Università degli Studi di Napoli "Federico II"

DPA Dipartimento di Progettazione Aeronautica

Aircraft Design AeroFlightDynamics Group

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Dipartimento di Progettazione Aeronautica

AIRCRAFT DESIGN AND AEROFLIGHTDYNAMICS GROUP (ADAG)

The ***AIRCRAFT DESIGN AND AEROFLIGHTDYNAMICS GROUP (ADAG)*** of DPA (Department of Aeronautical Engineering) of University of Naples "Federico II" is involved in programs addressing the following general areas :

- AIRCRAFT & AIRFOIL DESIGN.
- APPLIED AERODYNAMICS.
- WIND TUNNEL TESTS .
- FLIGHT TESTS.
- FLIGHT DYNAMICS & FLIGHT SIMULATION.
- SAILBOAT APPENDAGE & 3D SAIL ANALYSIS & DESIGN.
- RENEWABLE ENERGY.

Research Team

Prof. D. Coiro - Dr. F. Nicolosi - Dr. A. De Marco

Dr. F. Scherillo - Ing. U. Maisto - Ing. F. Bellobuono - Ing. S. Figliolia - Ing. S. Melone - Ing. F. Grasso - Ing. R. Addesso

The group makes use of Prof. Giordano's expertise and collaboration.

Active Collaborations

Universities:
Delft University of Technology (Holland), University of Alberta (Canada), Chalmers University of Technology (Sweden), Uppsala University, M.I.T. Dept. Mechanical and Ocean Engineering (USA)

Companies:
Aerosoft S.p.a., C.I.R.A., ELASIS, ElettroSannio, MoliseInnovazione S.r.l., OMA Sud, Piaggio Aero Industries, Ponte di Archimede S.p.a., Regione Campania, Regione Liguria

European projects:
CAPECON, USICO

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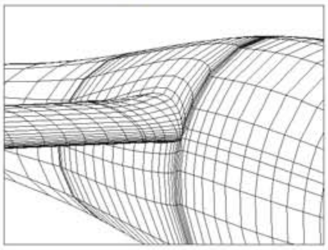
AIRCRAFT & AIRFOIL DESIGN

- Sailplane design.
- Light and ultra-light aircraft complete design.
- Low-Reynolds number aircraft and UAV design.
- Airfoil design.

The ADAG group has carried out researches on light aircraft design and sailplane design. In particular some research activities have regarded airfoil, wing and fuselage design, wing-fuselage interference effects and wing-fuselage junction design. The group has acquired a good expertise performing both numerical aerodynamic analysis and wind-tunnel test with majority of the work addressed to light aircraft. In the last years the group has been working on the design and construction of an UAV model (started as RPV model) with three lifting surfaces. The model is fully instrumented to measure all flight and control parameters and the final goal, among others, will be the investigation of canard influence on aircraft aerodynamics and dynamic behaviour.
At present the group is working on the complete design of a new composite STOL-ULM (Easy Fly project).

Sailplane Design

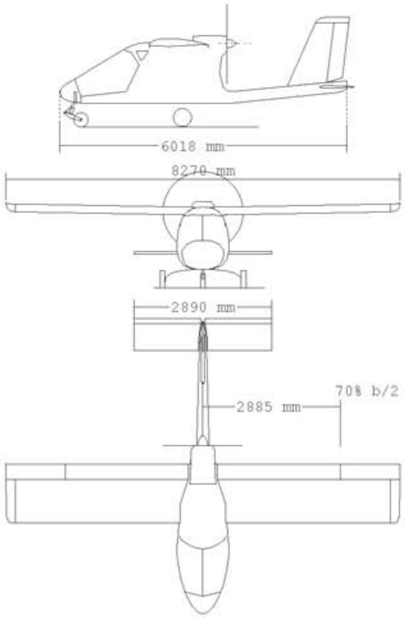
Antares wing-fuselage junction design (1996, designed with Prof. Boermans, Delft University of Technology Holland)



Researches in the fields of: low drag fuselages and airfoils, wing-fuselage junction.

Light & Ultra-Light (ULM) Aircraft Design

G97 Spotter light aircraft (Designed by Prof. Giordano)

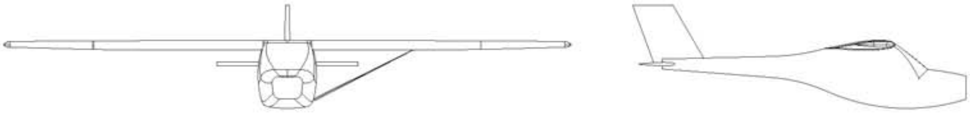


- Light aircraft for observation and reconnaissance.
- Unusual fuselage shape designed by 3D numerical calculations and tested in DPA wind-tunnel.
- Small wing-surface and ad hoc designed high-lift airfoil.

