7th EUROPEAN WORKSHOP ON AIRCRAFT DESIGN EDUCATION (EWADE 2005)

Laurea Specialistica in Ing Aerospaziale
(MSc in Aerospace Eng.)

Corso: PROGETTO DI AEROMOBILI

(Course: AIRCRAFT DESIGN)

Credits: 10 - Total hours: 115 (L. 80 + E. 35)

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POLITECNICO TORINO,
Dept. of Aerospace Engineering

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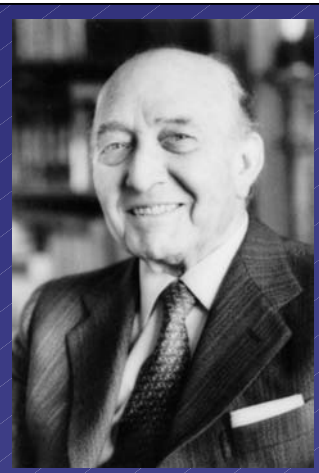
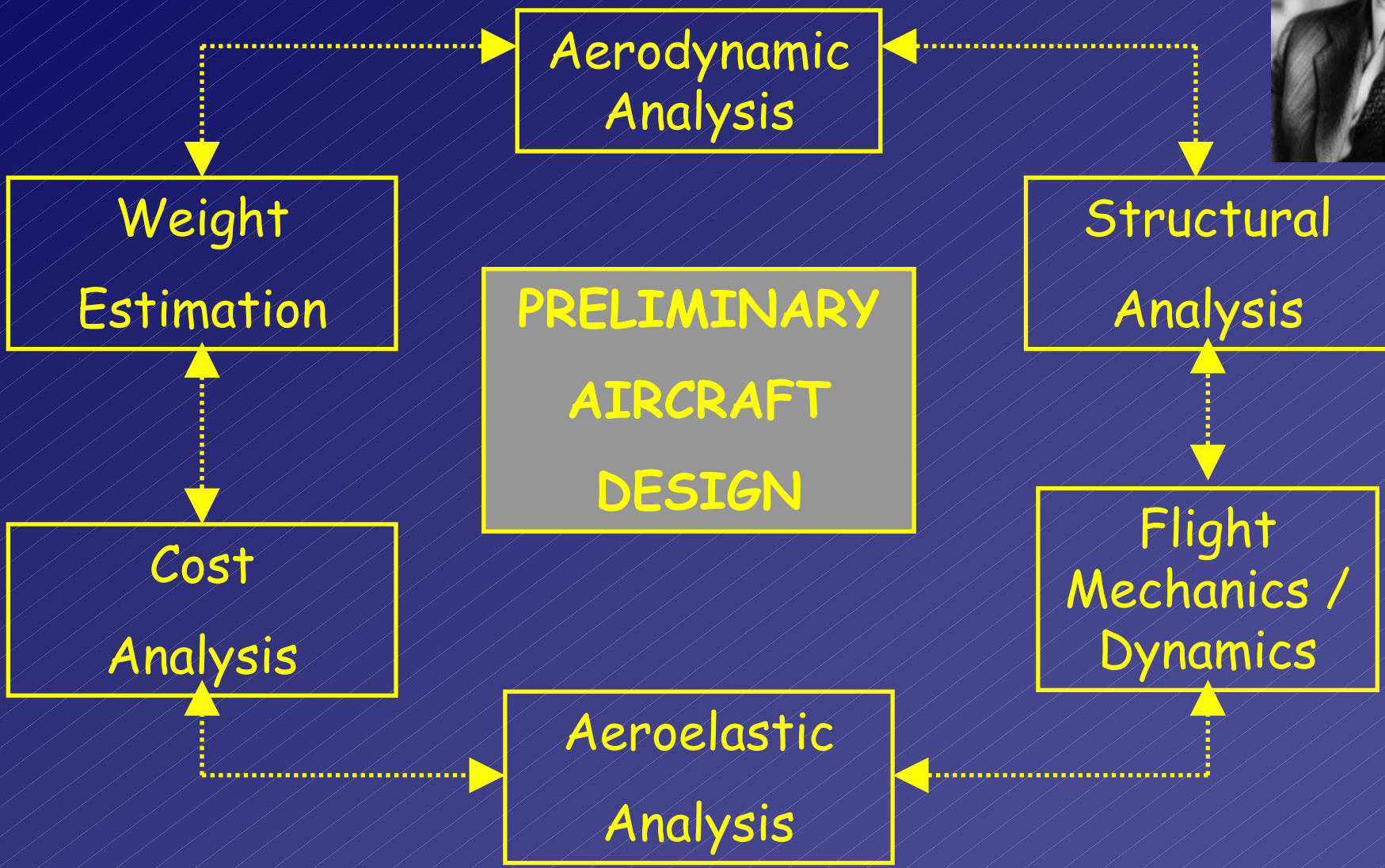
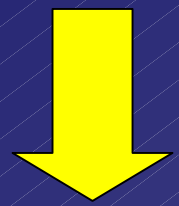
LA SCIENZA DEL PROGETTO DI AEROMOBILI
Prof. Ing. Giuseppe GABRIELLI

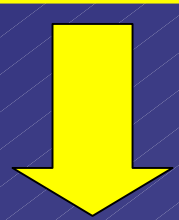




Theories and/or empirical methods concerning a single design aspect



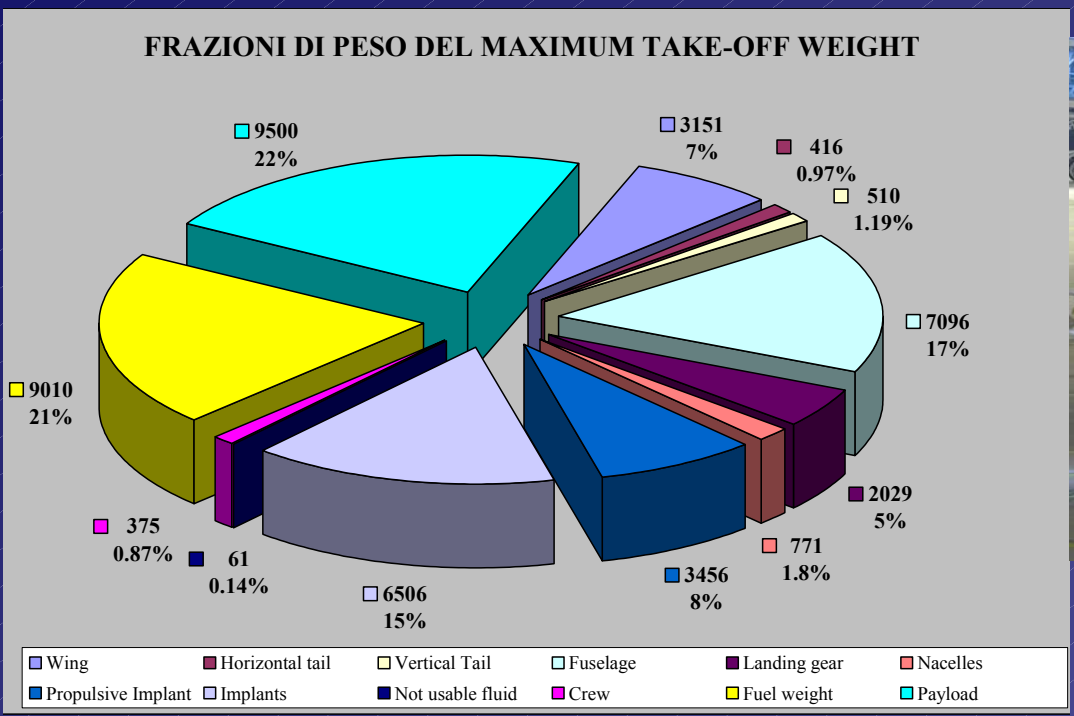
Use of commercial software and/or self-developed software to solve specific problems



Preliminary aircraft design by integration of the previously developed tools

Weight Estimation

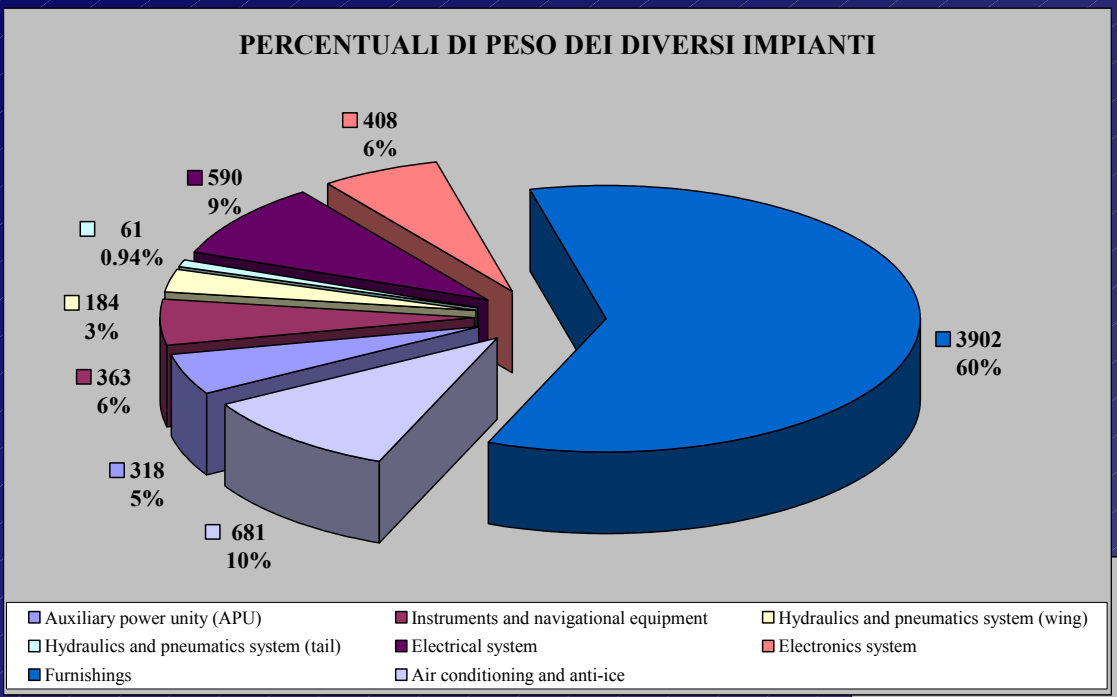
By adopting empirical methods, commonly found in literature (Torenbeek, Jenkinson, Stanford Univ., Howe, Raymer, etc…) and statistical data, students develop a software to evaluate total aircraft mass and masses of each of the sub-systems (structure, propulsion group, crew, equipments…)



Overall Aircraft Weight Breakdown

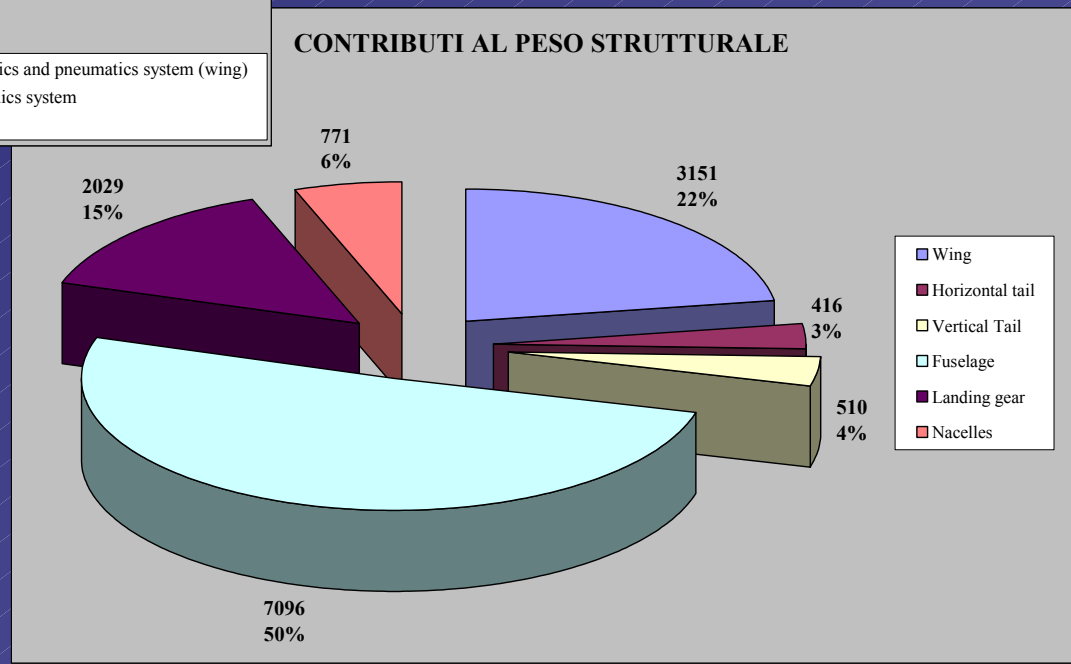
(Avro RJ100)

