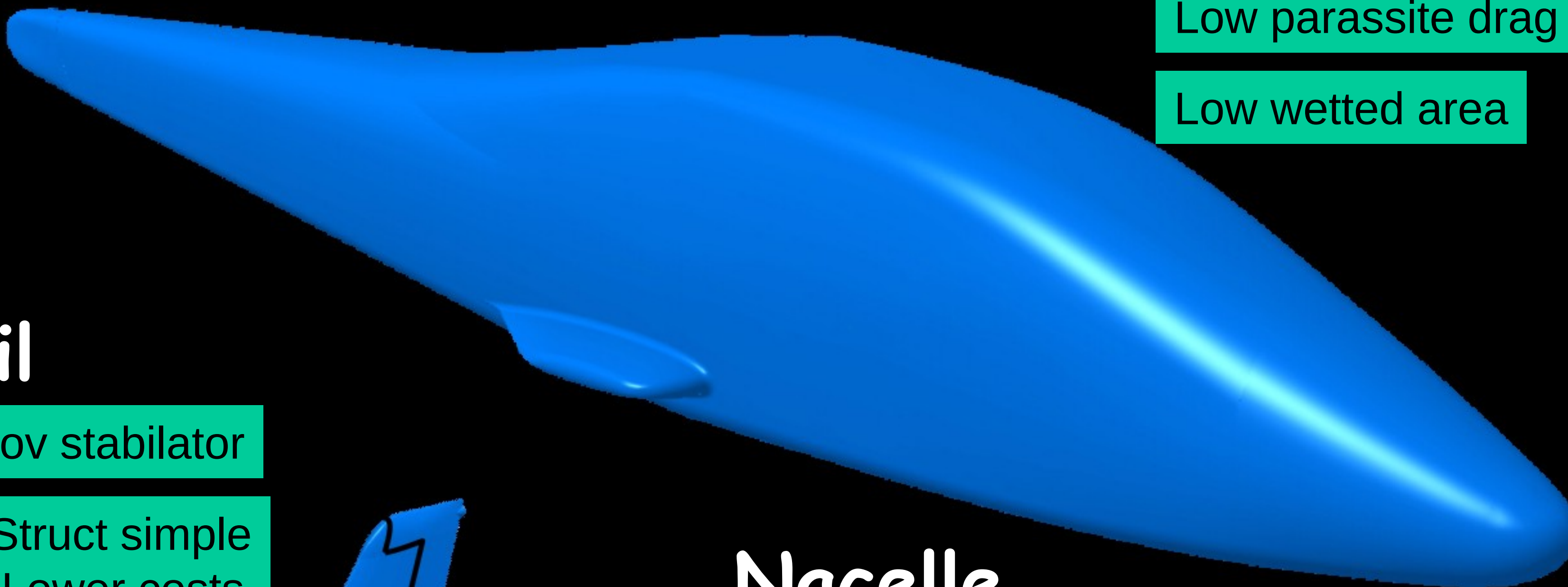


3D surfaces …

Fuselage

Low parassite drag

Low wetted area



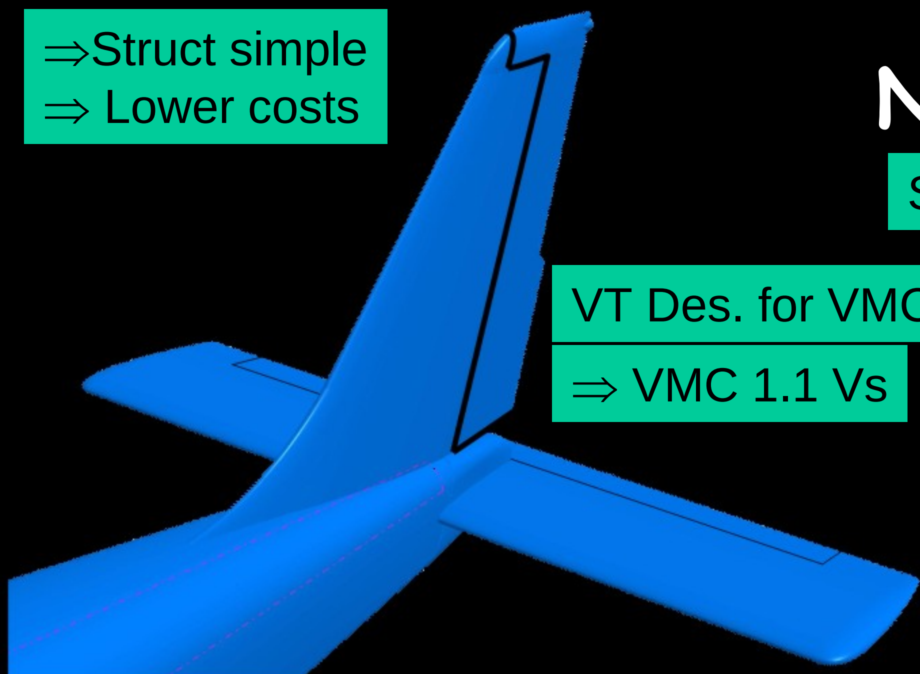
Tail

All mov stabilator

⇒Struct simple
⇒ Lower costs

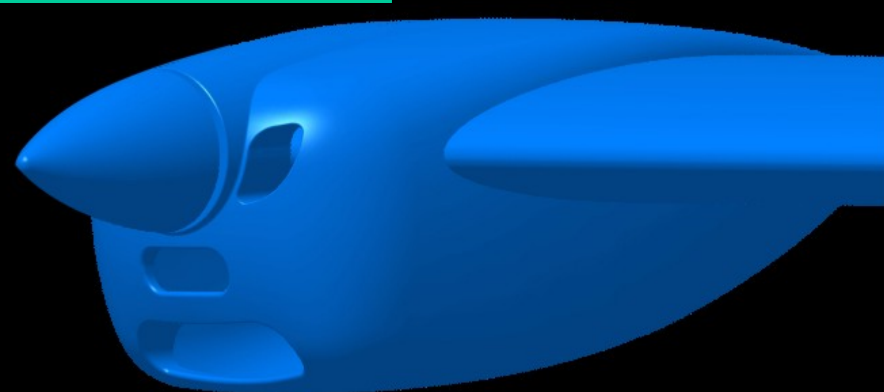
VT Des. for VMC

⇒ VMC 1.1 Vs

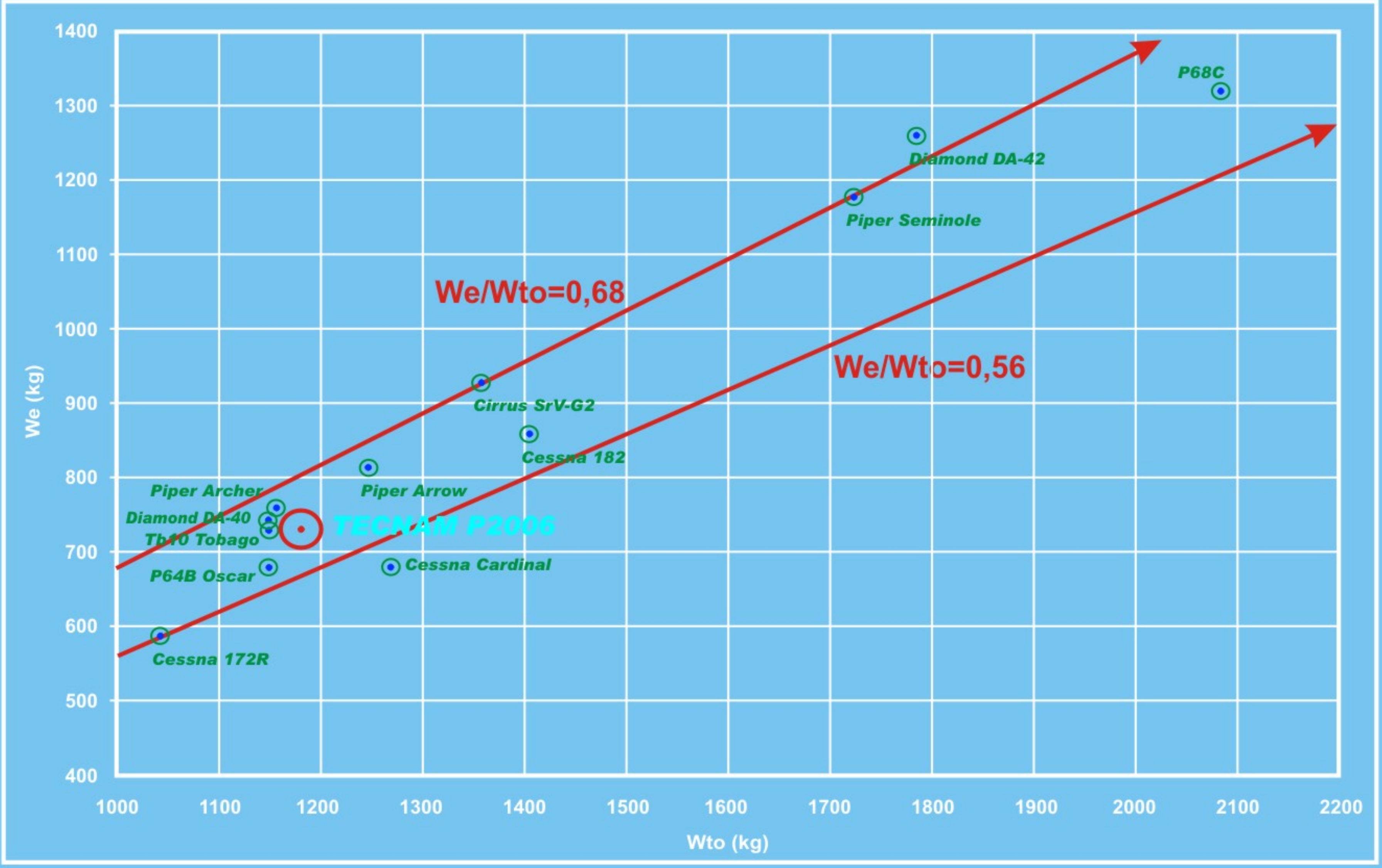


Nacelle

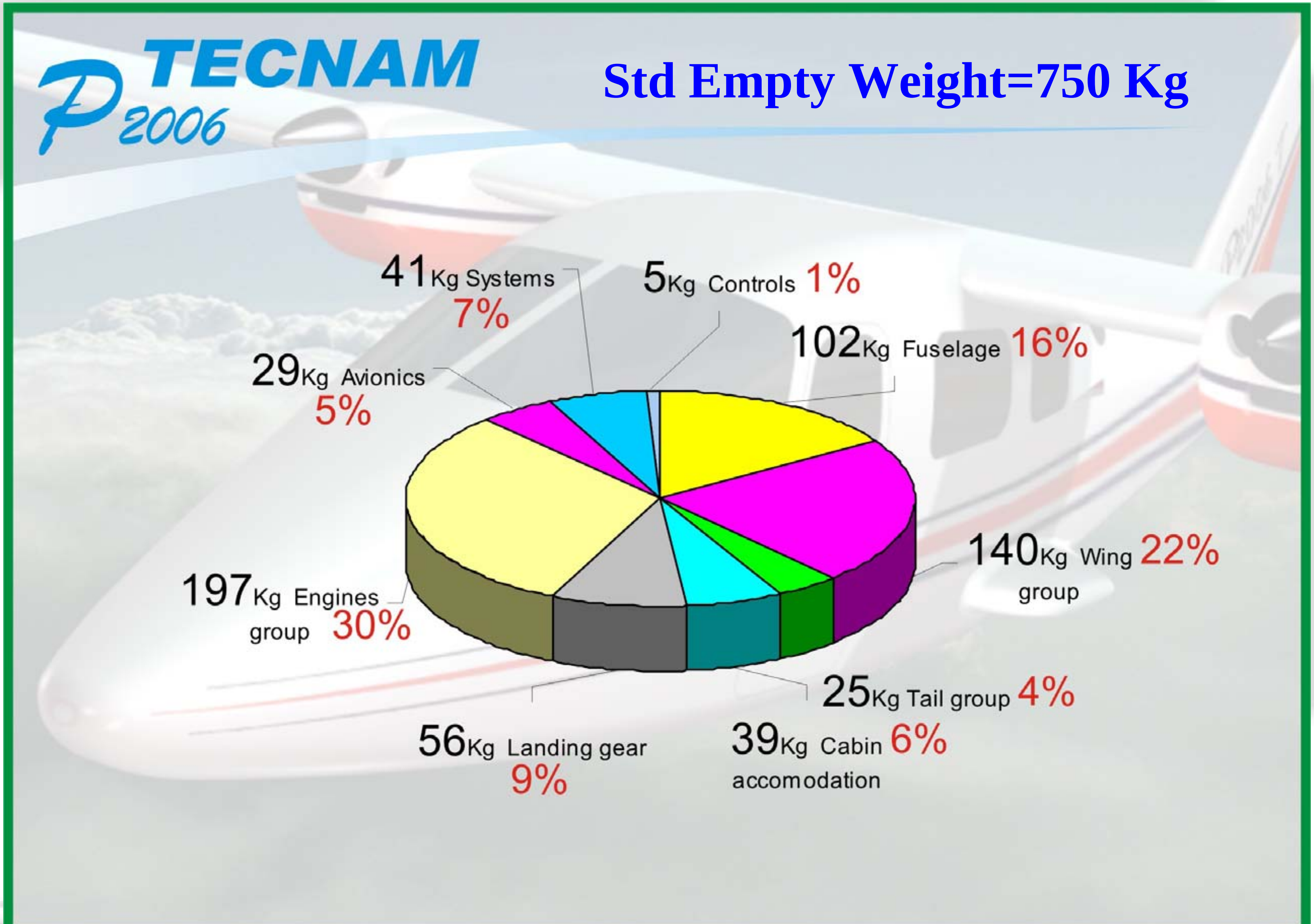
Small and streamlined



WEIGHT


We (kg)
Wto (kg)
1400
1300
1200
1100
1000
900
800
700
600
500
400