EXTERNAL DIMENSIONS & WEIGHT	
Wing surface	10.3 m^2
Wing span	8.25 m
Aspect ratio	6.6
Max TO weight	450 kg (4415 N)
Empty weight	280 kg (2747 N)

PERFORMANCES (Max weight, ISA, at sea level)	
Max level speed	195 km/h
Stall speed (flap up)	75 km/h
Stall speed (flap down)	63 km/h
Max rate of climb	4.5 m/s
Take-off run	80 + 80 m
Landing run	80 + 80 m

Easy Fly: complete design of a composite material S.T.O.L. ultra-light aircraft

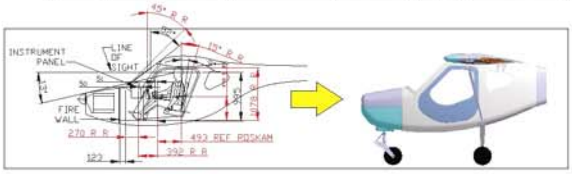


EXTERNAL DIMENSIONS					
WING	Span [m]	11.00	AREAS	Wing [m^2]	13.60
	Root chord [m]	1.40		Horizontal tail [m^2]	2.01
	Tip chord [m]	0.85		Vertical tail [m^2]	1.08
	Aspect ratio	8.90			
AIRCRAFT	Length overall [m]	6.52	PROPELLER (fixed-pitch)	Blade number	3
	Height overall [m]	2.60		Diameter [m]	1.66

Design goals:

1) Short Take-Off and Landing (STOL) aircraft capable of taking off and landing from an unprepared runway within 50 m.
2) Almost complete construction in composite material.
3) Foldable wing, in order to make the ULM very easy to use, to put on a trailer and to hangar in a normal size garage.
4) Wing with retractable leading edge slat and slotted flaps.
5) Maximum speed around 190-200 km/h at WTO of 450 kg.
6) Good flight and handling qualities, to be safely flown by inexperienced pilots.
7) Low cost.

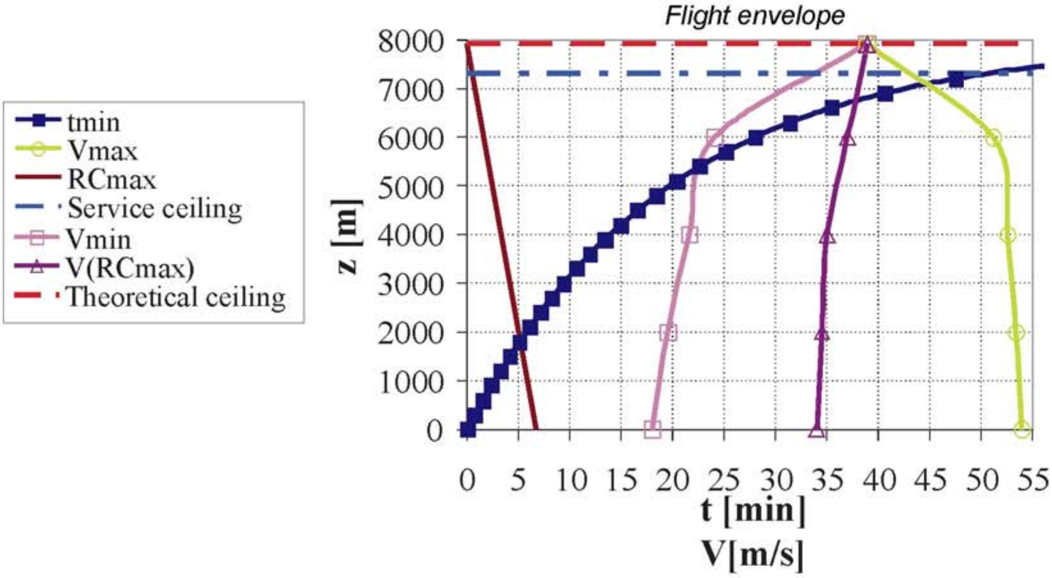
WEIGHTS AND LOADINGS		
Empty weight	280 kg	2747 N
Max T-O and landing weight	450 kg	4415 N
Max wing loading	33.09 kg/m^2	324 N/m^2
Max power loading	5.63 kg/hp	74 N/kW



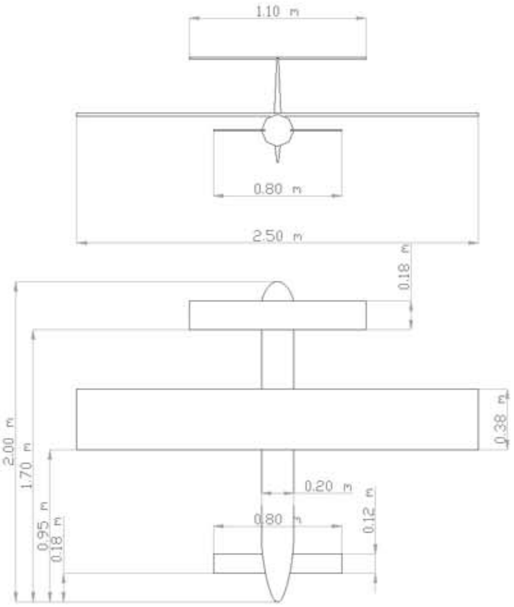
Cockpit design

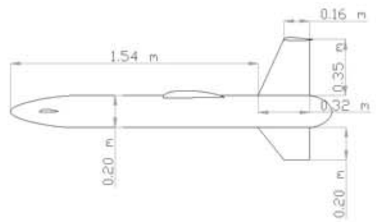
PERFORMANCES (Max weight, ISA, at sea level)	
Max speed [Km/h]	195
Cruising speed [Km/h]	165
Stall speed [Km/h]: flaps up	65
flaps down: slat - single slot	48
Max rate of climb [m/s]	6.18
Take off run [m]	55
Take off run to 15 m [m]	121
Landing run from 15 m [m]	100
Landing run [m]	50
Theoretical ceiling [m]	7908
Service ceiling [m]	7317