Weight Estimation



Systems Breakdown

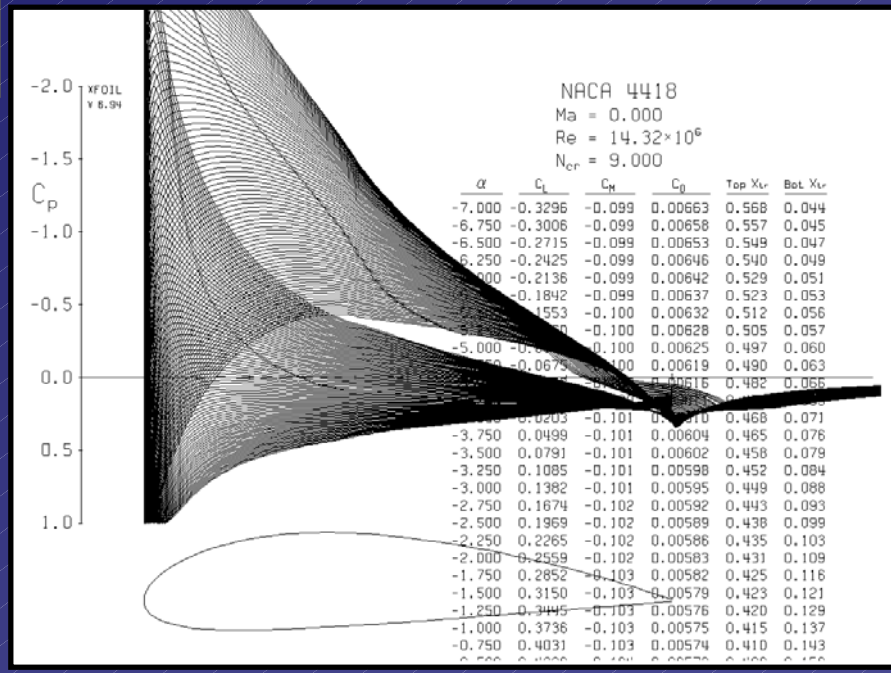
Structure Breakdown



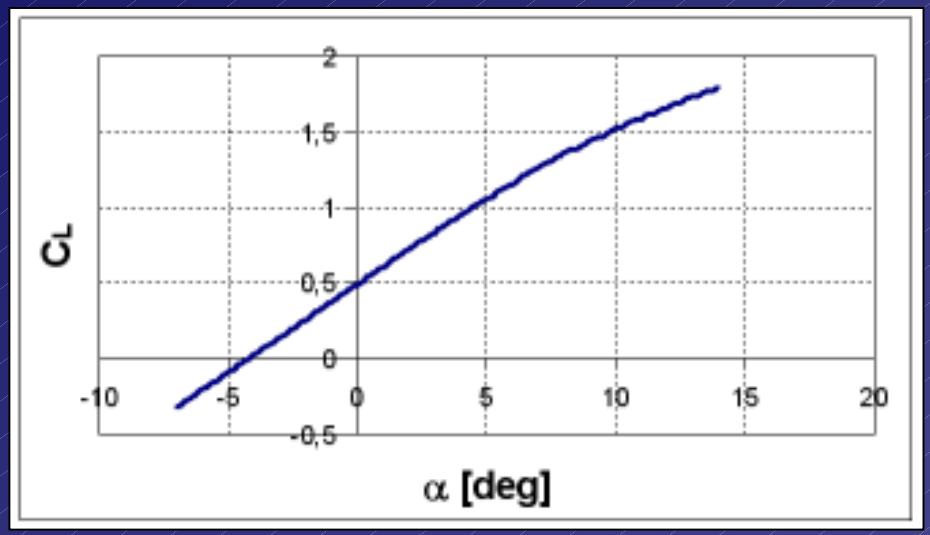
Aerodynamic Analysis

Airfoil → Wing → Aircraft

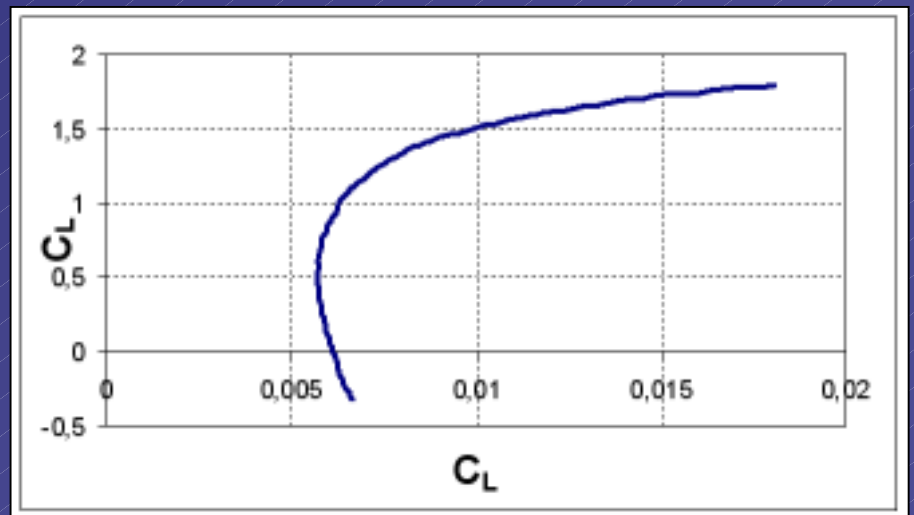
The panel code *XFOIL* has been used to study airfoil performances in subsonic flows…



α	C_L	C_M	C_D	Top X_{tr}	Bot X_{tr}
-7.000	-0.3296	-0.099	0.00663	0.568	0.044
-6.750	-0.3006	-0.099	0.00658	0.557	0.045
-6.500	-0.2715	-0.099	0.00653	0.549	0.047
-6.250	-0.2425	-0.099	0.00646	0.540	0.049
-6.000	-0.2136	-0.099	0.00642	0.529	0.051
-5.750	-0.1842	-0.099	0.00637	0.523	0.053
-5.500	-0.1553	-0.100	0.00632	0.512	0.056
-5.250	-0.1260	-0.100	0.00628	0.505	0.057
-5.000	-0.0967	-0.100	0.00625	0.497	0.060
-4.750	-0.0675	-0.100	0.00619	0.490	0.063
-4.500	-0.0382	-0.100	0.00616	0.482	0.066
-4.250	-0.0089	-0.101	0.00610	0.468	0.071
-3.750	0.0499	-0.101	0.00604	0.465	0.076
-3.500	0.0791	-0.101	0.00602	0.458	0.079
-3.250	0.1085	-0.101	0.00598	0.452	0.084
-3.000	0.1382	-0.101	0.00595	0.449	0.088
-2.750	0.1674	-0.102	0.00592	0.443	0.093
-2.500	0.1969	-0.102	0.00589	0.438	0.099
-2.250	0.2265	-0.102	0.00586	0.435	0.103
-2.000	0.2559	-0.102	0.00583	0.431	0.109
-1.750	0.2852	-0.103	0.00582	0.425	0.116
-1.500	0.3150	-0.103	0.00579	0.423	0.121
-1.250	0.3445	-0.103	0.00576	0.420	0.129
-1.000	0.3736	-0.103	0.00575	0.415	0.137
-0.750	0.4031	-0.103	0.00574	0.410	0.143