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
We/Wto=0,68
We/Wto=0,56
P68C
Diamond DA-42
Piper Seminole
Cirrus SrV-G2
Cessna 182
Piper Arrow
Piper Archer
Diamond DA-40
Tb10 Tobago
TECNAM P2006
Cessna Cardinal
P64B Oscar
Cessna 172R

Empty weight Break-Down



AERODYNAMIC NUMERICAL AND EXP ANALYSIS => At DIAS – Univ of Naples

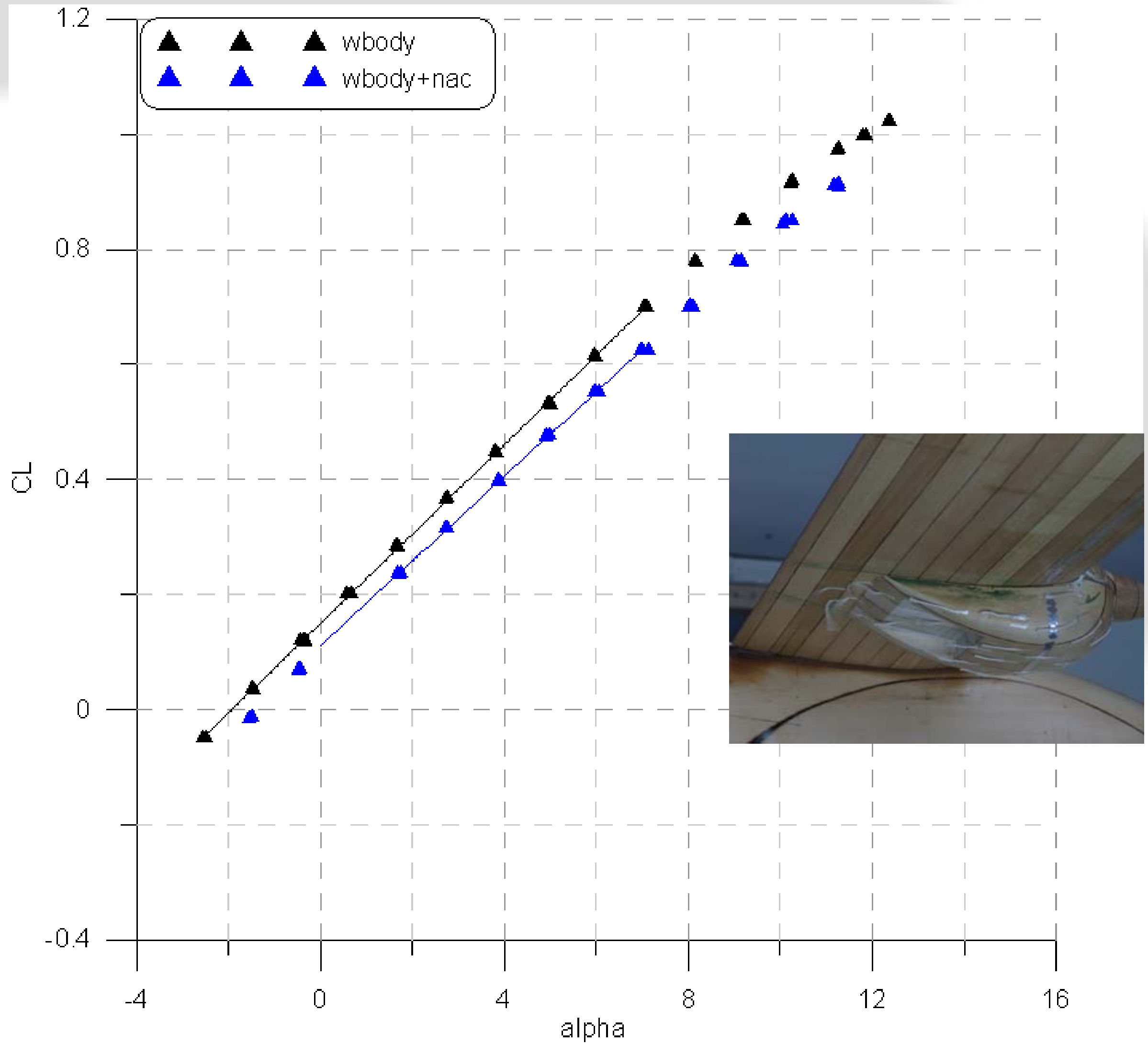
WIND-TUNNEL TESTS

- Scale 1:6.5
- Reynolds = 0.6 mill.

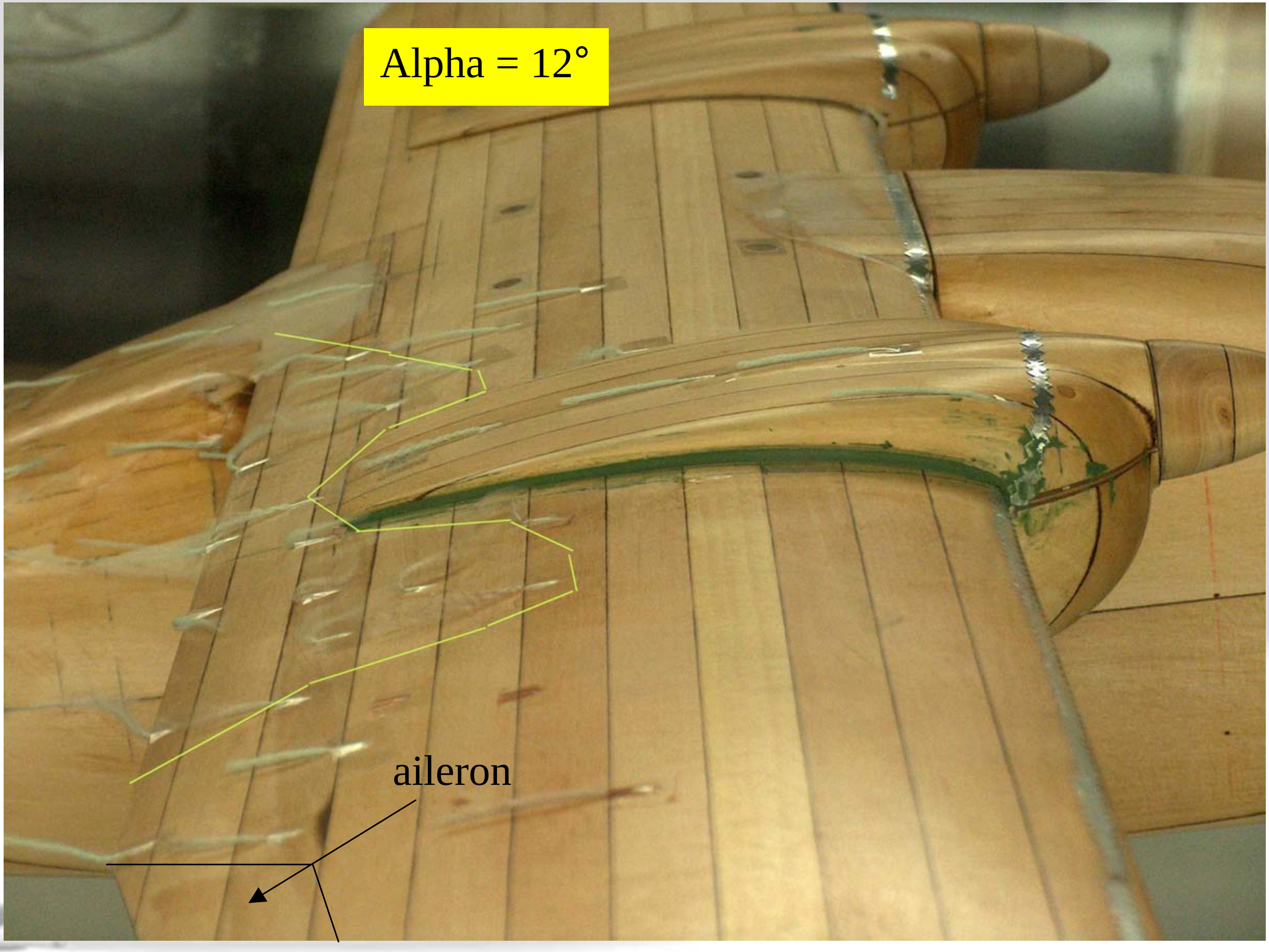
LIFT (nacelle effect)