Flight envelope



UAV & Radio-Controlled Model Design





EXTERNAL DIMENSIONS	
Wing span	2.50 m
Fuselage length	2.00 m
Wing surface	0.95 m^2
WEIGHTS AND LOADINGS	
Max TO weight	12 kg (118 N)
Engine max power	2.7 hp (1.99 kW)
PERFORMANCES (Max weight, ISA, at sea level)	
Max level speed	130 km/h
Cruise speed	90 km/h

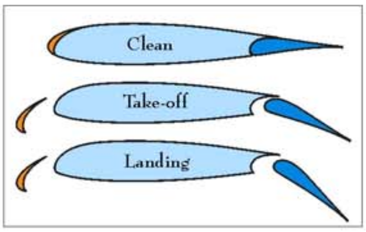
Flight test instrumentation

Main research objectives:

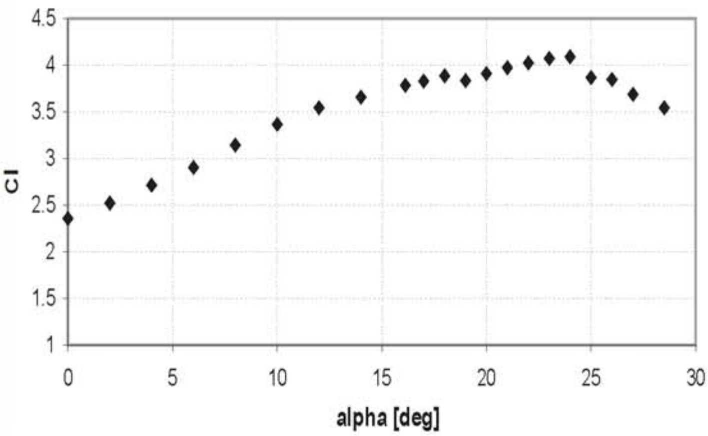
- Development of an unmanned aircraft for observation-reconnaissance (UAV).
- Analysis of canard influences on aircraft aerodynamics, static and dynamic flying characteristics (the model can fly with and without canard).
- Complete and accurate miniaturized flight instrumentation for flight parameter measurement and model maneuver analysis.
- Composite material & pusher propeller.
- Low costs.

Airfoil Design

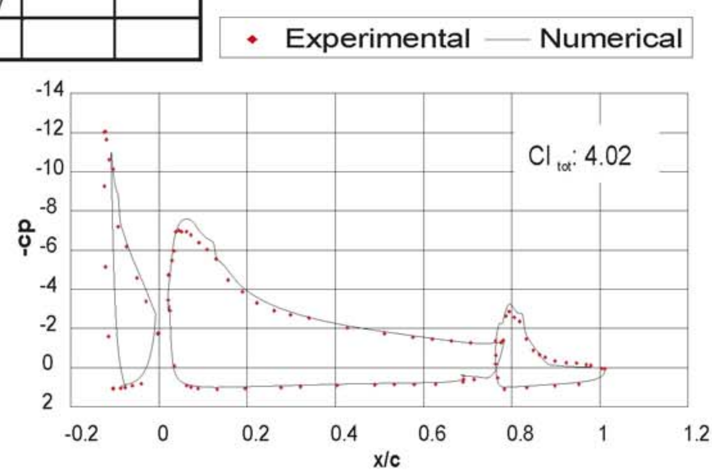
G1-3f: multi-element airfoil for S.T.O.L. applications



Experimental data (Re: 1.3e06)			
Configuration	Cl_{max}	$Cm_{c/4}$	Cd_{min}
Clean	1.6	-0.035	0.008
Take-off	3.37		
Landing	4		



Lift coefficient for 3-component airfoil in landing configuration: experimental results

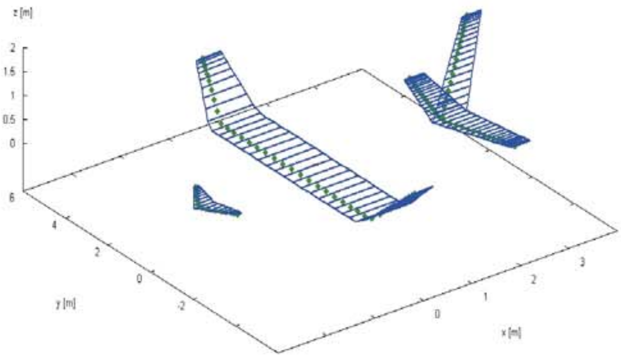


Pressure coefficient distribution on landing configuration airfoil

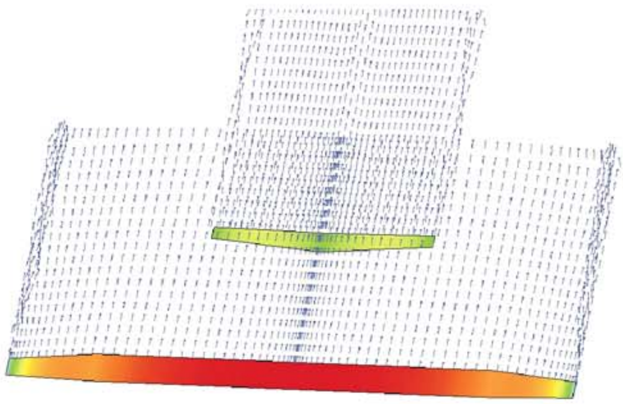
APPLIED AERODYNAMICS

VWing Numerical Code

An Unsteady Non Linear Vortex Lifting Line Method to Simulate the Aerodynamic Performances of Multi-body Configurations