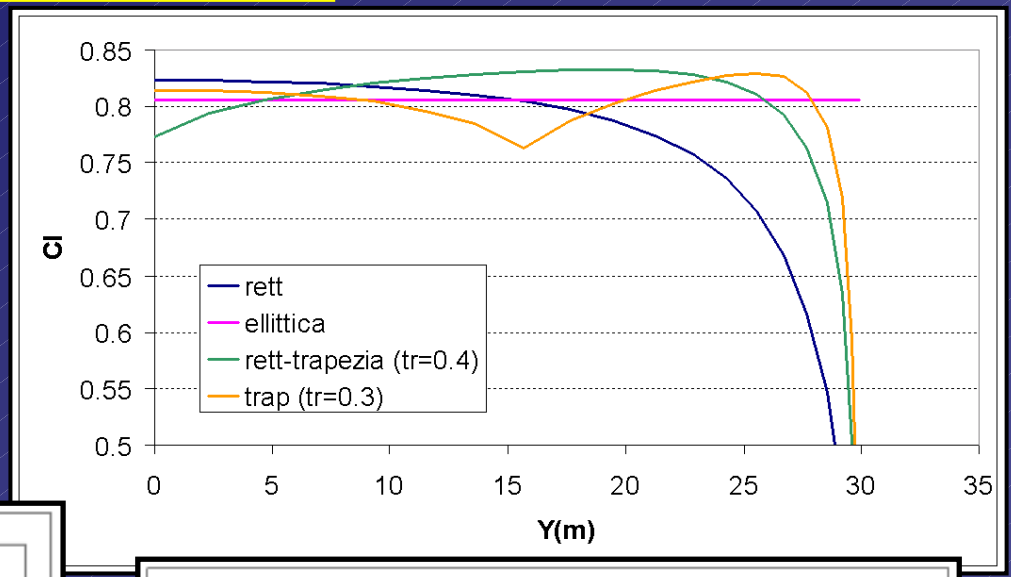
… and to draw Cl-α and polar curves

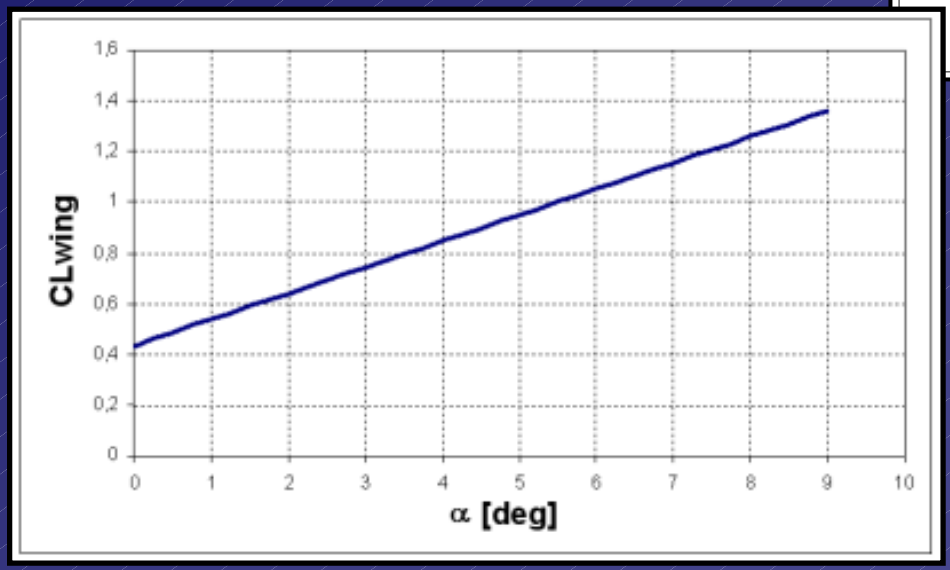


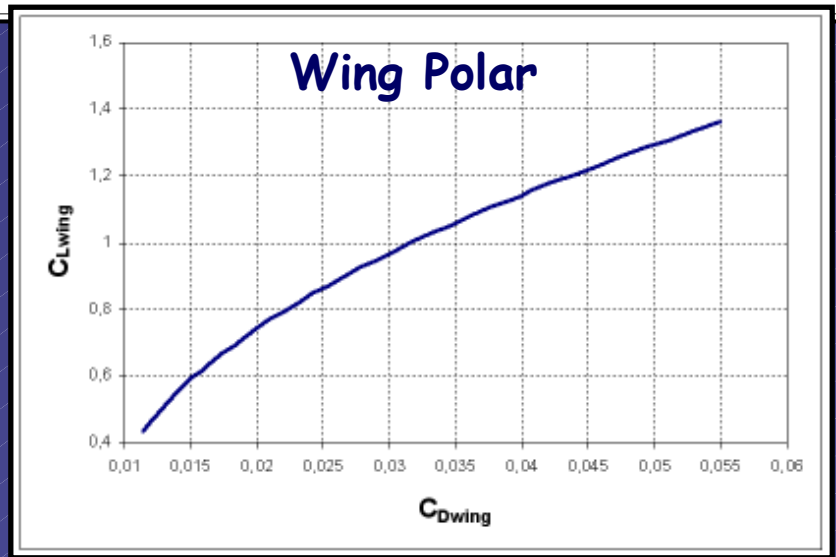
Aerodynamic Analysis

Airfoil → Wing → Aircraft

XFOIL results and Prandtl lifting line theory are implemented in a software developed by students in order to study wing aerodynamic behaviour





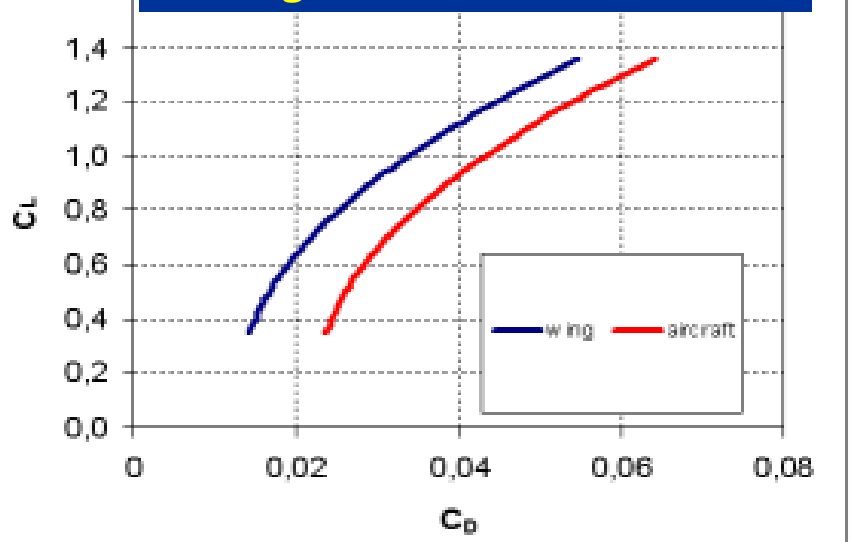


Aerodynamic Analysis

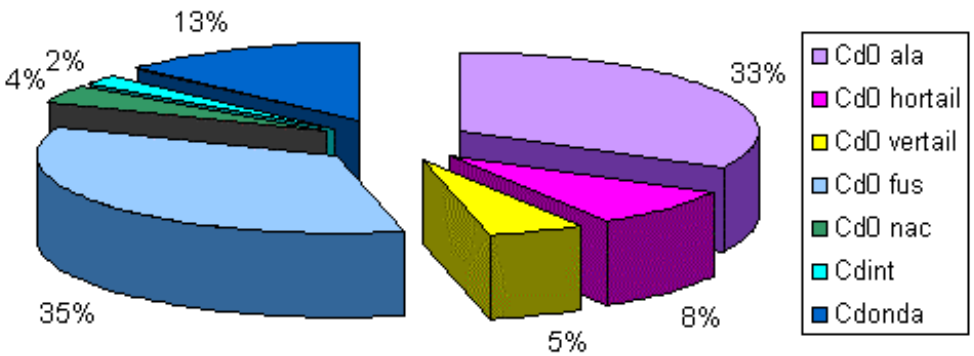
Airfoil → Wing → Aircraft

Parasite drags due to aircraft components are evaluated through empirical methods, allowing aircraft polar to be plotted

Wing and Aircraft Polar



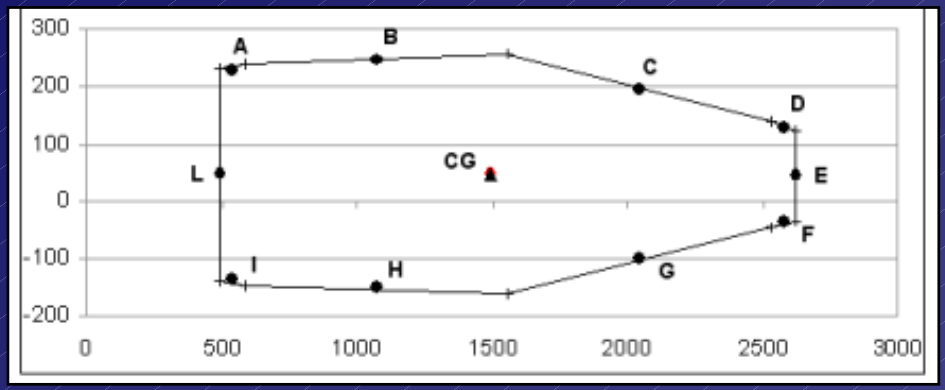
Parasite Drag Breakdown

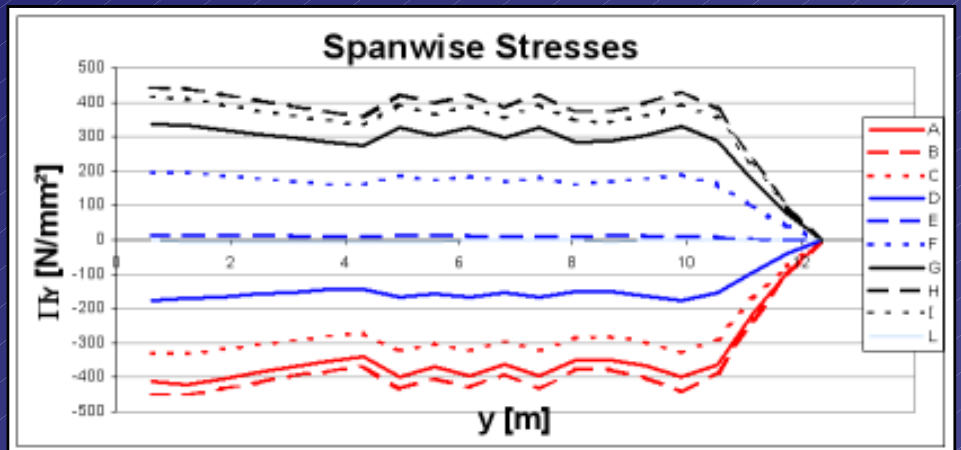


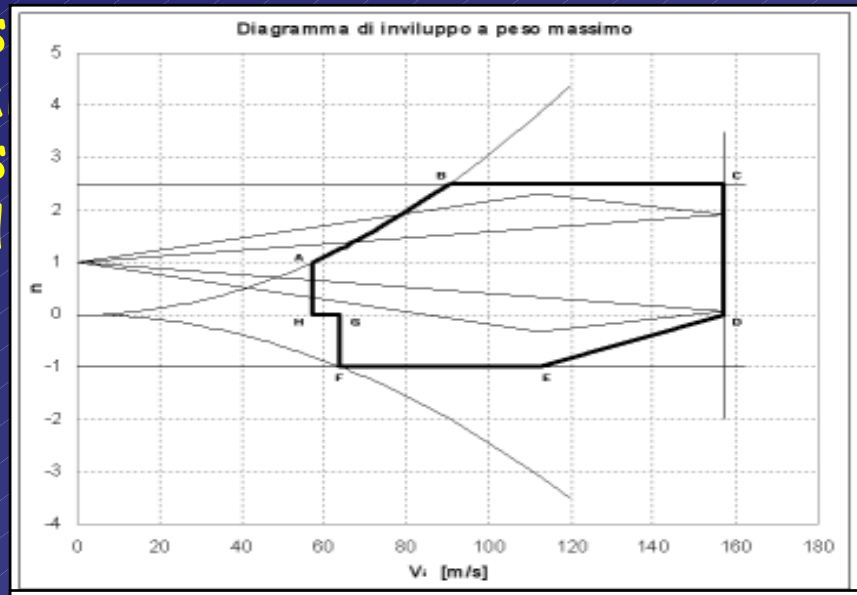
Structural Analysis

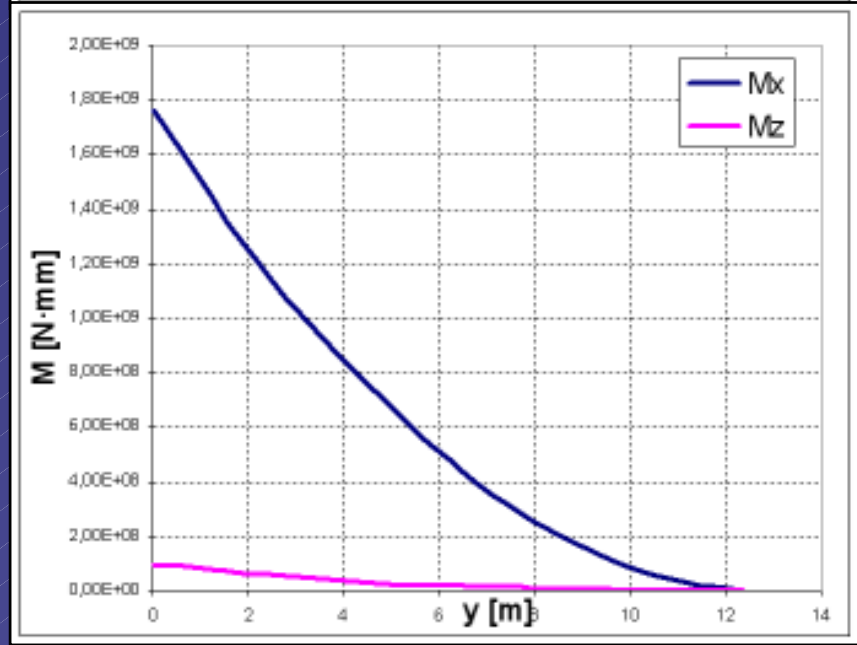
The structural analysis of wing-box is carried out by a preliminary structura design program developed by students

First attempt wing-box geometry and materials are defined and stress/strain state computed