$$CL_{\alpha} = 0.080$$

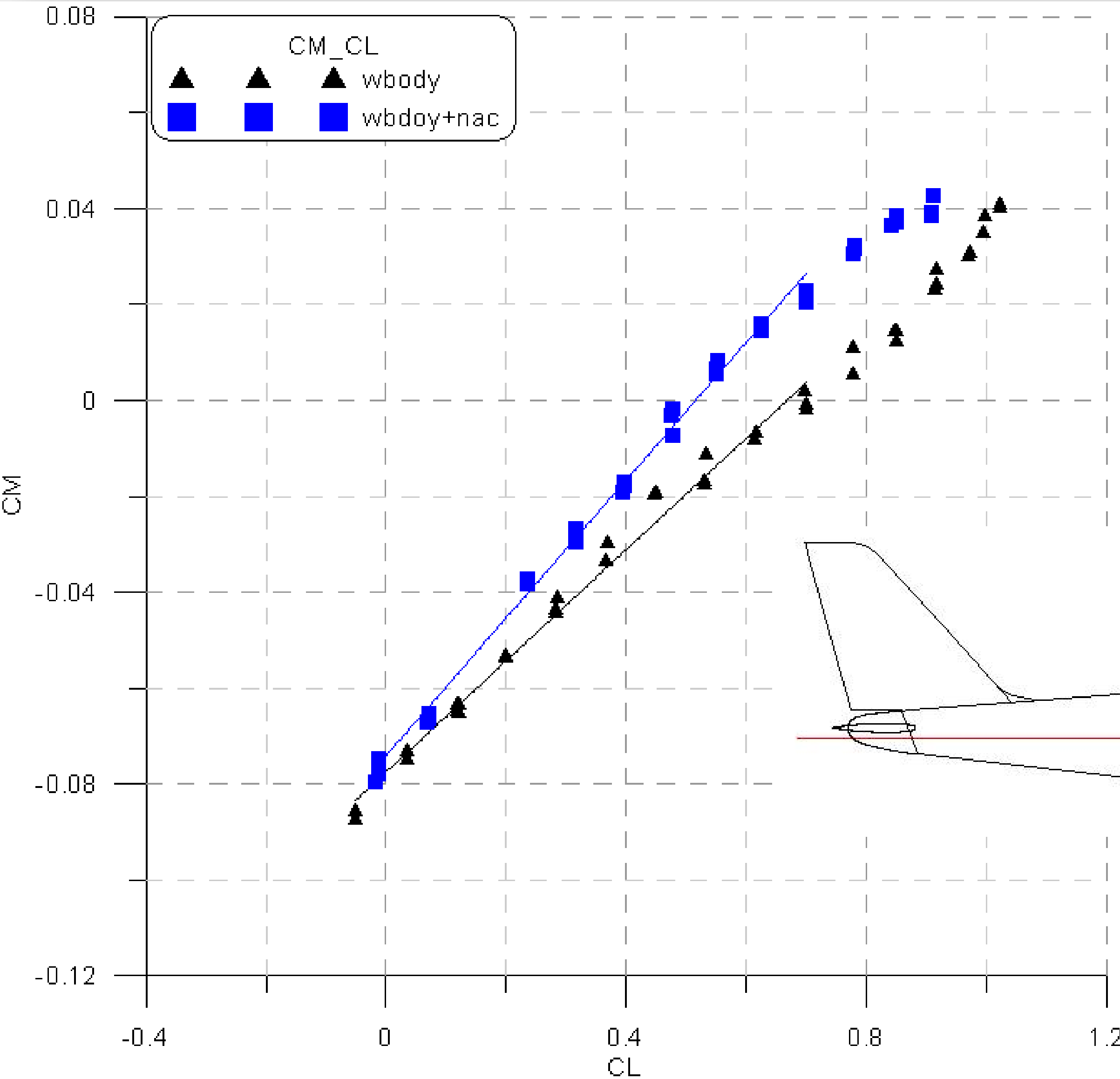
$$\Delta CL_{NAC} = -0.048$$



LIFT (stall path)