VWING pre-processing example



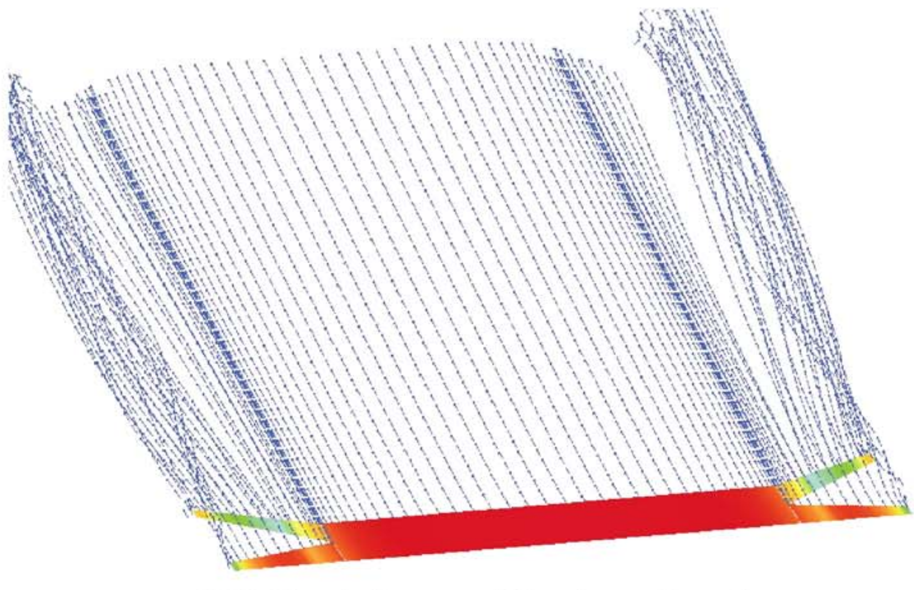
VWING analysis on a wing-tail configuration

Recently, a new aerodynamic simulation module has been developed by the ADAG group in order to predict the aerodynamic performances, both in steady and unsteady conditions, of multi-body lifting surface configurations with a generic shape.

This new simulation module, designated VWING, is based on the Prandtl's lifting line theory.

The basic concept is to model the blade with a discrete number of elementary lifting surfaces modelled by vortex filaments: bound vortices, trailing vortices, and spanwise vortices. This vortex system causes induced velocities on the lifting surfaces and in the wake; in this way the effective angle of attack can be obtained and, consequently, the fluid dynamic forces acting on the surfaces. The fluid dynamic two-dimensional lift, drag, and pitching moment characteristics of the airfoils are assumed to be known.

VWING simulation module introduces unsteady wake effects by using a discrete wake vortex system that trails behind the primary bound lifting line. The strength of each shed vortex is related to the corresponding bound vortex at an earlier point in time and the shape of the wake of the lifting surface is free to develop in time in order to represents the wake roll-up. Three-dimensional unsteady aerodynamic effects are therefore included in the development.



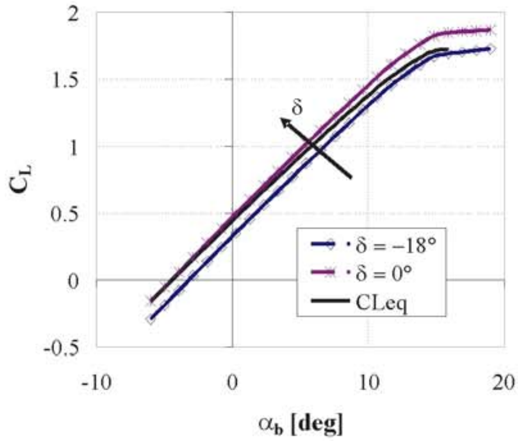
VWING analysis on a split-tip wing configuration

AEREO Numerical Code

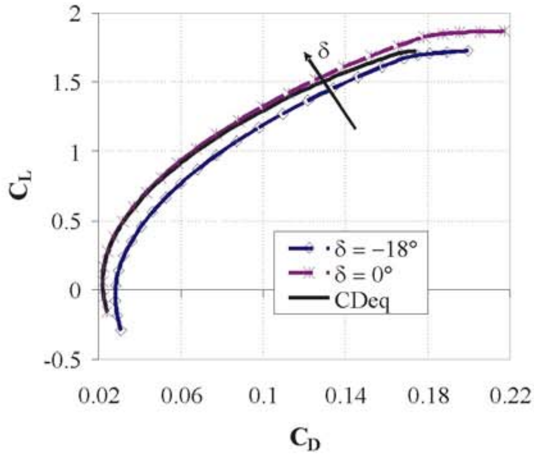
Fast (and enough accurate) menu-driven and user-friendly code capable of predicting complete aerodynamic performances for propeller driven aircraft and sailplanes.
It is based on a combination of standard semi-empirical methods with some more sophisticated methodology like the extension of the Prandtl lifting line theory to high angles of attack range (NLWING routine).