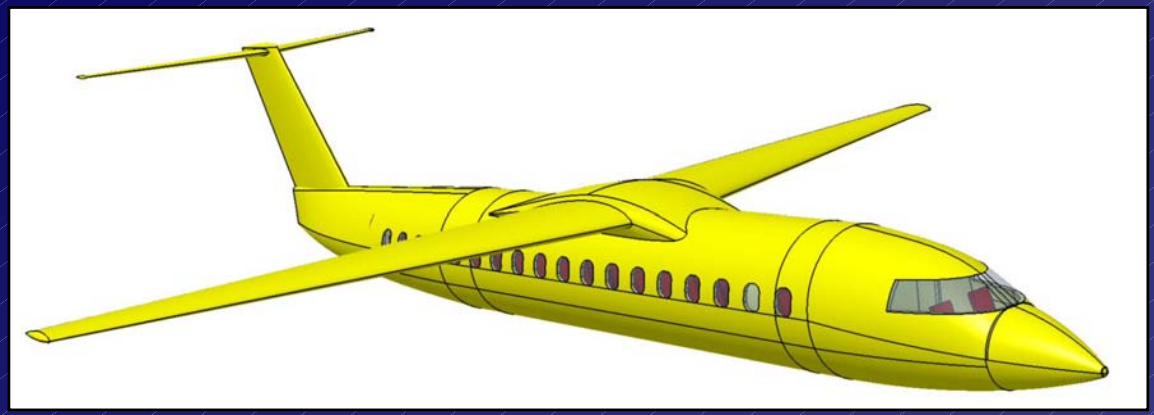




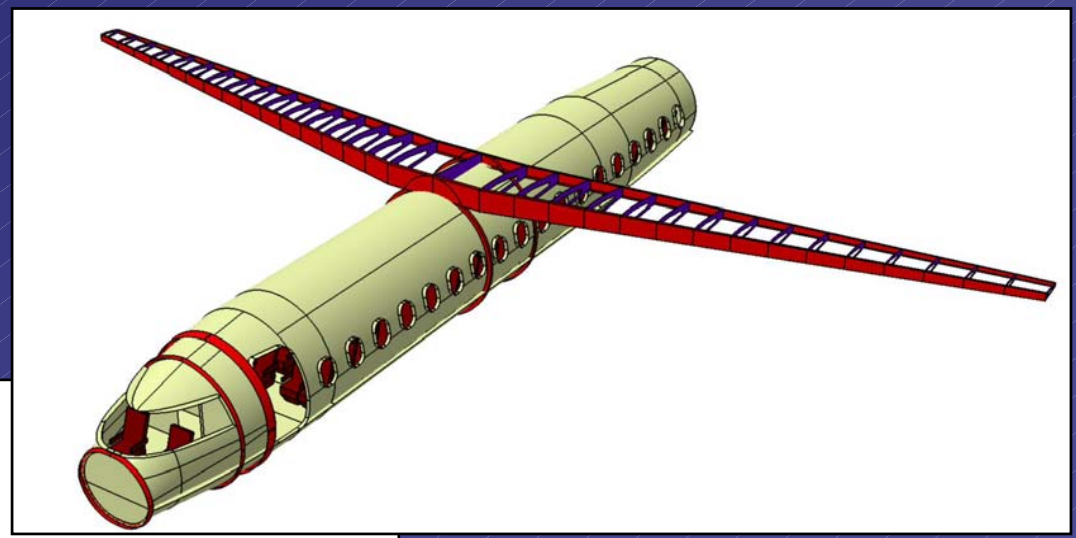


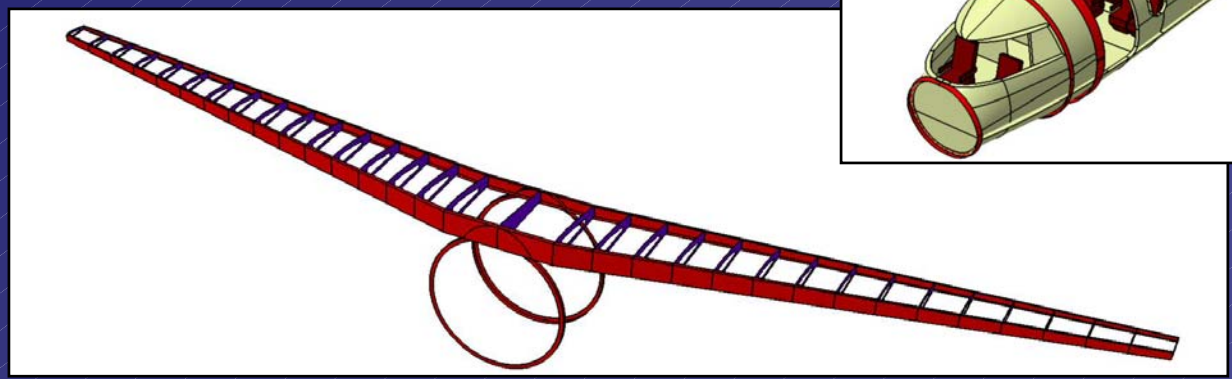


Structural Analysis



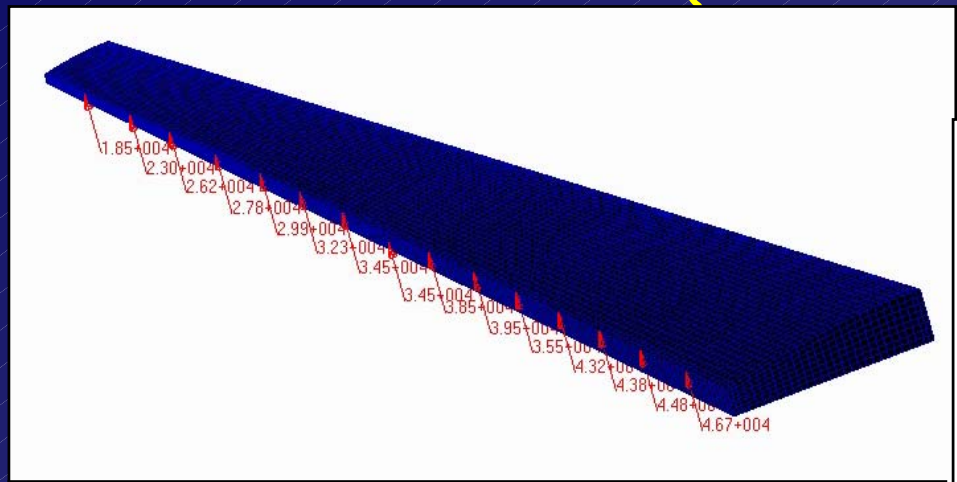
A *CATIA V5* model is built to outline a 3D external & internal configuration and to define geometries for *MSC PATRAN*…

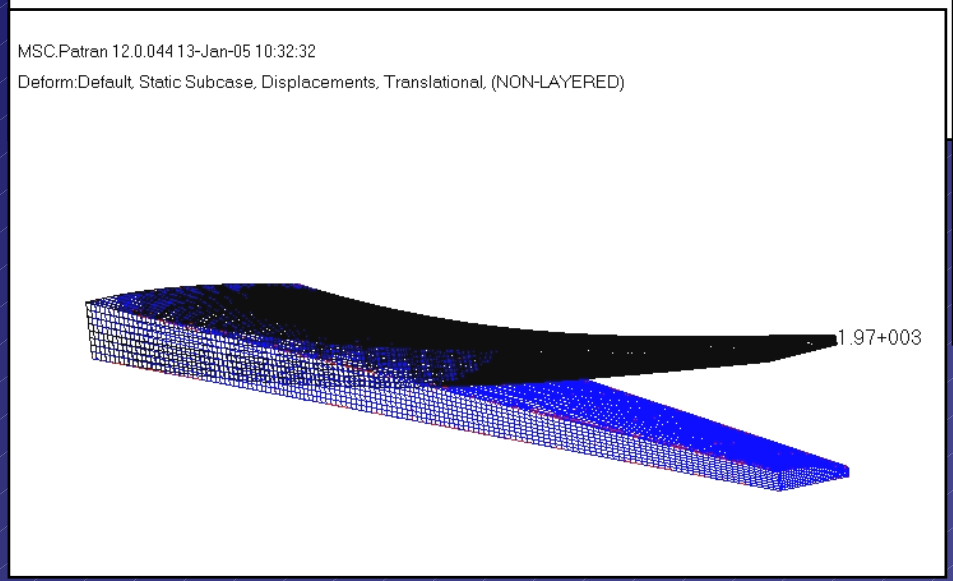


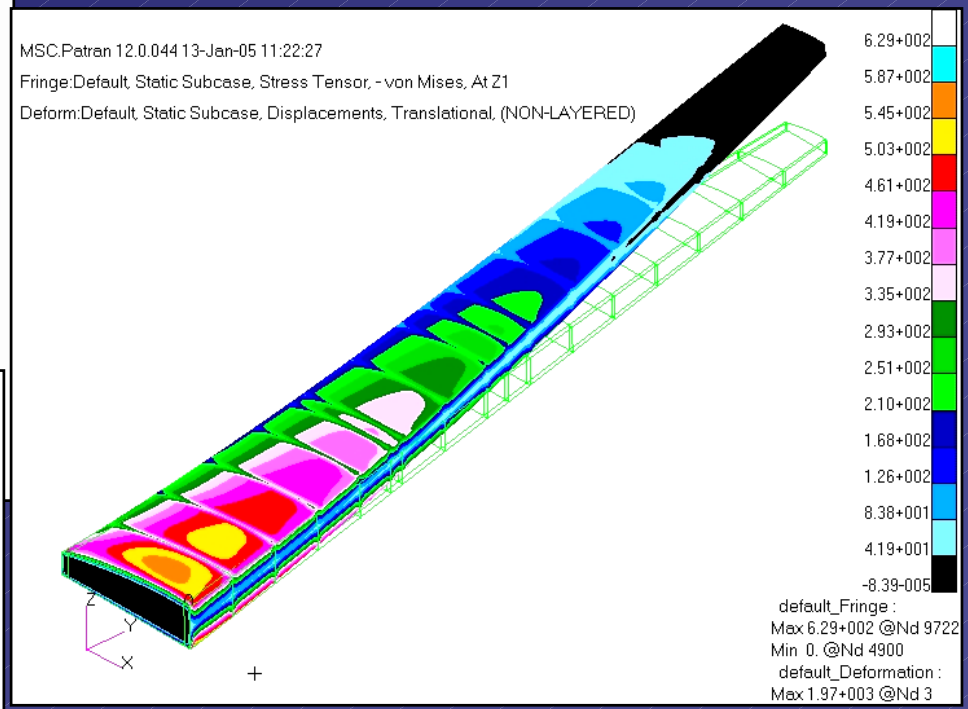


Structural Analysis

… and a more accurate analysis is achieved through FEM (*MSC NASTRAN*)