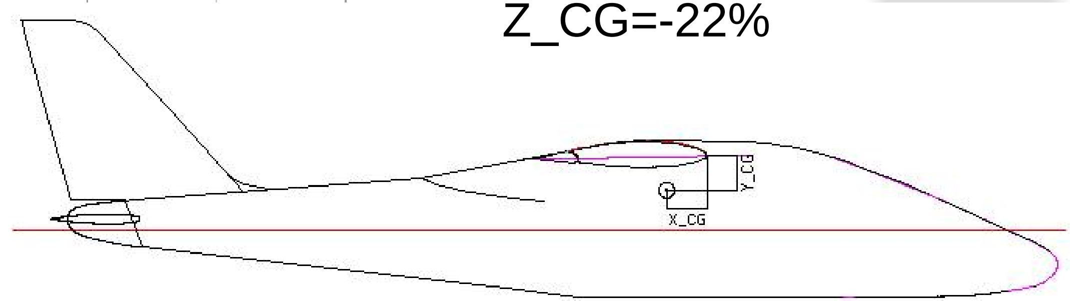
WB mom curve



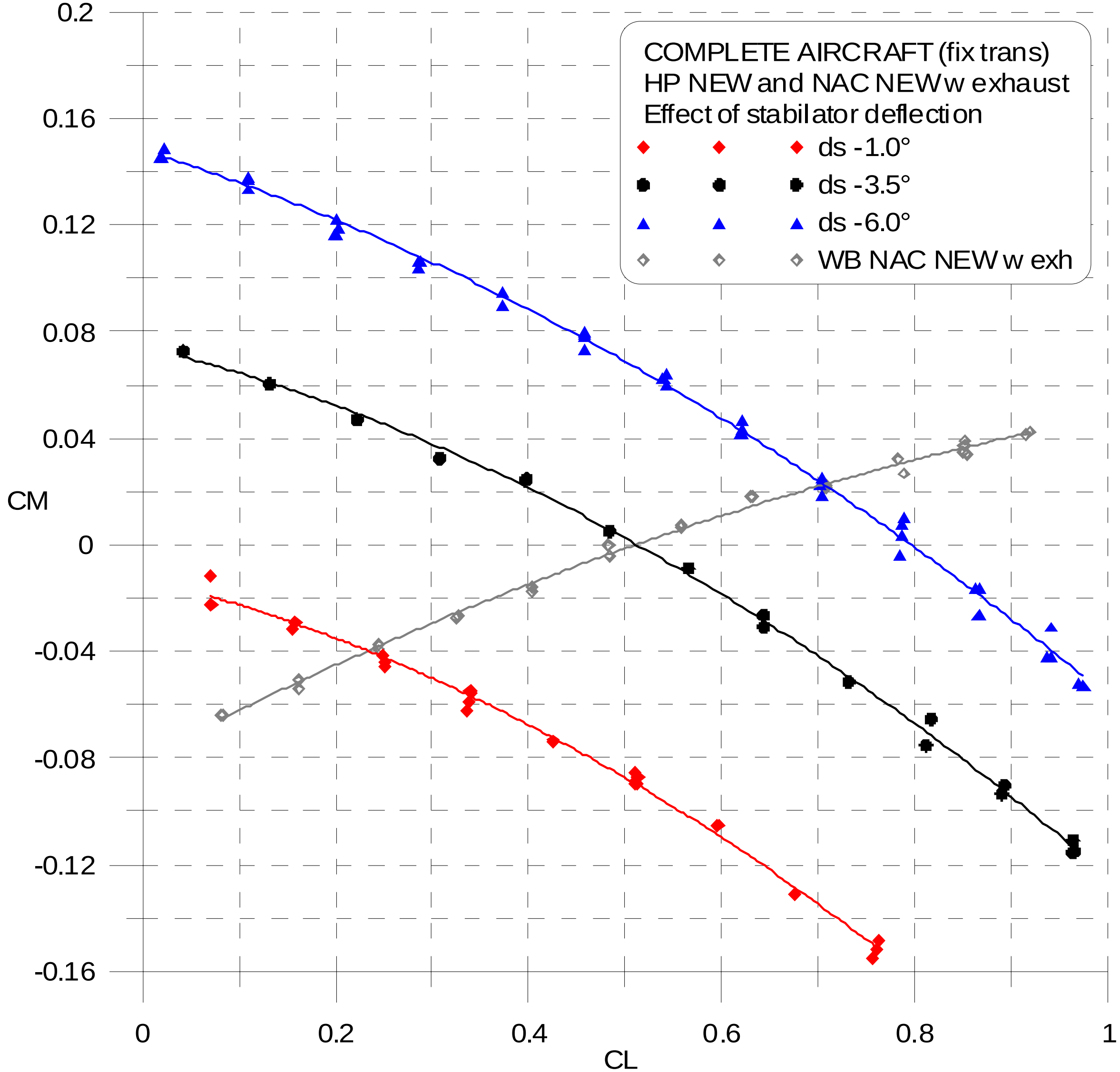
$X_{AC\_WB} = 14\,\%\ MAC$

$X_{AC\_WB+NAC} = 11\,\%\ MAC$

X_CG=25%
Z_CG=-22%



Long Stab & Control



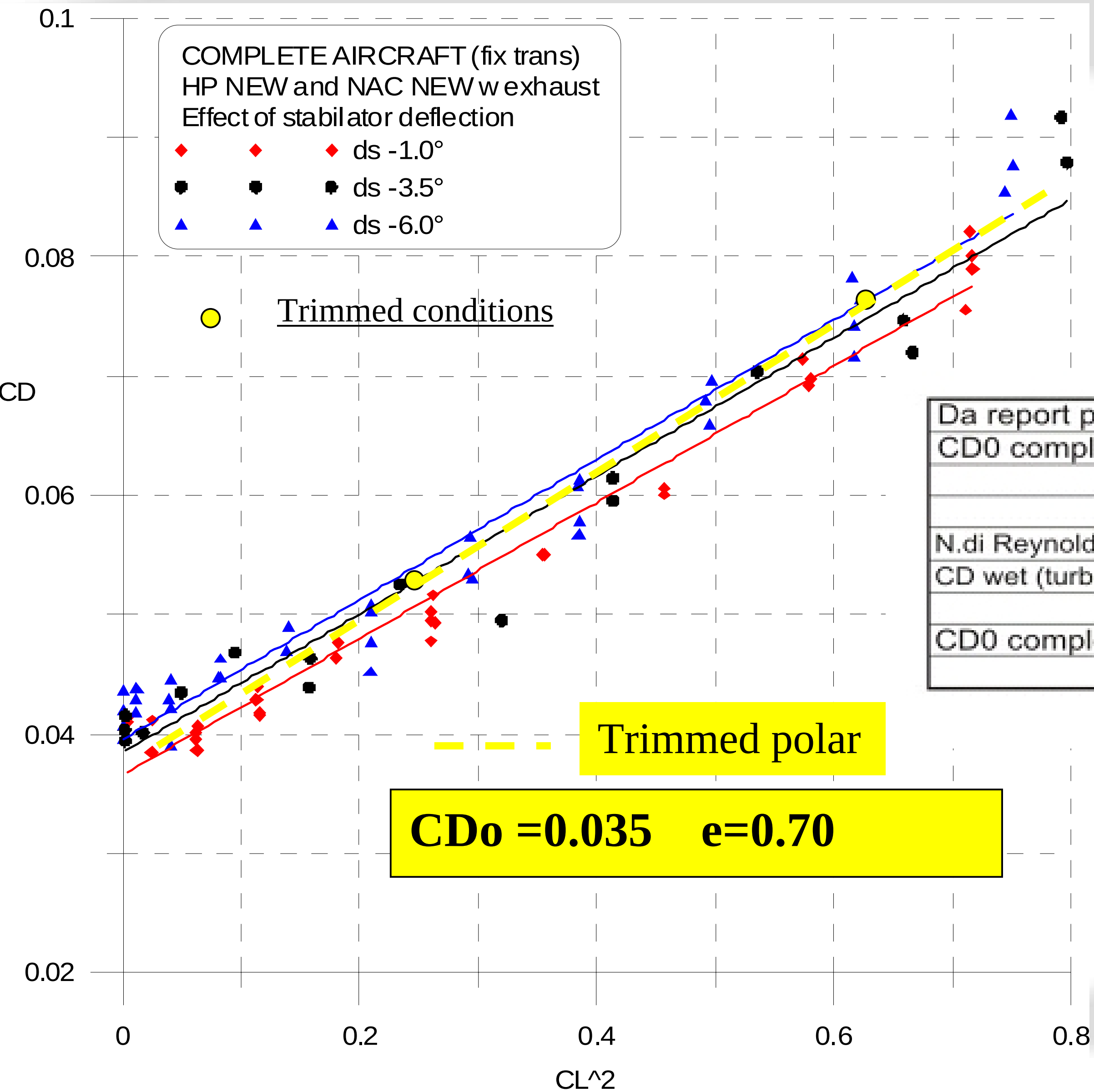
No = 38% in cruise cond.

Pendular stability

CM_ds = 0.033 [1/°]

1.89 [1/rad]

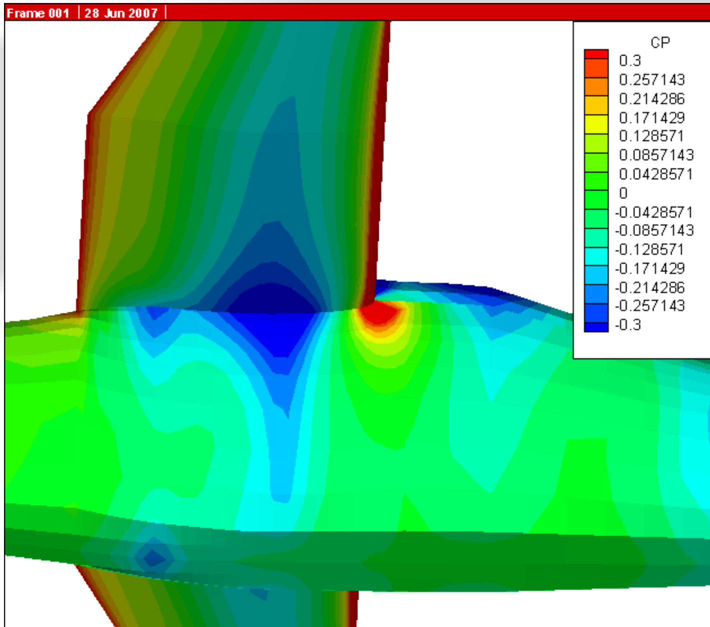
Complete aircraft trimmed polar (NO WINGLET)

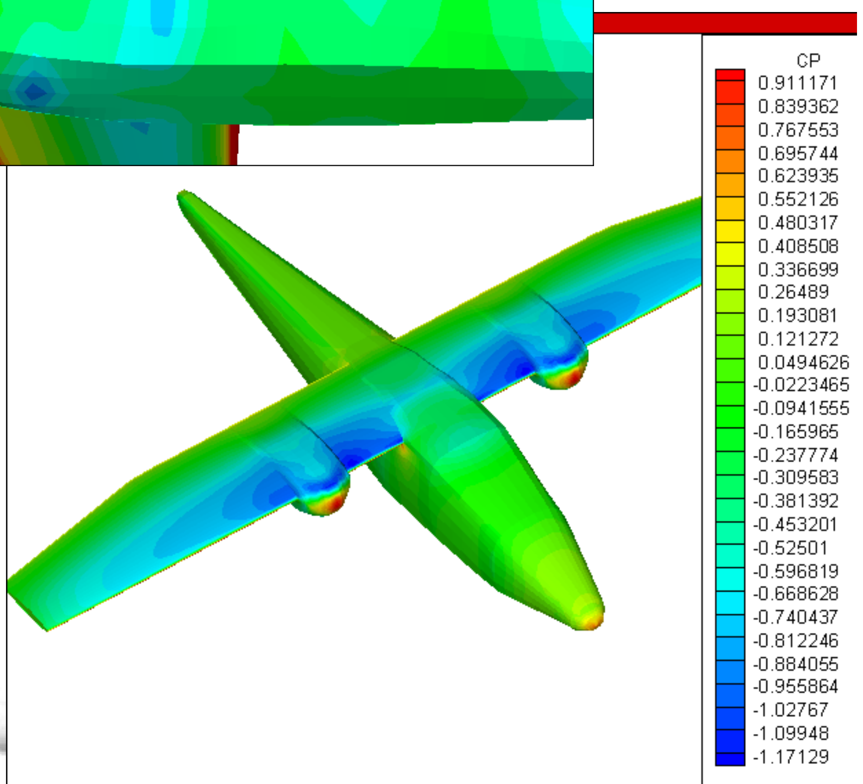


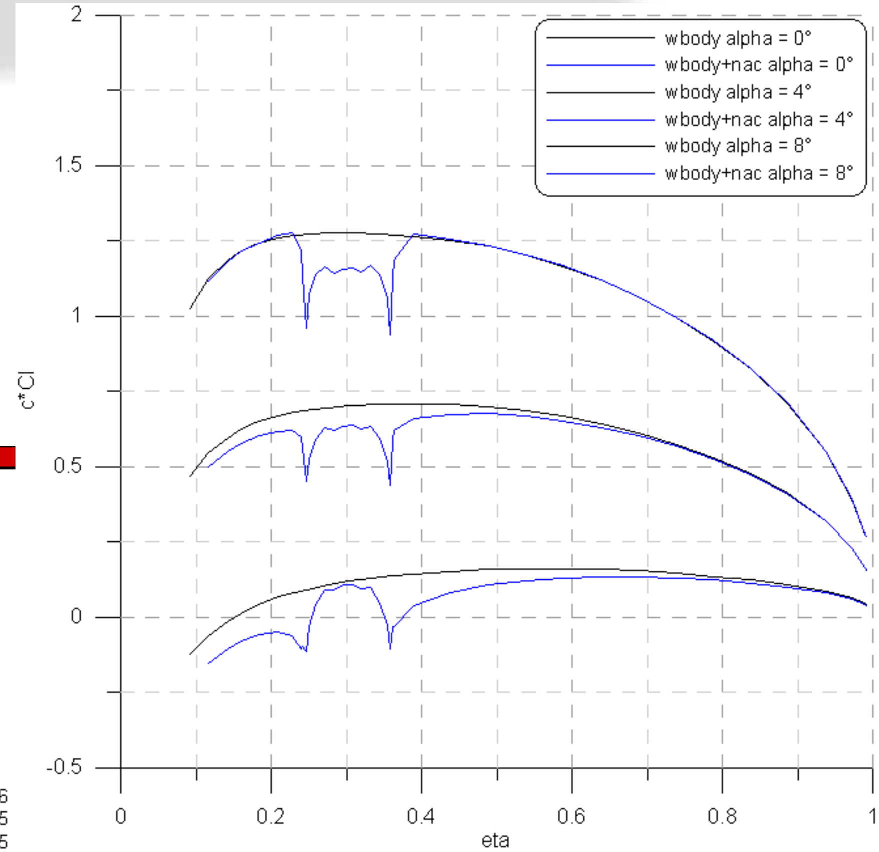
Da report prove tunnel			
CD0 complete aircraft trimmed condit.			**0.0360**
	Tunnel	Volo	
N.di Reynolds	600.000	7.000.000	Rapporto
CD wet (turbul.)	0,00483	0,00306	0,633
CD0 complete aircraft corretto per N.R.			**0,0254**
		Area parassita	**0,361**