AEREO is capable of predicting:

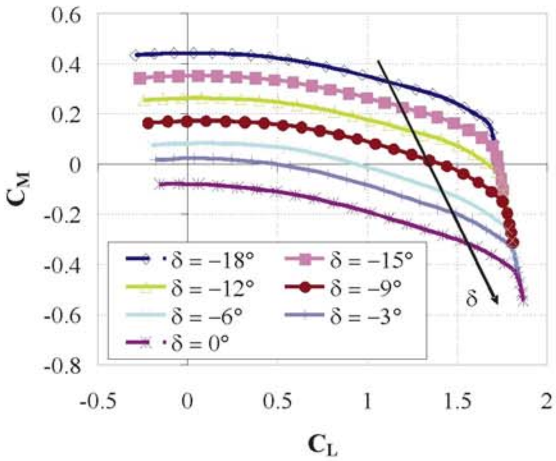
- Longitudinal and lateral - directional aerodynamic coefficients for the whole angle of attack range (also non-linear).
- Static and dynamic stability (stick fixed and free).
- Trimmed curves and complete aircraft performances.



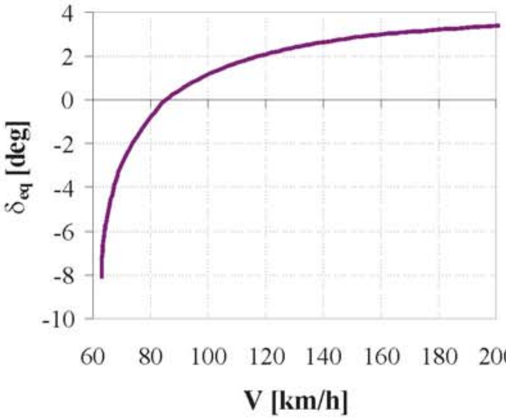
Lift coefficient of the aircraft versus alpha body (incidence angle measured in regard to the thrust axis) parameterized in δ (horizontal all-movable tail deflection) and equilibrium lift coefficient



Polar curves parameterized in δ (horizontal all-movable tail deflection) and equilibrium polar curve



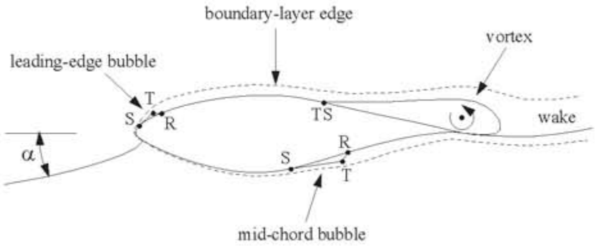
Pitch moment coefficient versus lift coefficient parameterized in δ (horizontal all-movable tail deflection).

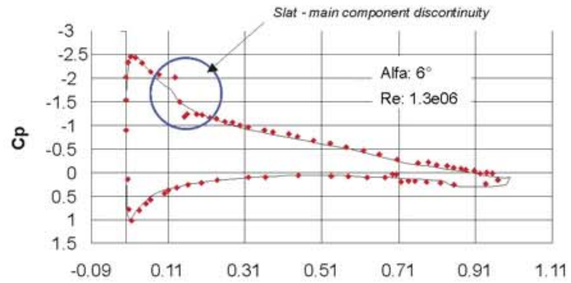


Equilibrium horizontal all-movable tail deflection versus speed (center of gravity position is at 25% of mean aerodynamic chord).

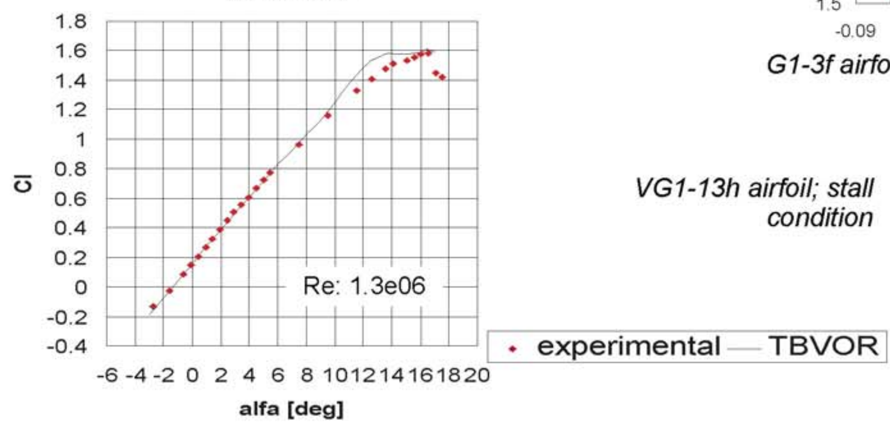
TBVOR Numerical Code

2D analysis code based on viscous/inviscid interaction (panel+integral direct/inverse boundary layer) capable of predicting subsonic and low Reynolds number flows (laminar bubbles) around mono- and multi-component airfoils up to stall and post-stall condition