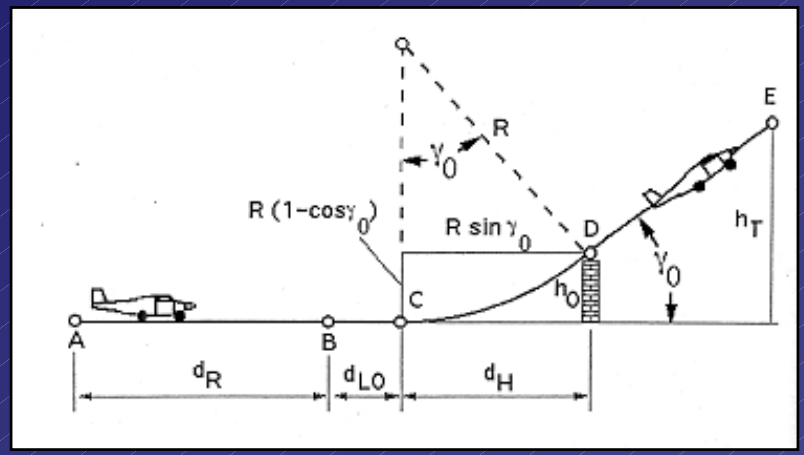


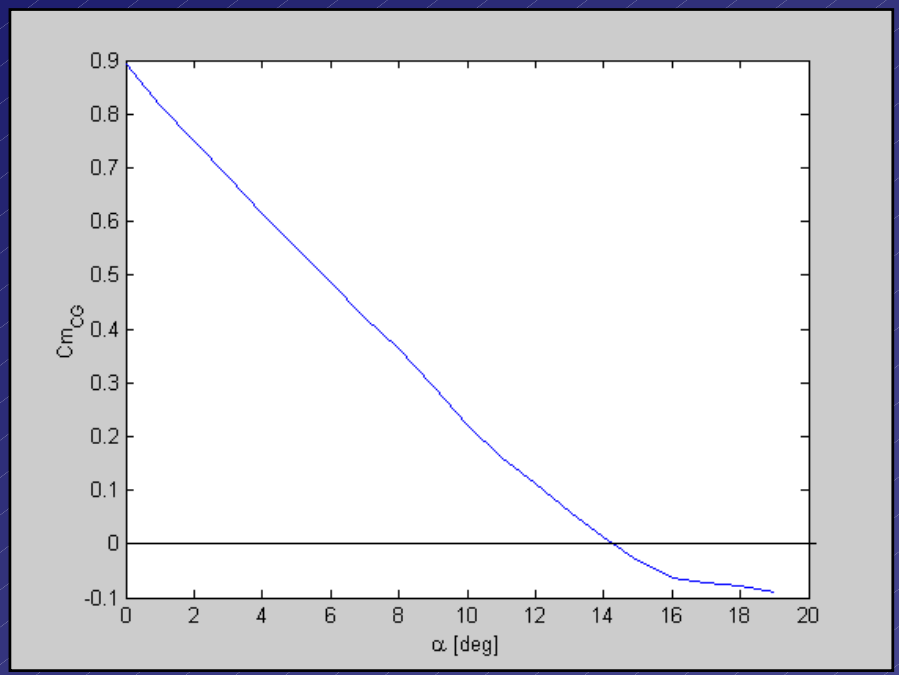


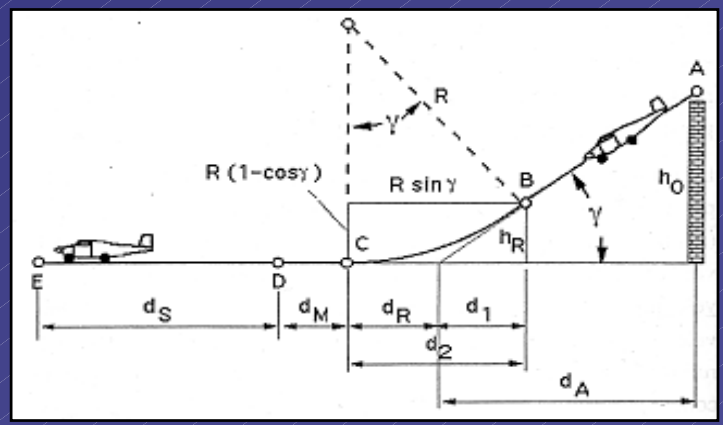
Flight Mechanics / Dynamics

Main flight qualities as well as static and dynamic stability are evaluated.

static longitudinal stability evaluation







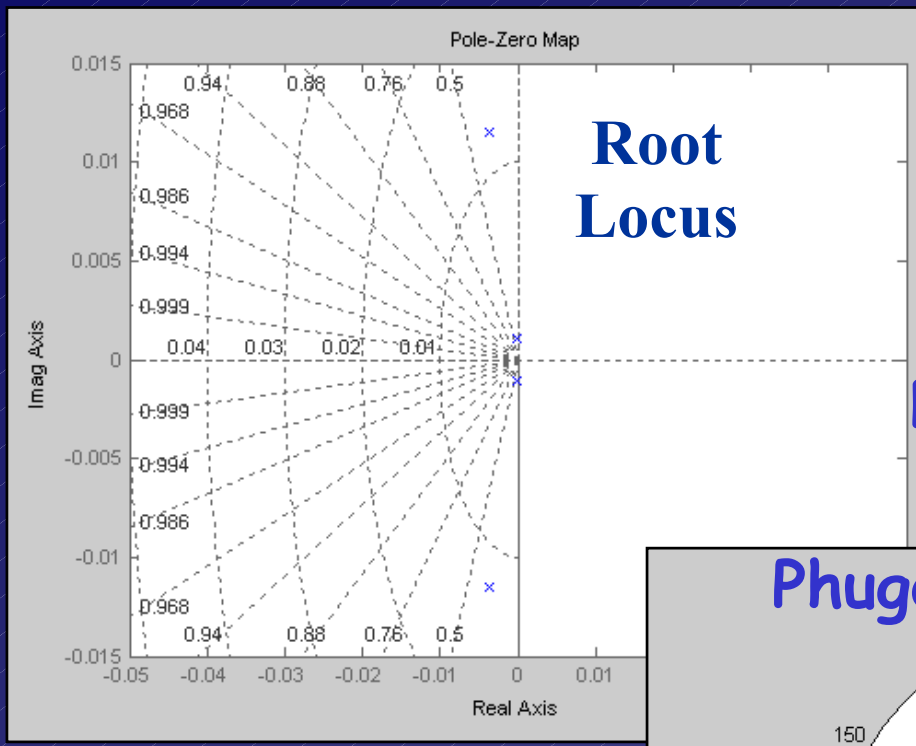
$$dCm_{CG} / d\alpha < 0$$

$$Cm_{CG} = 0 \text{ for } \alpha = 0$$

G. ROMEO – Aircraft Design, Politecnico Torino, DIASP, giulio.romeo@polito.it

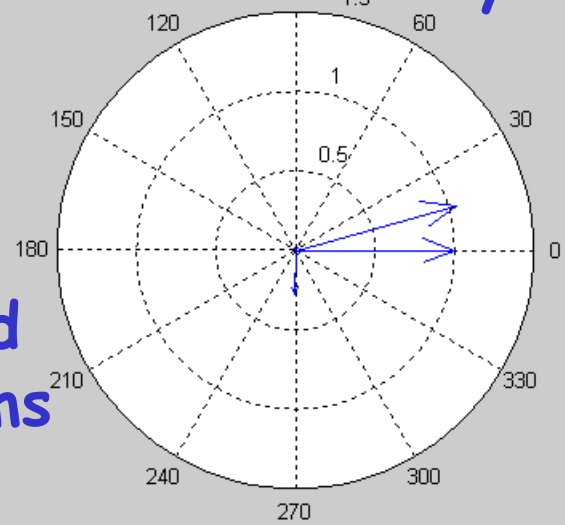
Flight Mechanics / Dynamics

Root Locus

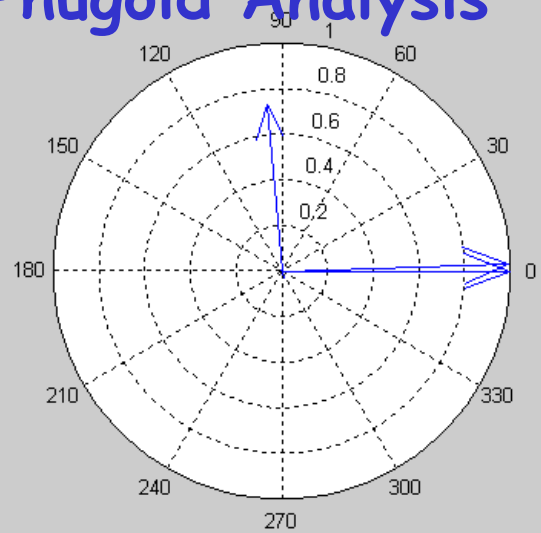


Short Period Analysis

Argand Diagrams



Phugoid Analysis

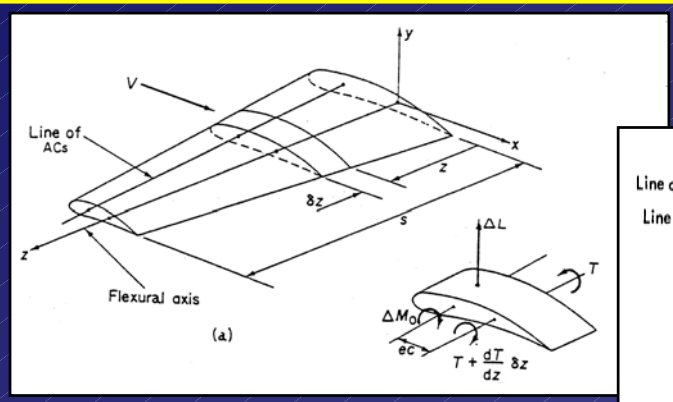


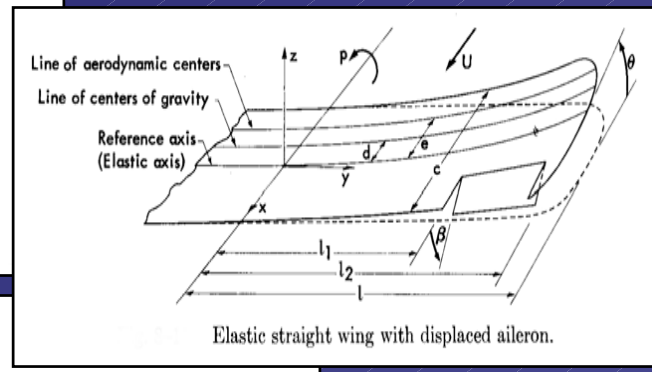
Aeroelastic Analysis

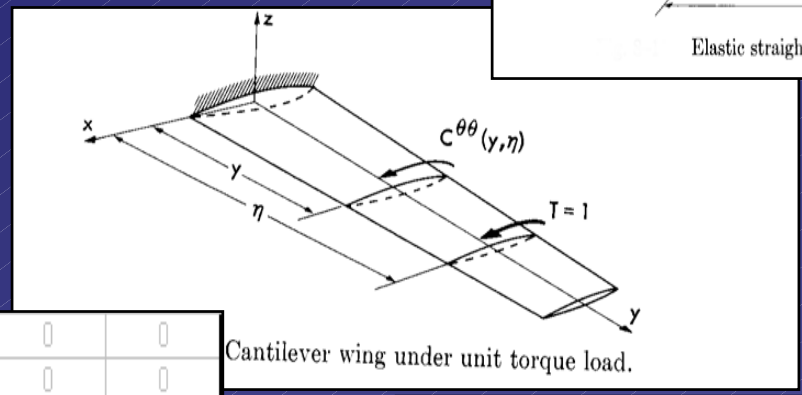
Static aeroelastic problems :

- Divergence Speed
- Aileron Reversal

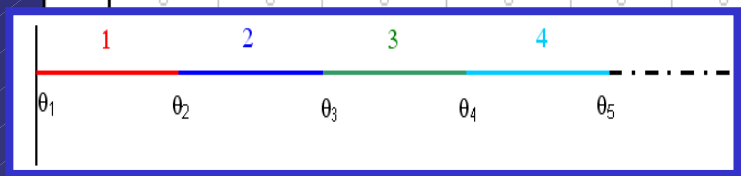
Both FEM approach & Influence Coefficients approach are used