Flight polar
C_{D0}=0.0254 f=0.361m^2

Fuselage and nacelle effect on wing-span load



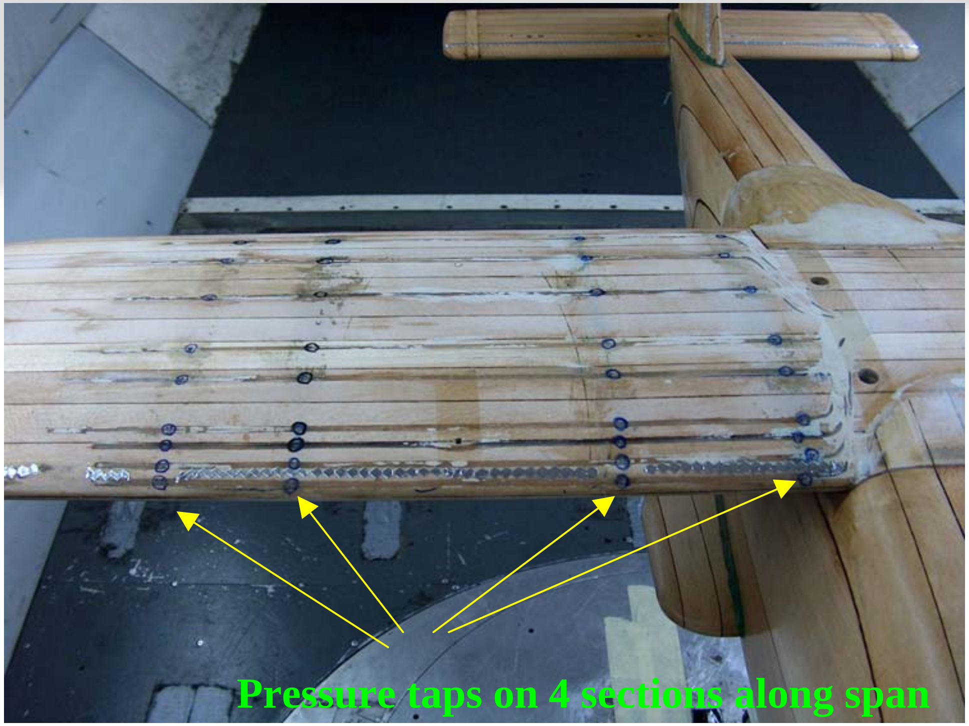


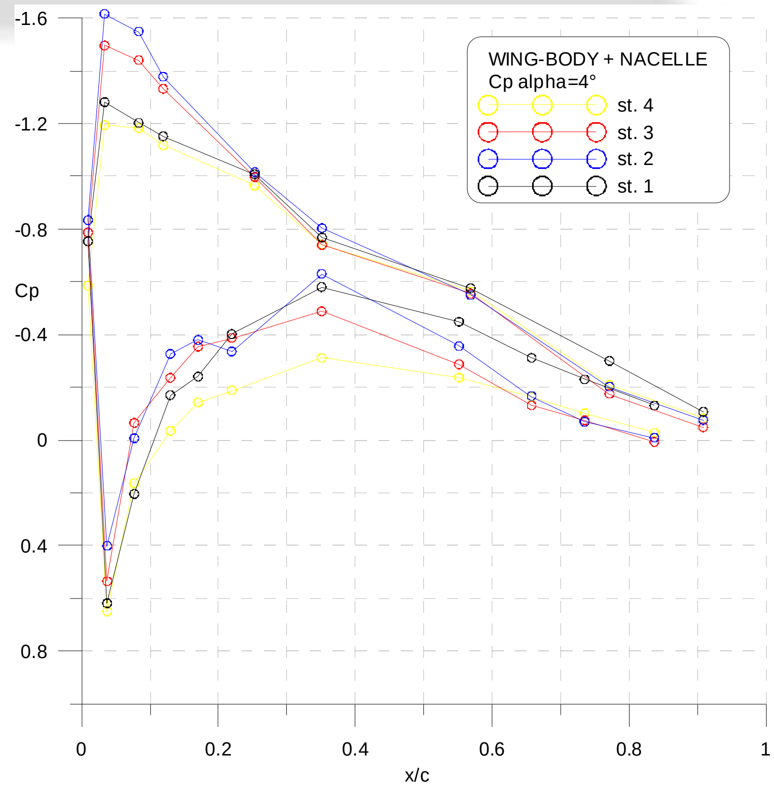


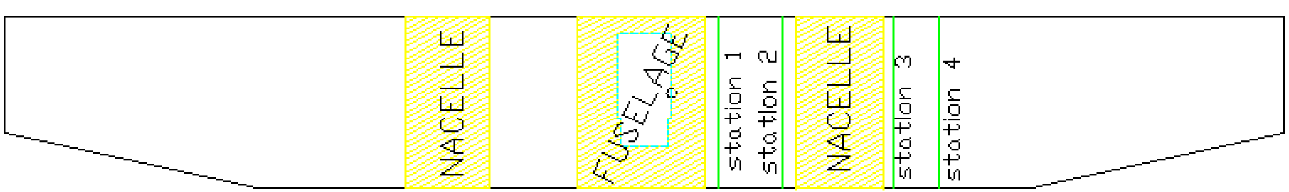
Numerical analysis

Fuselage and nacelle effect on wing-span load

Wind-tunnel tests

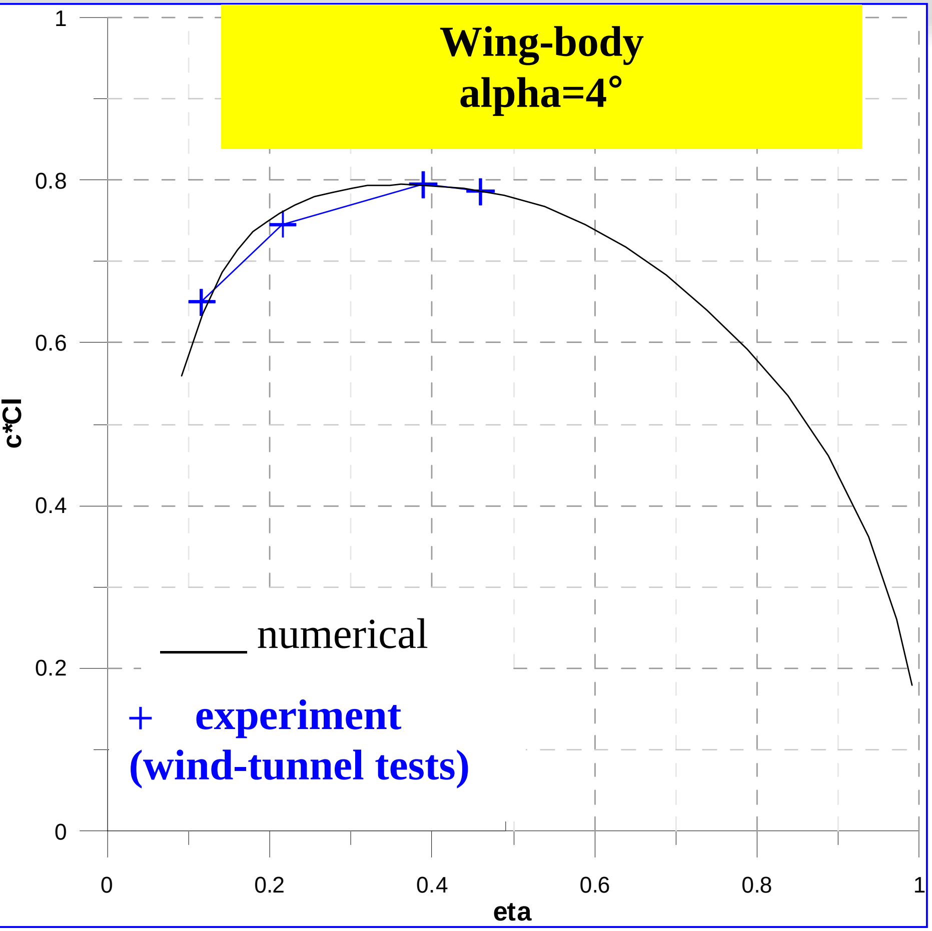


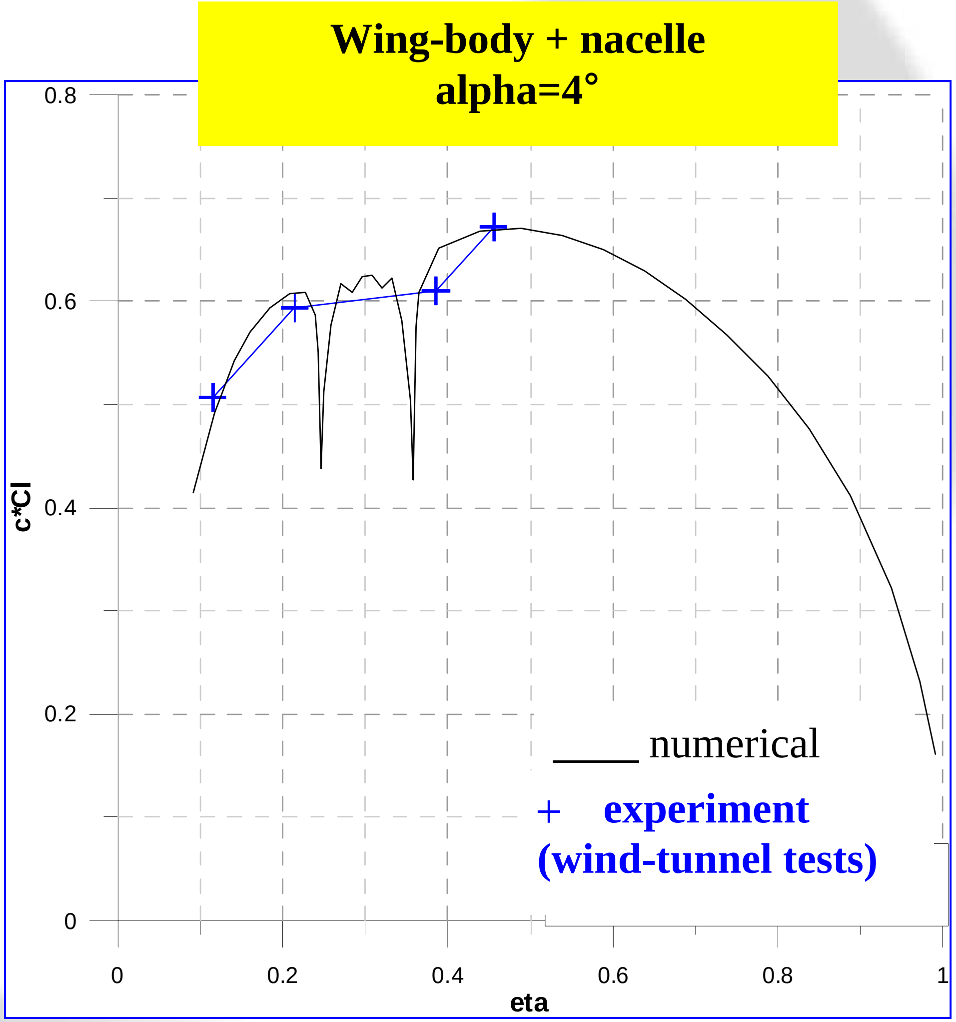




Fuselage and nacelle effect on wing-span load

Wind-tunnel tests

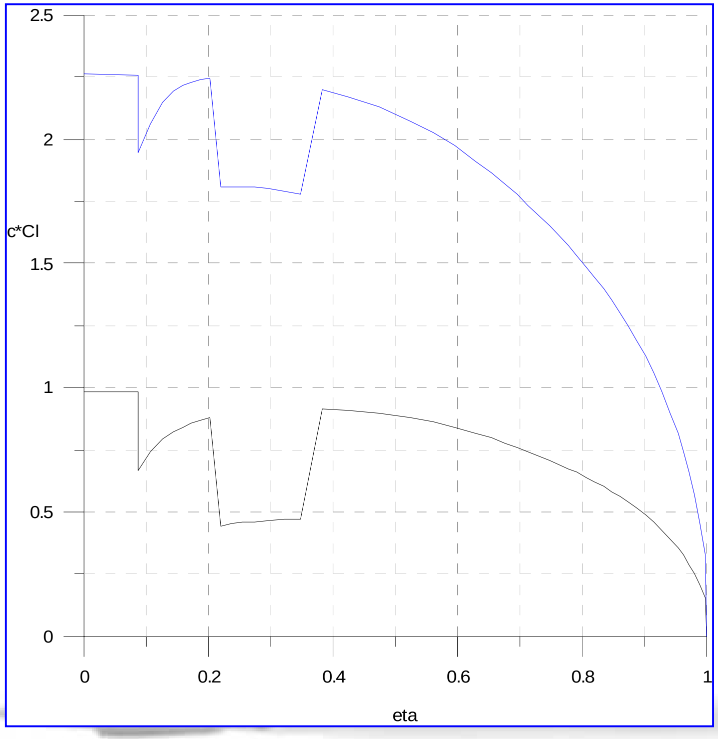


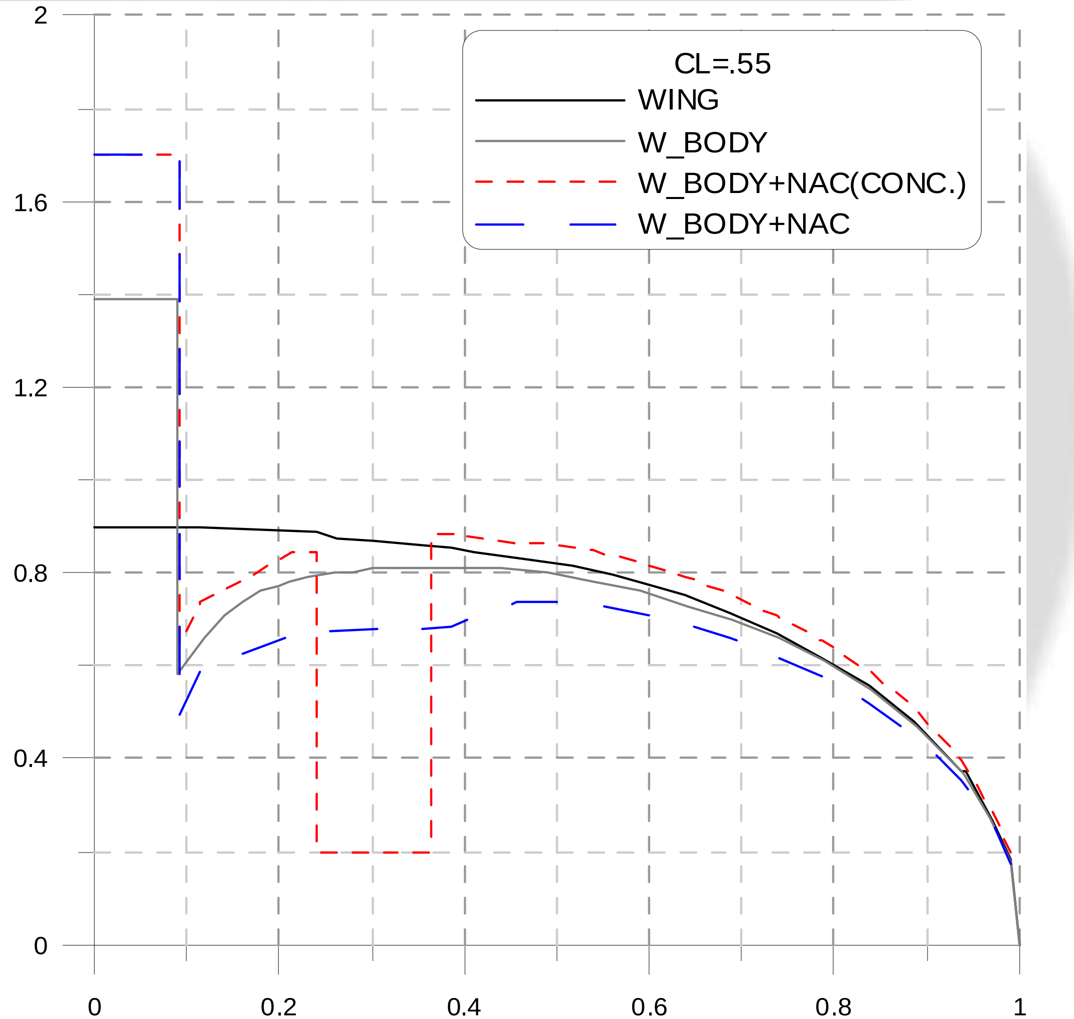


Effects on span aerodynamic loading (certification & evaluation of flight loads)

D point of Man. Diagram

CL=0.535
n=3.8

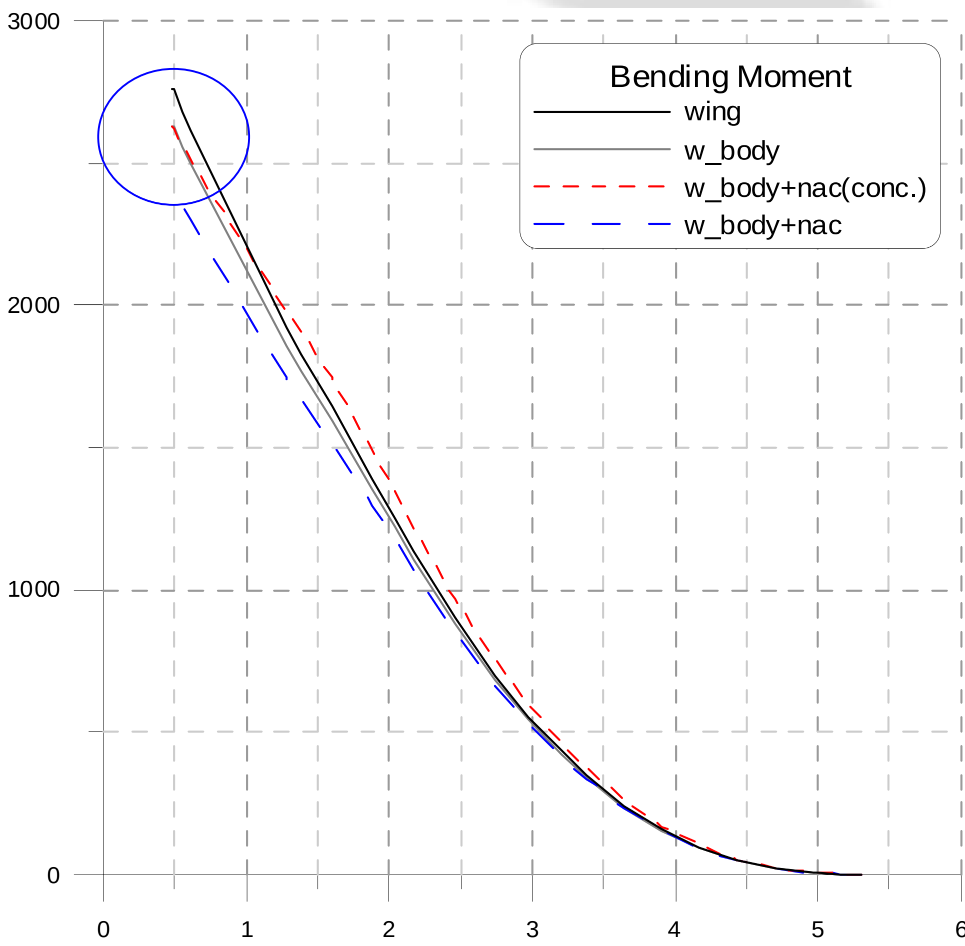