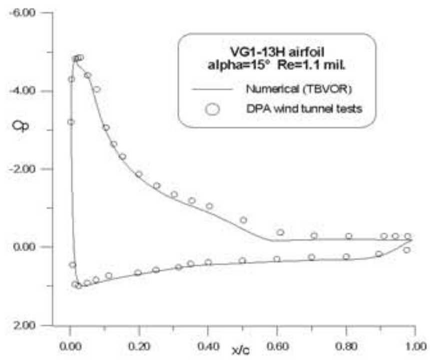


G1-3f airfoil; numerical and experimental pressure coefficient distribution

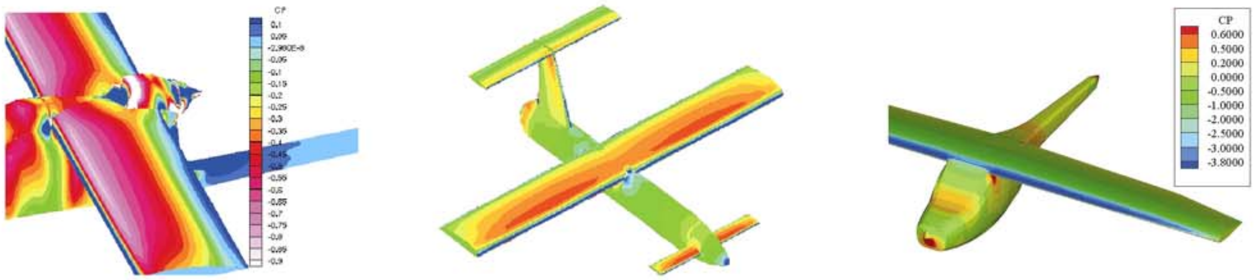


G1-3f airfoil; numerical and experimental lift curve

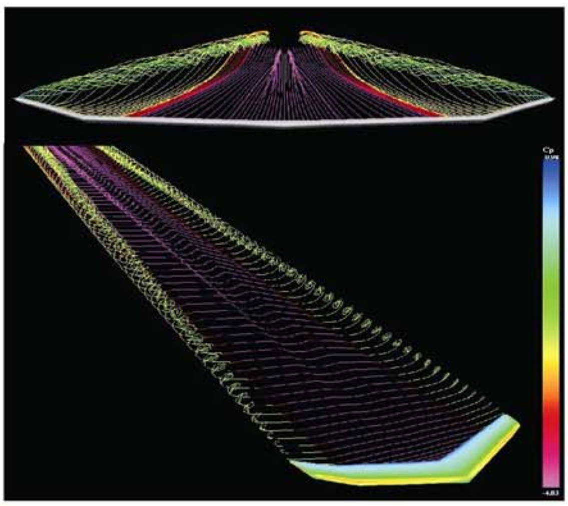
VG1-13h airfoil; stall condition



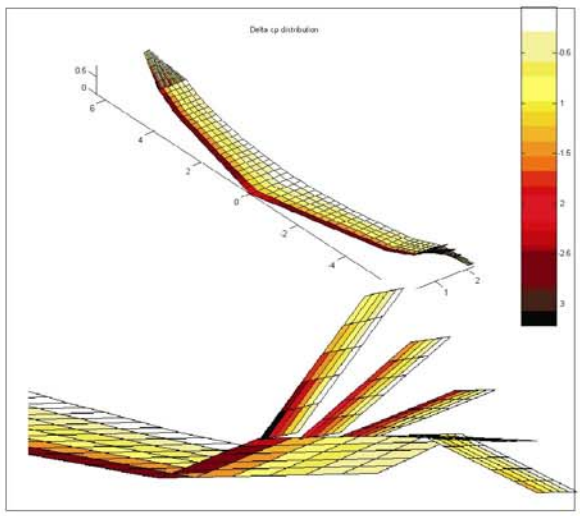
Numerical Analysis



3D Pressure coefficient distributions (panel methods)