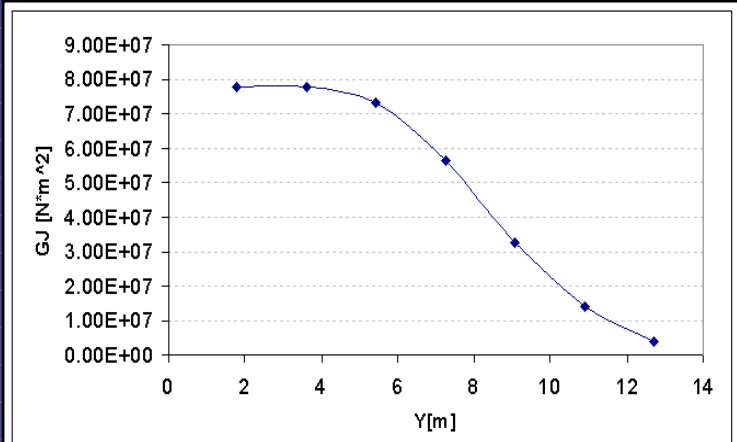






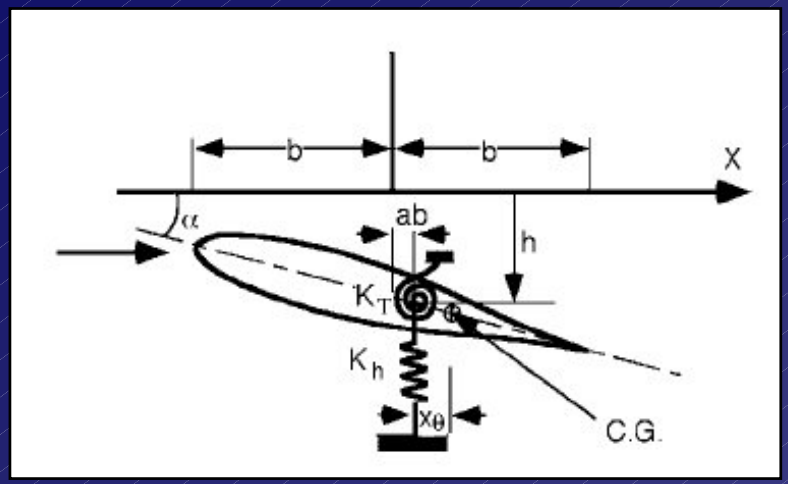
Kg*								
9,75E+07	-4,88E+07	0	0	0	0	0	0	
-4,88E+07	9,75E+07	-4,88E+07	0	0	0	0	0	
0	-4,88E+07	9,71E+07	-4,84E+07	0	0	0	0	
0	0	-4,84E+07	9,20E+07	-4,36E+07	0	0	0	
0	0	0	-4,36E+07	7,51E+07	-3,15E+07	0	0	
0	0	0	0	-3,15E+07	4,97E+07	-1,82E+07	0	
0	0	0	0	0	-1,82E+07	2,61E+07	-7,94E+06	
0	0	0	0	0	0	-7,94E+06	7,94E+06	



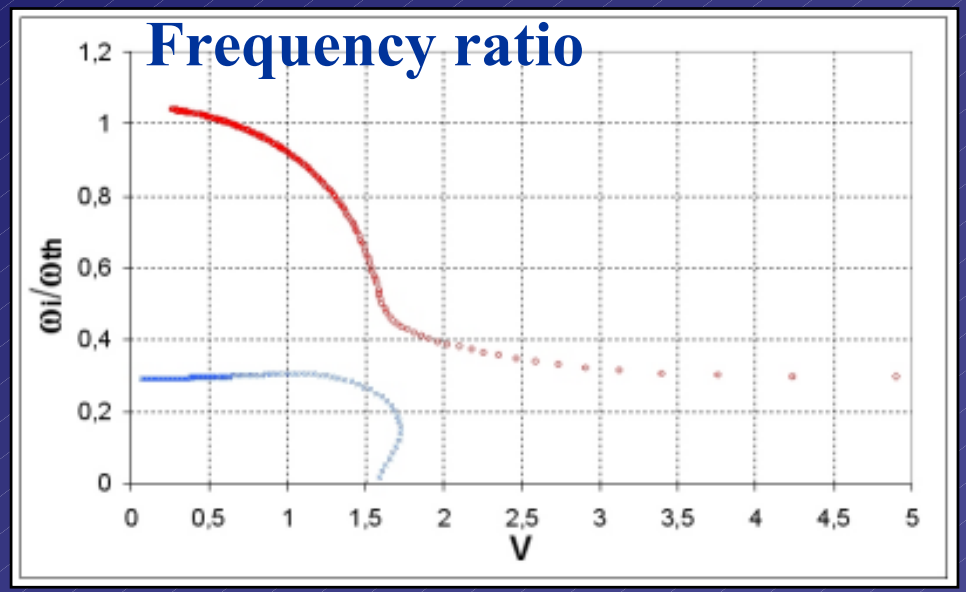


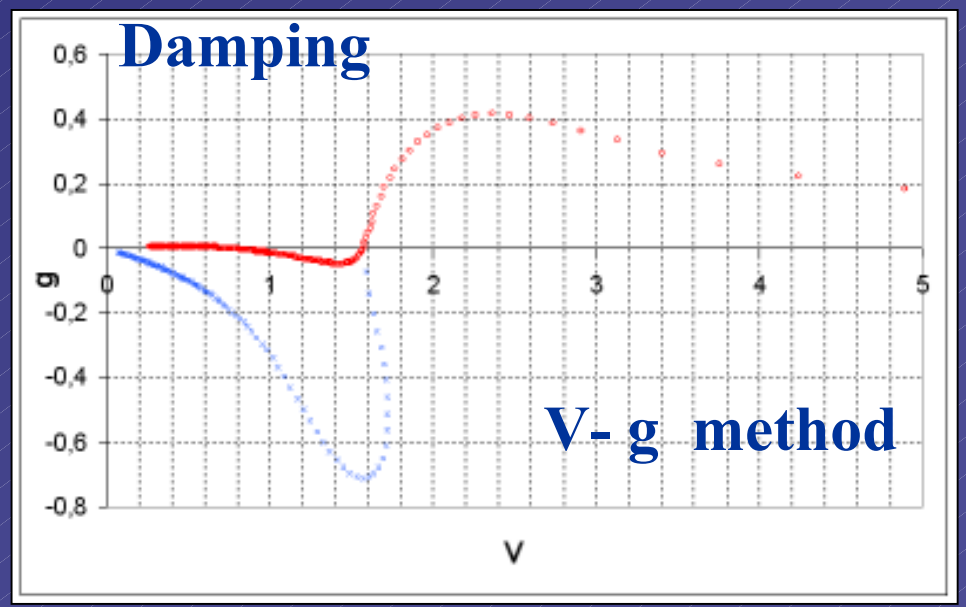
Aeroelastic Analysis

Dynamic Aeroelastic problem:
•Flutter

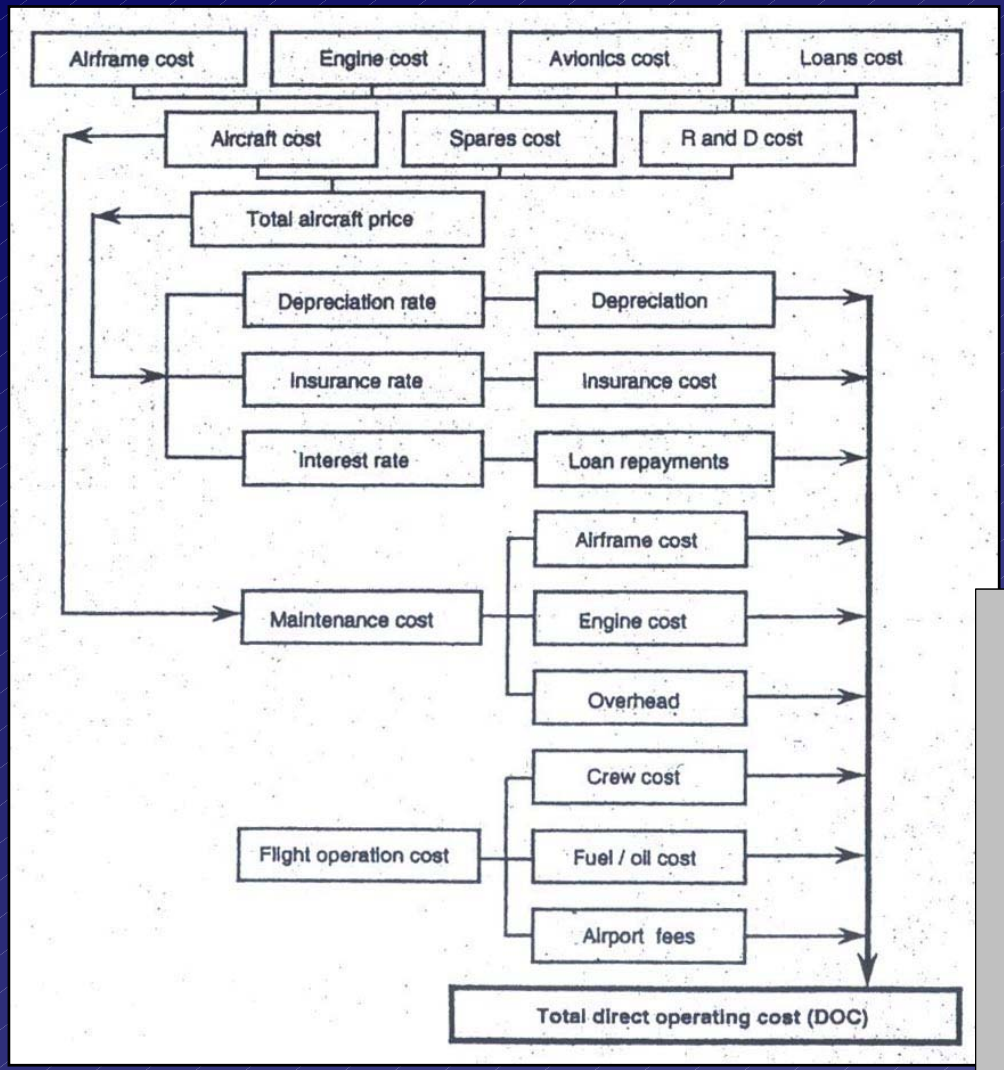


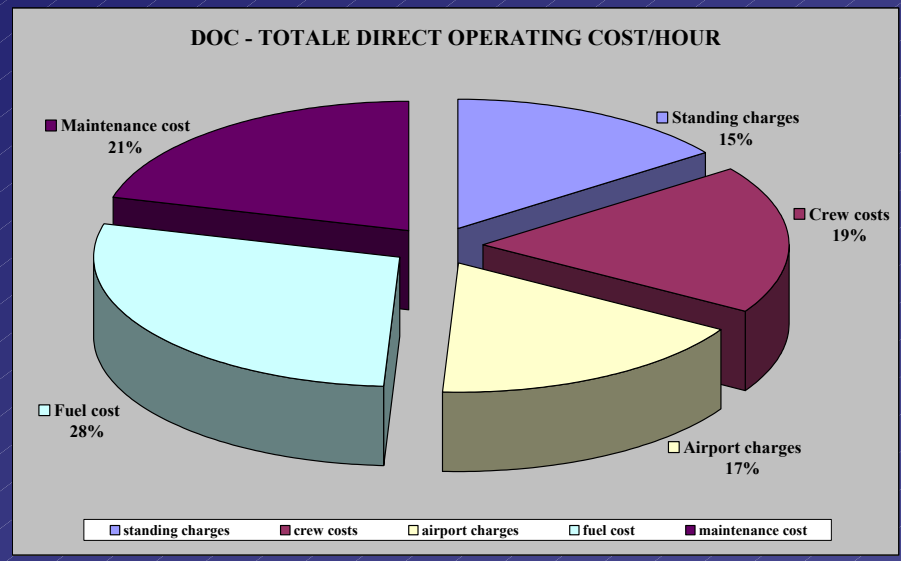
- Typical Section Approach
- Theodorsen Aerodynamic Theory