Effects on span aerodynamic loading (certification & evaluation of flight loads)

Up to 10% difference In "bending" moment @ junction

The calculation and experiments were able to demonstrate a possible 10% increase of aircraft weight to cert. authorities



WINGLET DESIGN SPECIFICATIONS

⇒ **After first flight without winglets it was noticed a low (even accettable for certification) RC in OEI cond.**

⇒ **Very important to improve induced drag**

⇒ **Minor modification to the wing structure**

⇒ **Contained increase of wing bending moment at root** (about 5-7%).

DESIGN

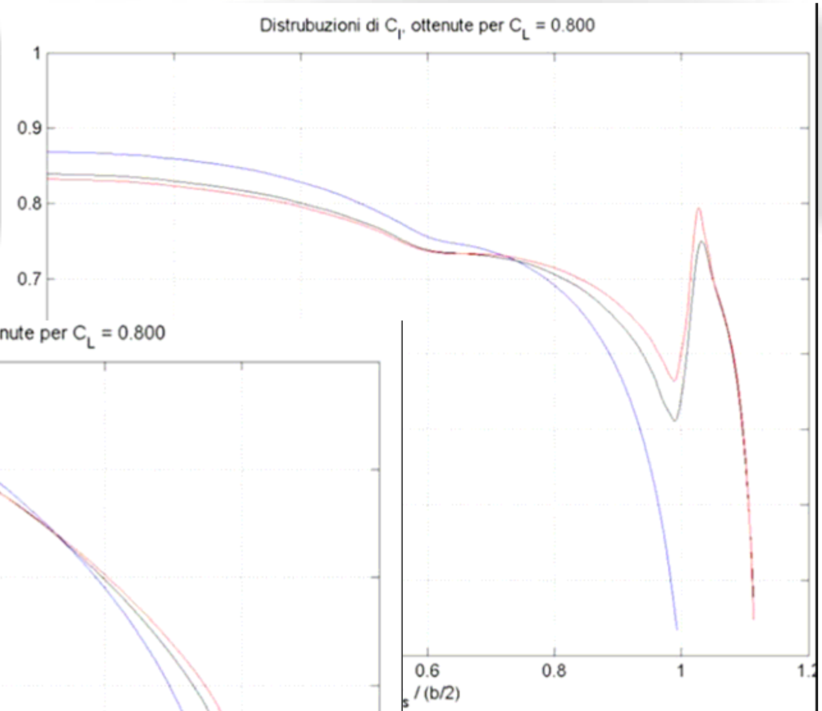
⇒ **HEIGHT limited to 60 cm.**

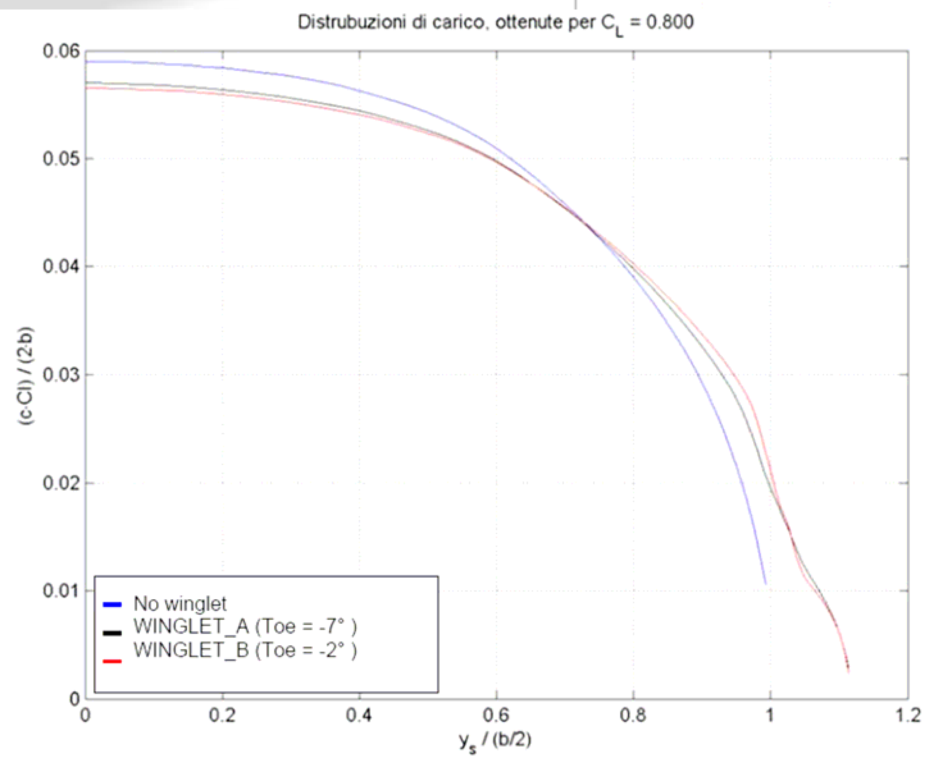
⇒ **To include appropriate wing-winglet fairing wing span was changed from 11.20 to 11.40 m.**