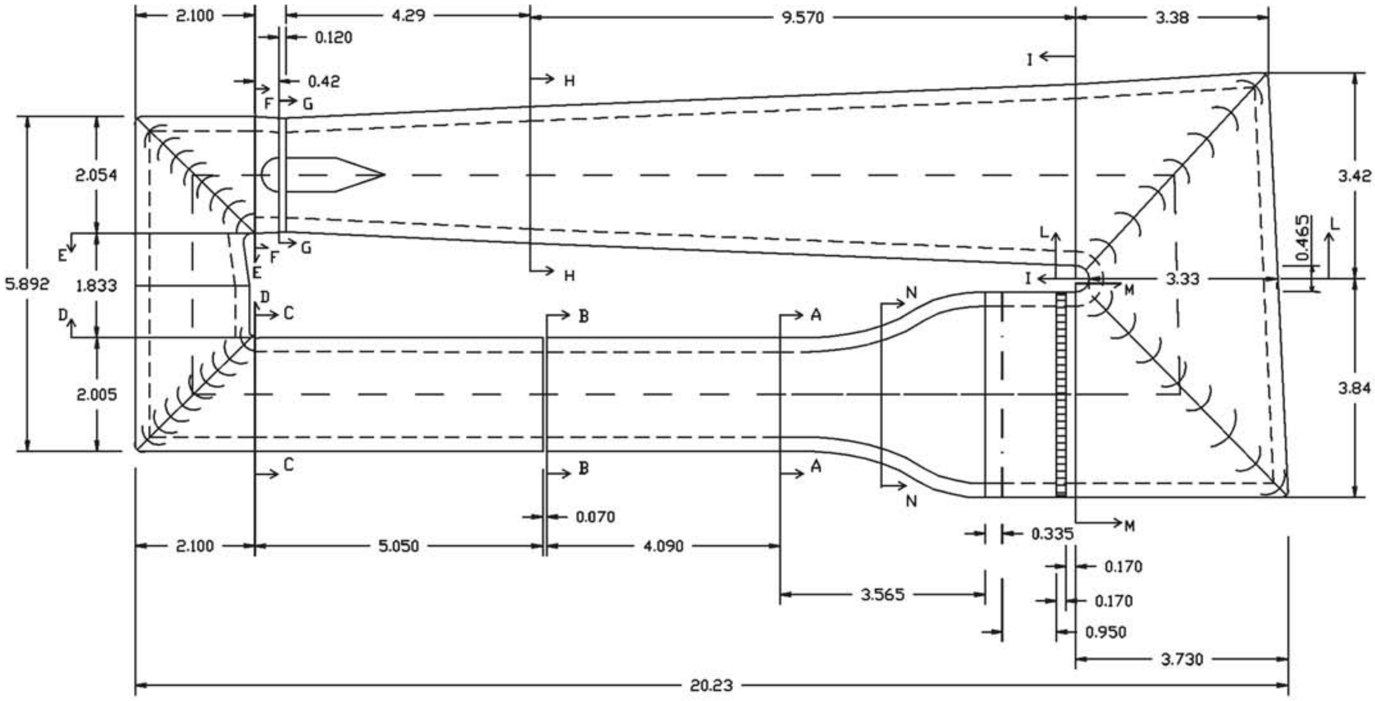


3D Pressure coefficient distribution and wake shape (panel methods)



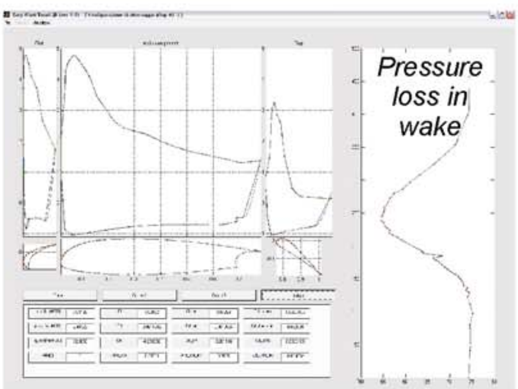
Multiple winglet design

WIND TUNNEL TESTS



Pressure measurement system

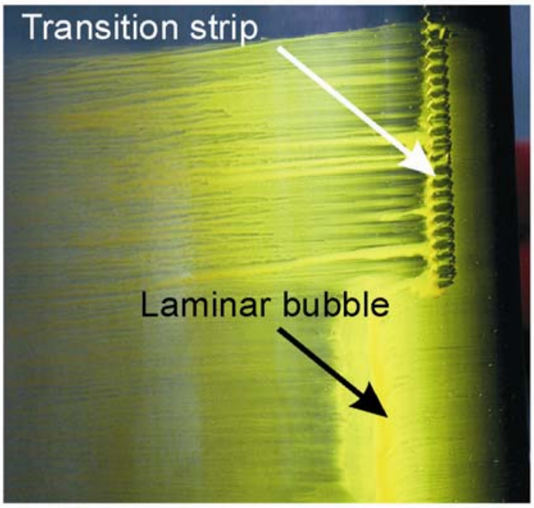
MAIN CHARACTERISTICS	
Test section dimensions	2.0m x 1.4m
Maximum speed	150 Km/h
Turbulence level	0.1%



EWT2D numerical code: acquisition and management of experimental data in real time

The ADAG group has performed extensive research activities in the low speed wind-tunnel belonging to Dipartimento di Progettazione Aeronautica regarding airfoil, wing and aircraft scaled model tests. Pressure measurements are performed with: 1)multimanometer with high accuracy and automatic readings (designed and built in house); 2) pressure scan system. The group has worked on the design and set up of strain-gages balances (both internal and external) for wind tunnel forces measurement. Several wind tunnel tests have been carried out on models of airfoils, wings, wing-fuselages, light aircraft. For example, P92, P96 and G97 light aircraft models have all been tested in our tunnel. Experimental work regarding single-component, two-component and three-component airfoils has been carried out with particular attention to side-wall interference. Suction devices have allowed accurate measurements on this high-lift multi-component airfoil. Experimental test regarding vertical axes and horizontal axes wind turbines have also been performed.
Tests on half model aircraft and wings have also been performed in the wind tunnel. Particular attention has lately been devoted to multiple winglet design to optimize gliding performances of aircraft and hang-gliders.