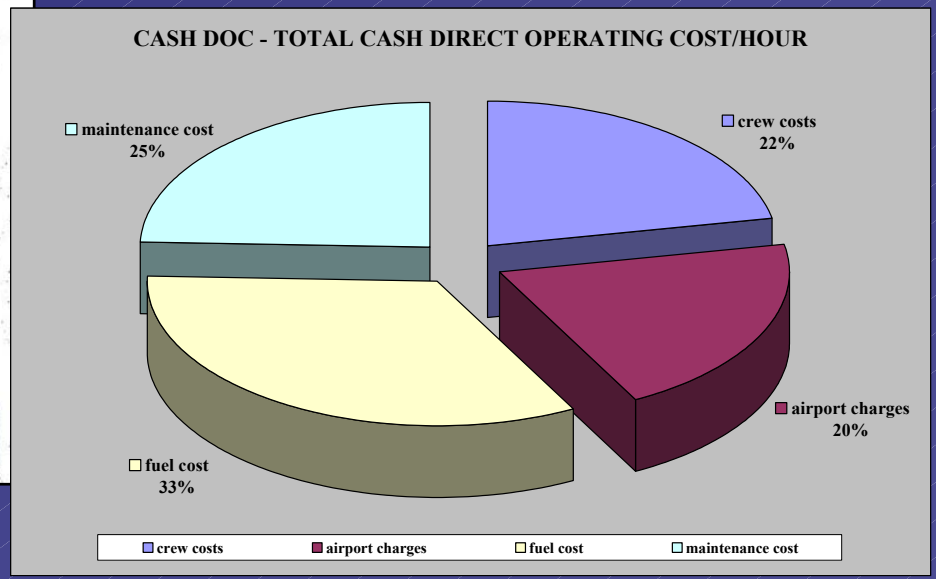




Cost Analysis







DIASP

HELIPLAT

COST MODEL

Total Life Cycle Cost

Index Project Name: **HALE Solar - 2 (1.1,40prod,2920fh) [27/01/05]**

Project Name:	HALE Solar
Configuration:	2 (1.1,40prod,2920fh)
Analysis Date:	27/01/05
Currency:	€
Exchange Rate: 1 $ =	0.766 €

Manufacturer

- Development & Production Cost >>
- Price >>

Operator

Inputs	Outputs
Acquisition >>	Direct Cost >>
Initial Support >>	Fixed Cost >>
Operating >>	Flight Hour Cost >>
Infrastructure >>	Annual Budget >>
	Life Cycle Cost >>

Operative Costs

Total Life Cycle Cost Project Name: **HALE Solar - 2**

Operating cost per year	€ 28°743°960	% of LCC
Years of operation	20	
Development	€ 3°054°012	0%
Acquisition	€ 101°329°438	13%
Initial Support	€ 19°505°888	3%
Operating	€ 574°879°201	77%
Infrastructure (7.50% of sub total)	€ 52°407°640	7%
TOTAL LCC	**€ 751°176°180**	
TOTAL LCC / FLIGHT HOUR [€/FH]	**€ 713**	

Total Operating Cost per Year Project Name: **HALE Solar - 2**

ITEM	NOTES	DESCRIPTION	Flight line workers	GCS workers	Supervisor	TOTAL WORK	LOCAL EXPENSE	LOCAL SUB CONTR-ACTOR	TOTAL OPERATING COST
1	Labor	Flight line (pre flight - 1 shifts/day)	€ 23°424	€ 140°544	€ 29°280	193°248			193°248
2	Labor	Flight line (flight - 3 shifts/day)	€ 702°720	€ ########	€ 878°400	5°797°440			5°797°440
3	Labor	Flight line (post flight - 1 shifts/day)	€ 234	€ 1°405	€ 293	1°932			1°932
4	Food ...	Food & sleeping expense					€ 102°147		102°147
5	Car	Car rent					€ 16°119		16°119
6	Generators	Rent of Generators						€ 64°475	64°475
7	Generators	Fuel for Generators						€ 40°297	40°297
8	Engineering	Engineering support						€ 384°000	384°000
9	Communication	Communication support						€ 120°000	120°000
10	Propulsion	Propulsion system inspection	€ 78°080			78°080	€ 231°800		309°880
11	Propulsion	Propulsion system replacement	€ 14°757			14°757	€ ########		4°283°781
12	Spares for UAV	Other spares- 5% of UAV value					€ ########		3°372°811
13	Spares for GCS	Other spares- 5% of GCS value					€ 70°000		70°000
14	Spares for GDT	Other spares- 5% of GDT value					€ 60°000		60°000
15	Inspection labor	Included in items 1-3							
16	Insurance	Insurance of ground equipment (2.0					€ 52°000		52°000
17	Insurance	Insurance of UAVs (14.1%)					€ ########		13°875°830
18	Fuel	Fuel & Additives					0		0
	TOTAL	OPERATING COST PER YEAR	€ 819°215	€ ########	€ 907°973	6°085°458	€ ########	€ 608°771	28°743°960

#	NOTES	DESCRIPTION	Maintenance hours	Maintenance hours / FH
1	Labor	Flight line (pre flight - 1 shifts/day)	586 hr	0.01
2	Labor	Flight line (flight - 3 shifts/day)	17°568 hr	0.33
3	Labor	Flight line (post flight - 1 shifts/day)	6 hr	0.00
10	Propulsion	Propulsion system inspection	1°952 hr	0.04
11	Propulsion	Propulsion system replacement	369 hr	0.01
	TOTAL Maintenance Hours per Year		20°480 hr	0.39

<<<<>>>>

To compare to DB values press here:

Maintenance Hour(s) per Flight Hour DB

Rules | Propulsion | Assumptions | << Back to Index

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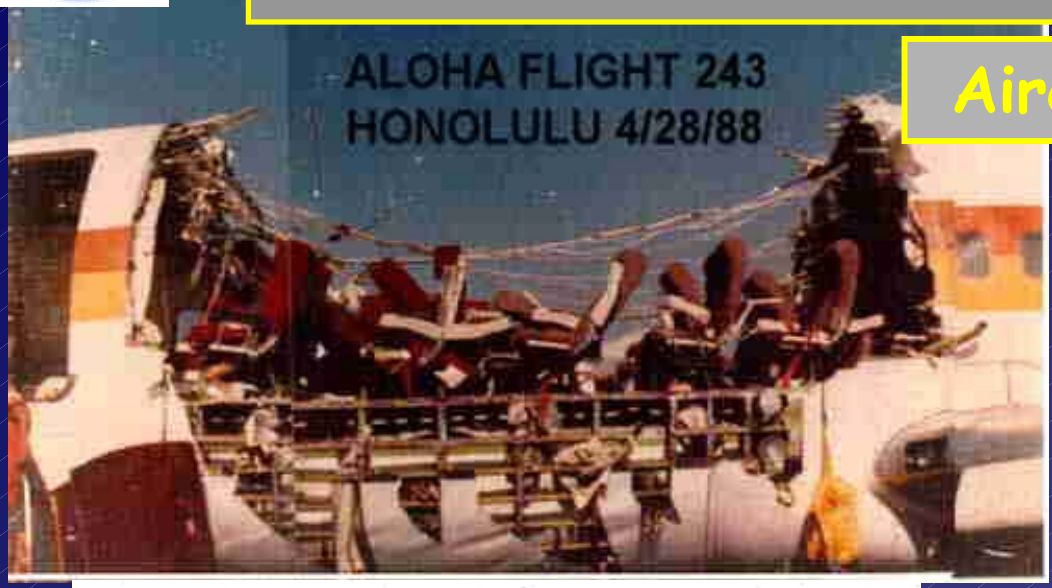
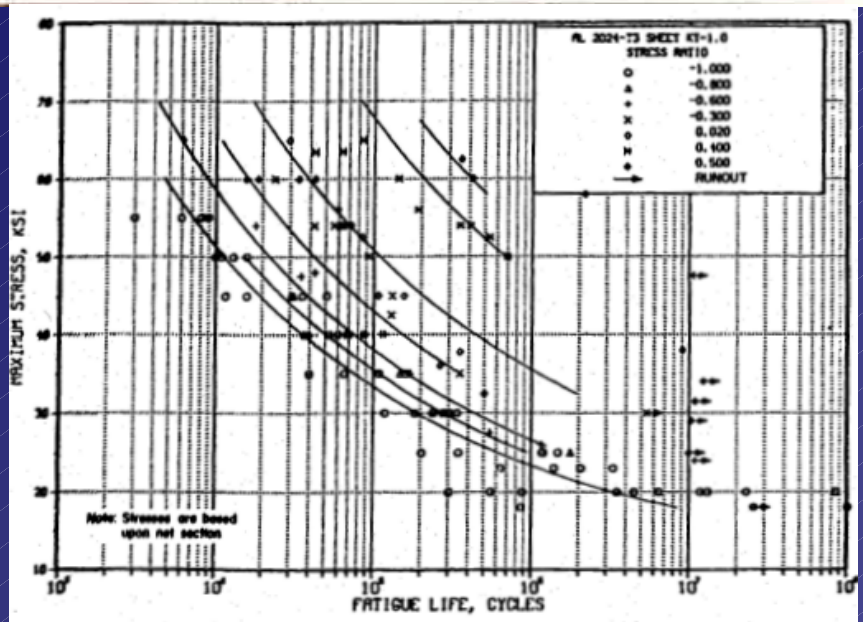
Airframe Structure Design

Aircraft Structural Integrity

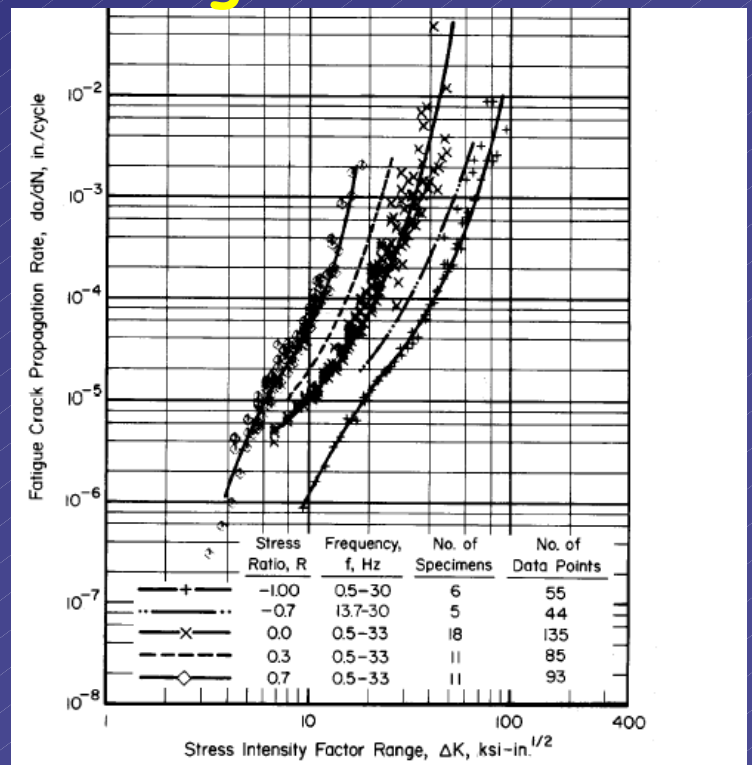


Design Philosophies:

- "safe life"
- "fail safe
- "damage tolerance"



E 3.2.3.1.8(e). *Best-fit S/N curves for unnotched 2024-T3 aluminum alloy sheet, long direction.*