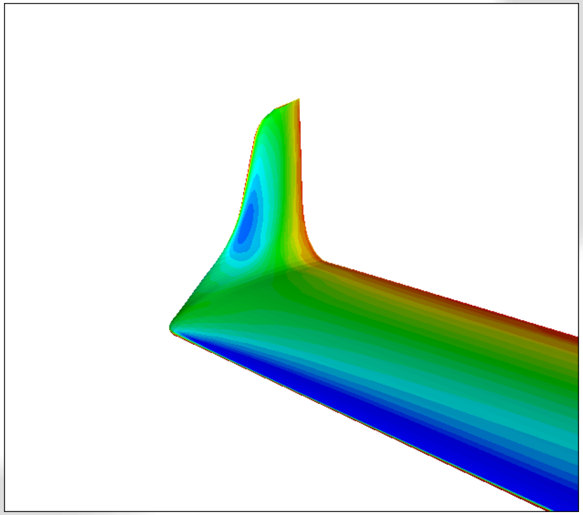
⇒ **The wetted area was only 1% higher of the original tip**

⇒ **Increase in bending moment was limited to 5%**

WINGLET DESIGN







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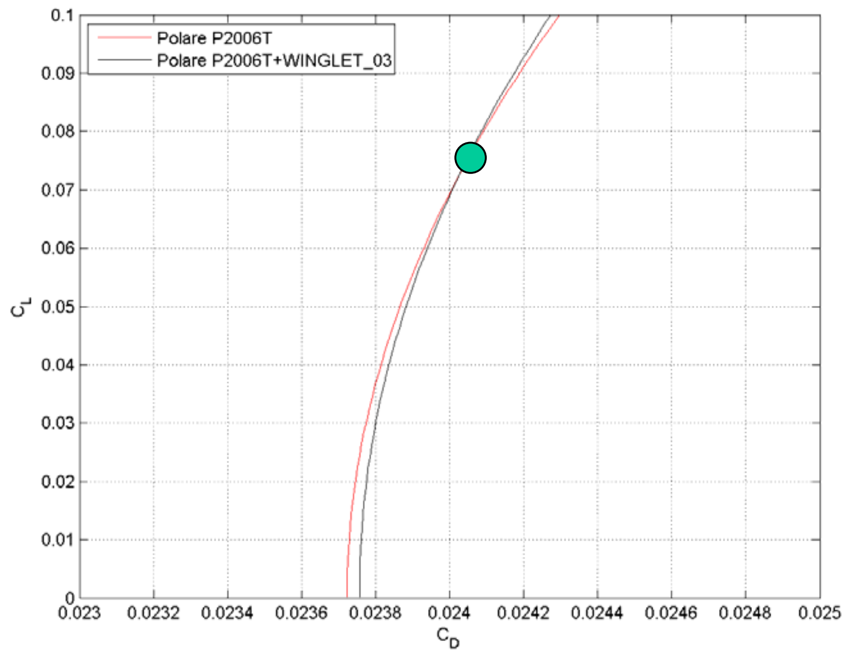
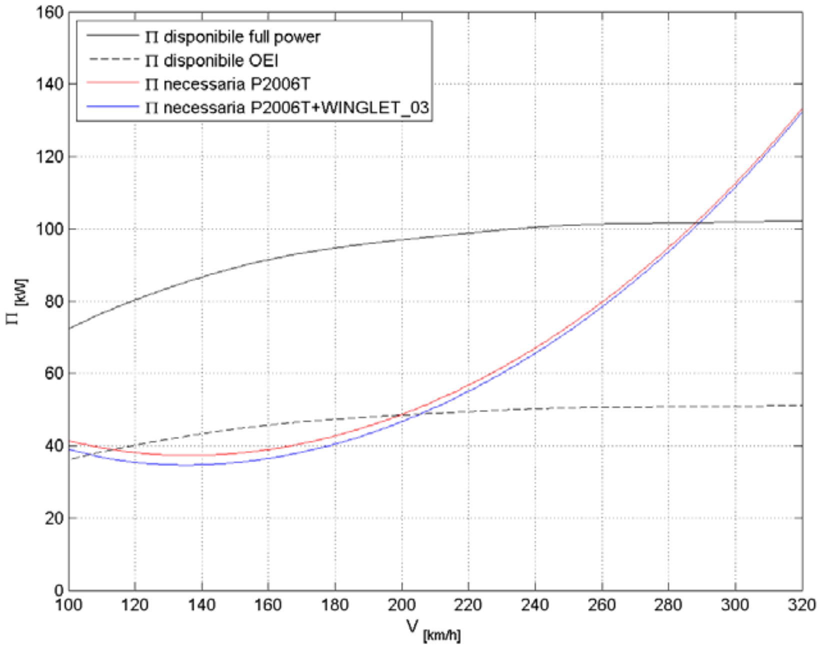
WINGLET aerodynamic effects

ESTIMATED AIRCRAFT PERFORMANCES (OEI) - 6000 ft





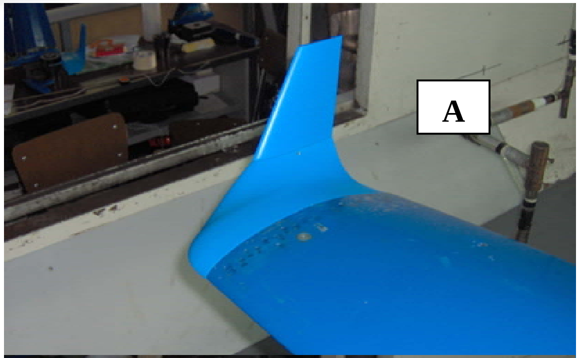
MAX RC increase @ S/L

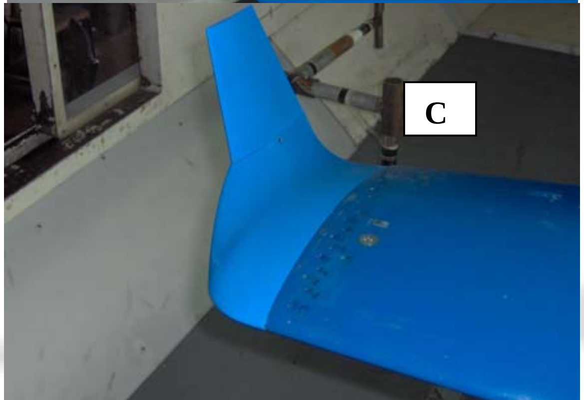
NO WLET	WLET
120 ft/min	320 ft/min

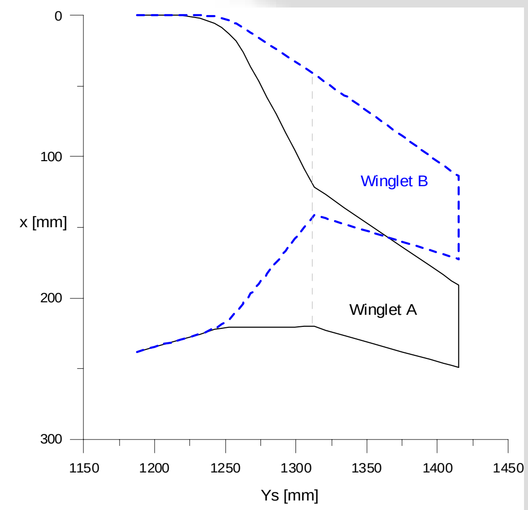
(ESTIMATIONS)

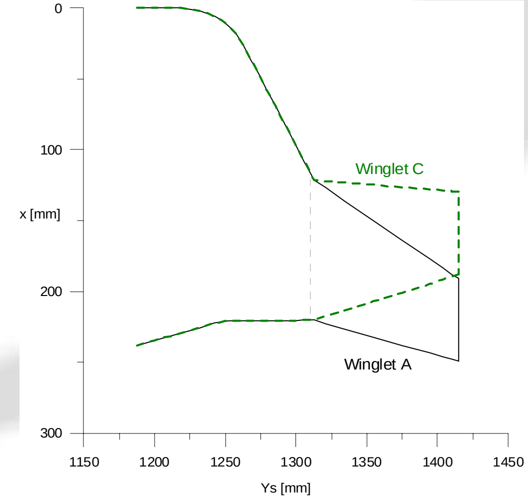
WINGLET TESTS

• Wind-tunnel tests were performed on similar winglet shape mounted on an elliptical wing semi-model.



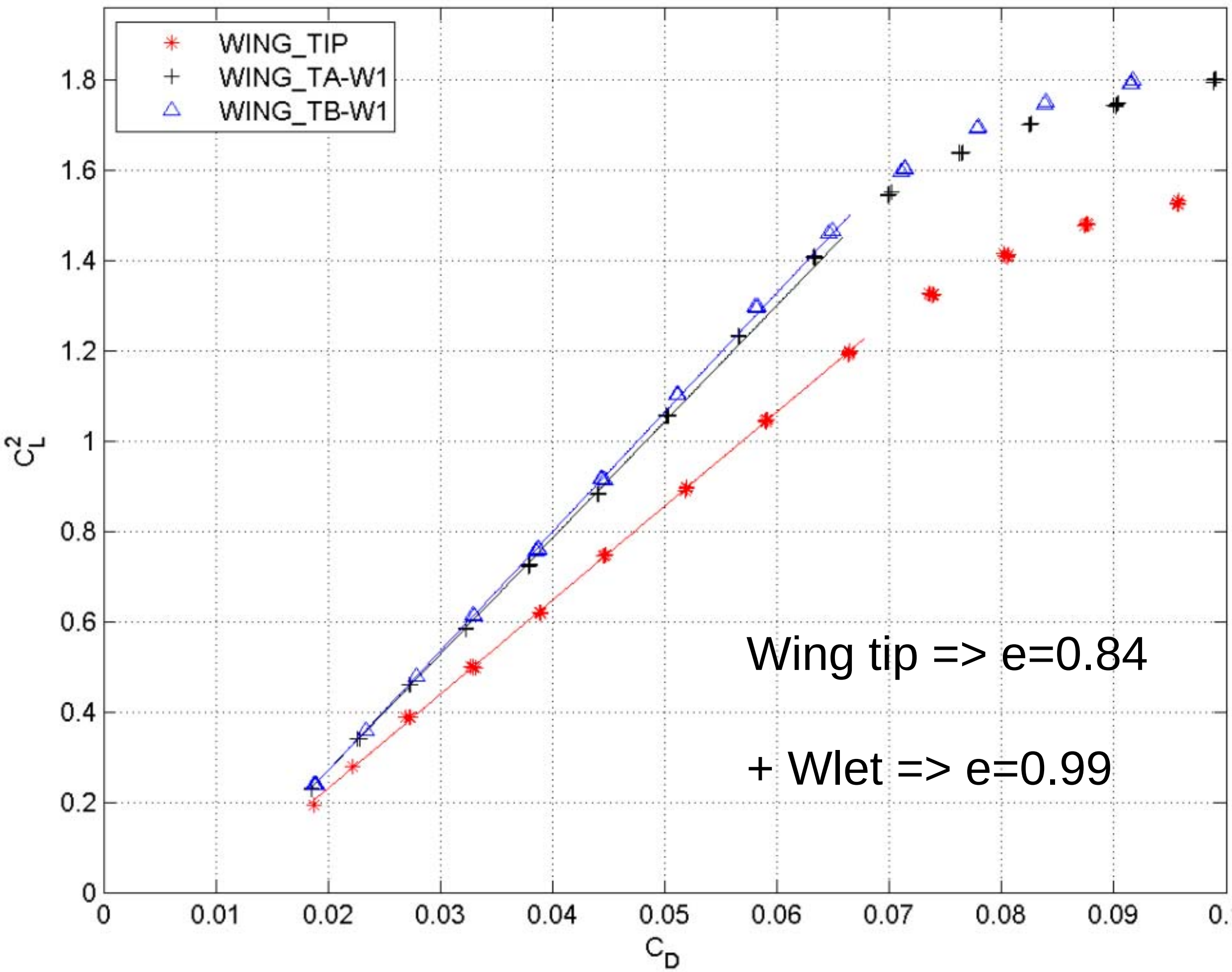






WINGLET WT TESTS

As numerical calculations both winglet A and B (with different and well designed root toe angles) showed an oswald factor gain of about 15%.



WINGLET EFFECTS :
=> FLIGHT TESTS

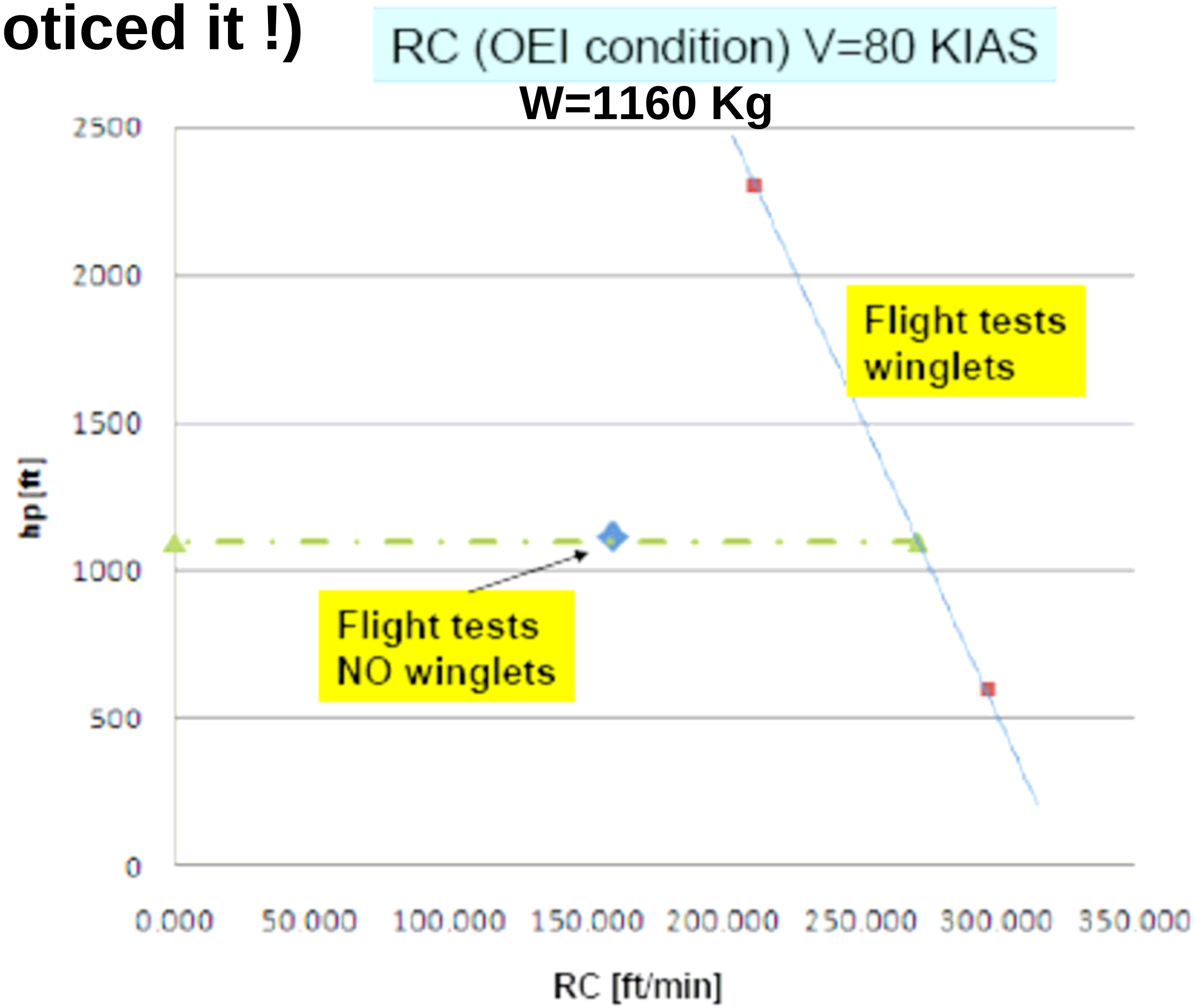
The oswald factor should increase from 0.70 (model wt tests, including nacelle effects) to about 0.85 !!

FINAL ESTIMATED DRAG POLAR
CDo=0.027 (f=0.40 m2) e=0.85

WINGLET EFFECTS

In OEI condition RC was increased by 170 to 280 fpm !

(The pilot clearly noticed it !)



…al prototipo…

Flight Performances

Peso massimo al decollo	1180 kg
Carico alare	80 kg/m^2
Stall speed	56 kts
Stall speed flap down	47 kts
Best Rate-of climb-speed (Vy)	80 kts
Take-off run - ground	235 m
Take-off distance	450 m
MAX Rate of climb	1300 ft/m' (6.6m/s)
EFF CEILING	>15000 ft (4570m)
MAX Rate of climb (OEI)	300 ft/m'
Max lev speed	151 kts
Cruise 75% @ 7000ft	145 kts
Autonomia specifica cruise 65%	7.5 km/lt
Cruise Range	600 nm

COSTRUZIONI AERONAUTICHE
TECNAM

General performance parameter introduced by Oswald NACA TR 408 of 1932

$$\Lambda = \frac{\lambda_S \cdot \lambda_T^{4/3}}{\lambda_P^{1/3}}$$

λt = W/(ηPa) Weight/propulsive power

λs = W/(eb^2) Weight/effective wing span

λp = W/f Weight/parassite area

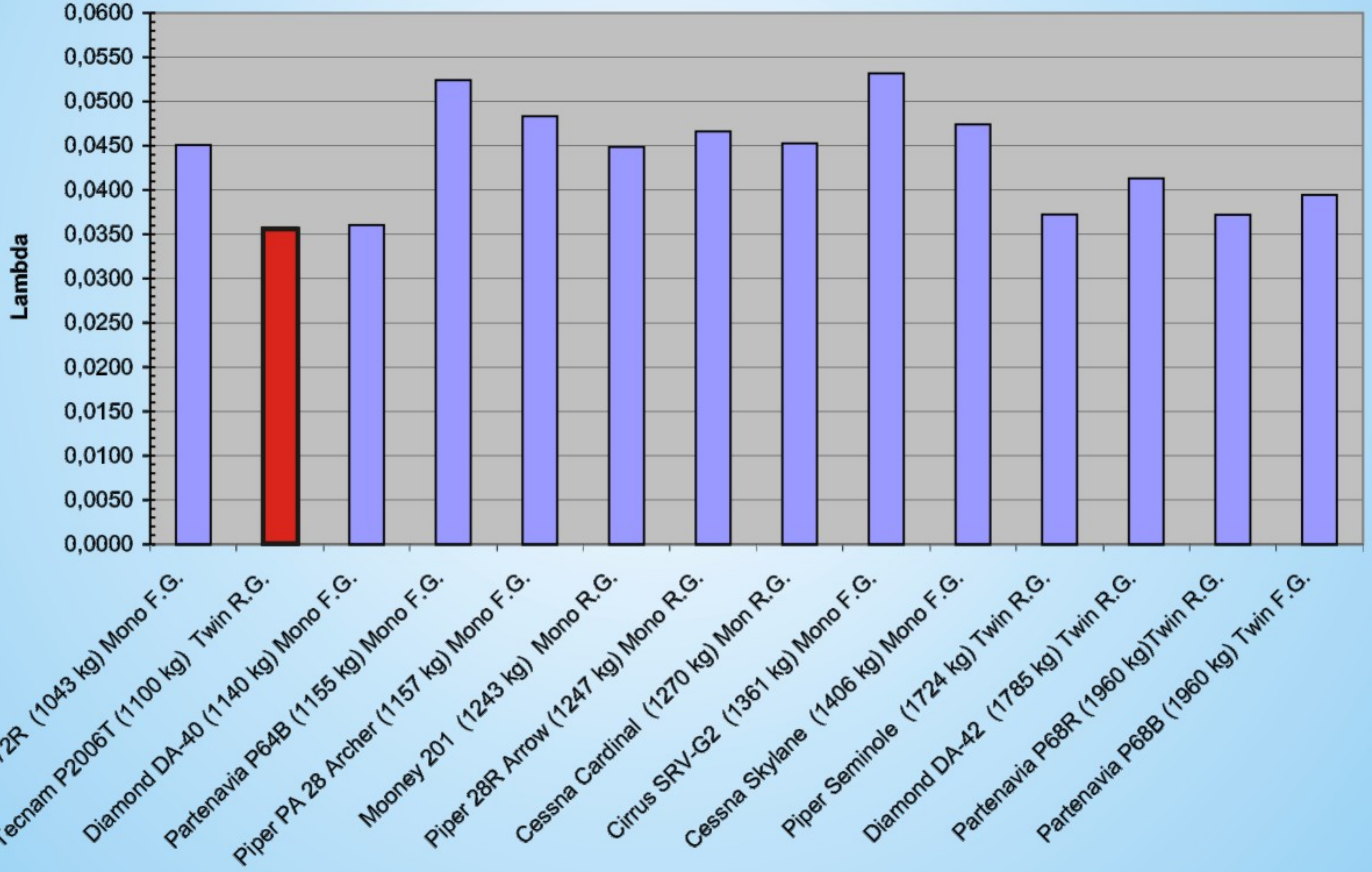
Ratios that indicates:

- Available Thrust energy
- Energy used to produce Lift
- Energy used to win flight drag

Indicates aircraft performances

LOWER Λ => HIGHER PERFORMANCES

Parametro di *performance*



APPLIED RESEARCH AND EDUCATION:

In both research activities (EASY-FLY and P2006T) :

- **3 research contracts for DIAS**
- **6 months wind-tunnel tests (3 m. EASY-FLY, 3 m. P2006T)**
- **10 MSC thesis**
- **2 PHD thesis**
- **6 grants for graduated neo-engineers**

ALL the research was really applied

2 of them were employed

THANKS FOR THE ATTENTION and…

…. See you soon …..