7.4.1.9. Fatigue-crack-propagation data for 0.090-inch-thick 7075-T6

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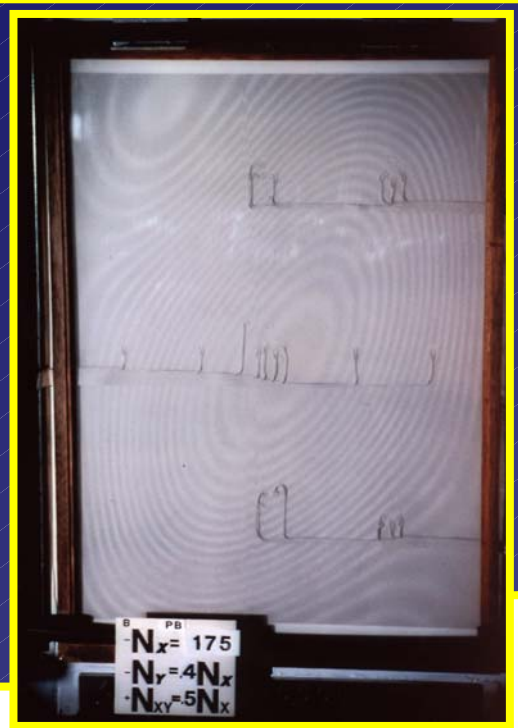
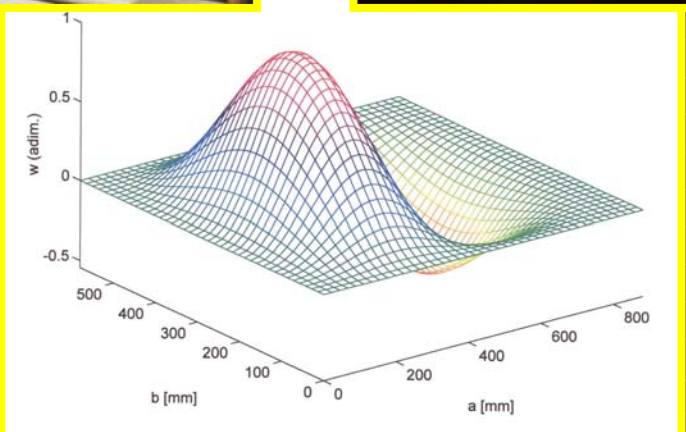
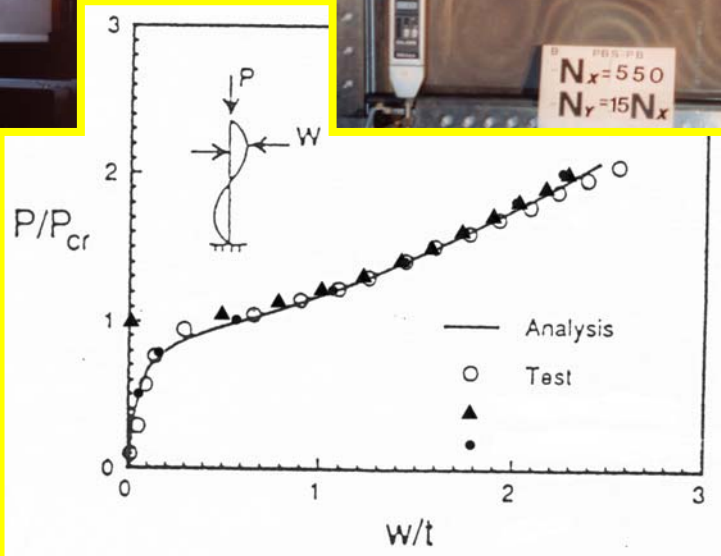
Design of Advanced Composite Structure

Buckling & Post-buckling of CFRP Panels Under Combined Loads







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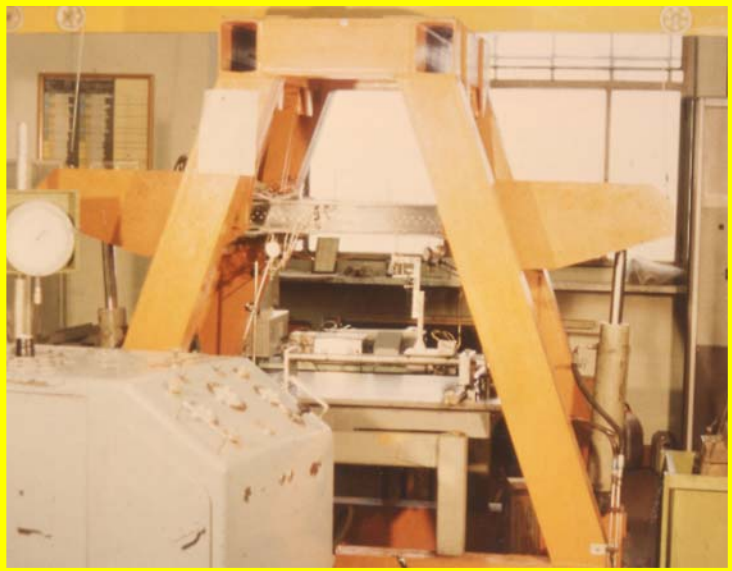
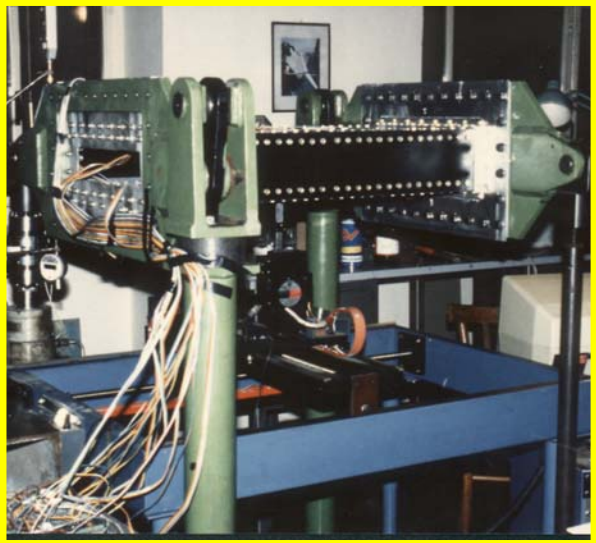
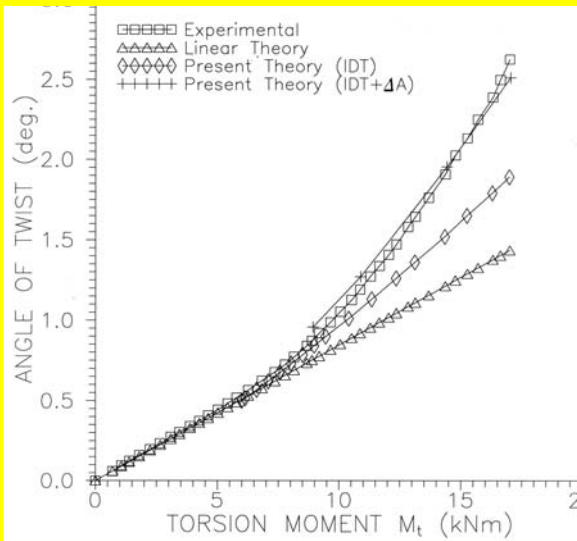
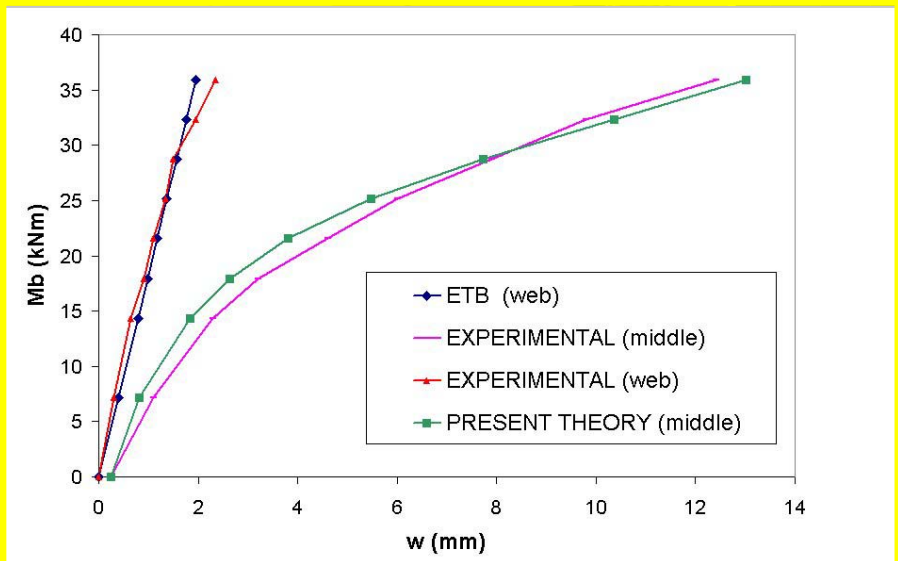
Design of Advanced Composite Structure

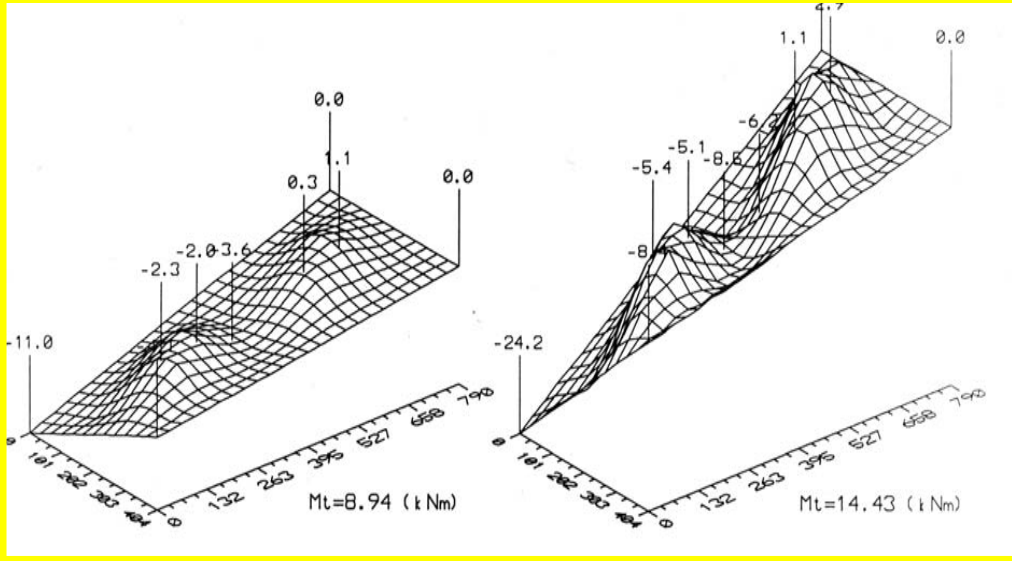
Non-linear Analysis of CFRP Wing Box Under Bending or Torsion











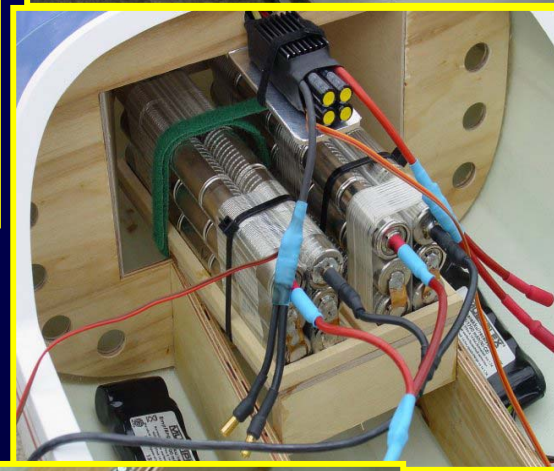
DIASP

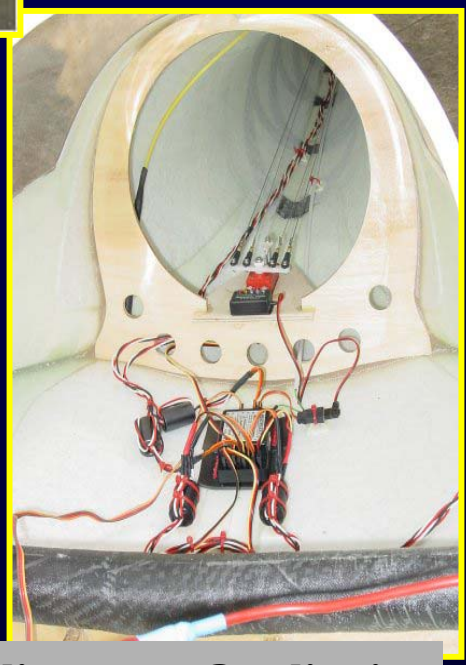
HELIPLAT

FLIGHT MODEL

SUPER DIMONA

b = 5.8 m - W = 20kg





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FLIGHT MODEL

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FLIGHT MODEL

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