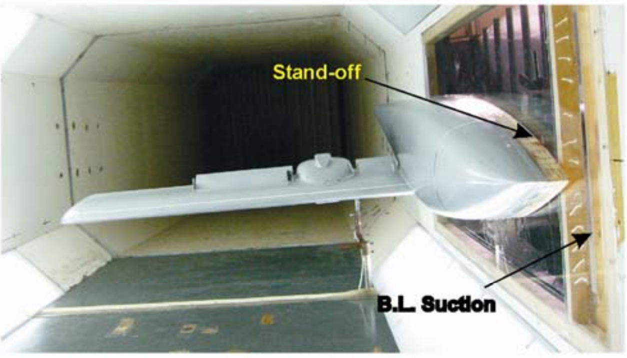
2D Model Test



Flow visualization with oil

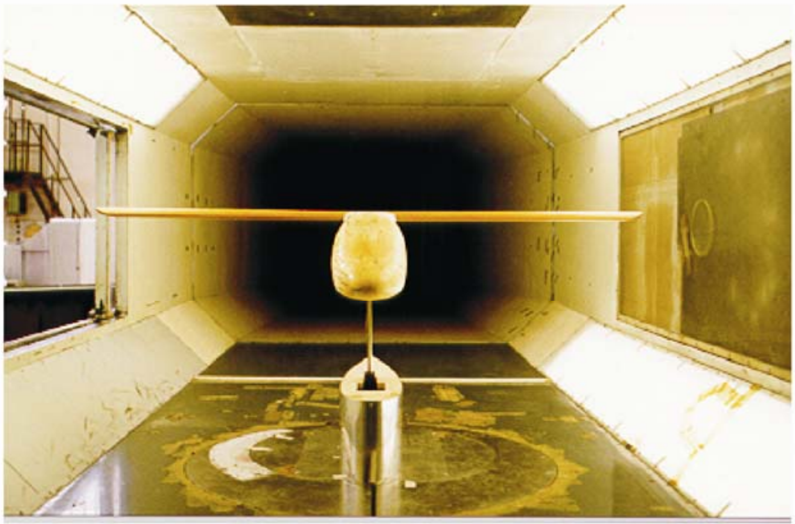
3-Element airfoil test

Half Model Test: wing-body



Half model visualization

Whole Model Test



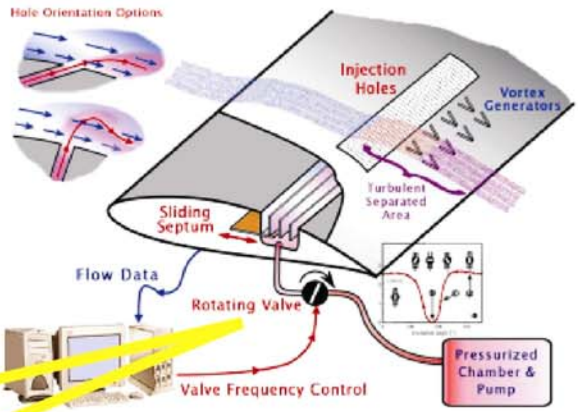
Turbulent Separation Control (Drag reduction & high-lift improvement)

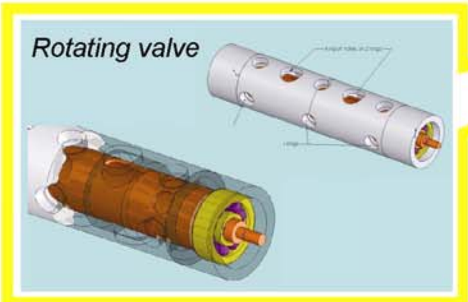
Introduction

•Boundary layer suction/blowing is one of the most advanced method in order to reduce aircraft parasite drag and flow separation at high angles of attack. In this way high lift can be achieved or low-drag can be obtained at high lift coefficient.
•Suction/Blowing is an interesting solution especially for UAV aircraft characterized by low flight Reynolds numbers and relatively high lift coefficient at cruise condition.

Main problems

•Main questions to be answered are : - is the system consistent and robust ?- is the system economically and practically viable?
•For example it is important to evaluate the net balance between the needed power reduction due to aerodynamic improvements and power used to produce this improvement.



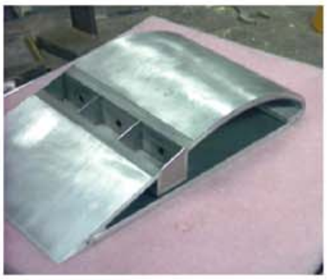


Research steps

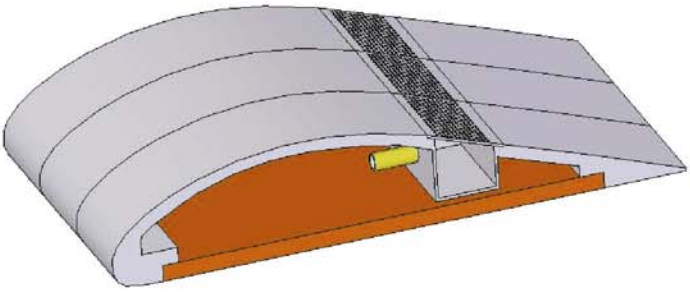
•Designing of suitable airfoil shape to perform wind tunnel test.
•Numerical analysis of suction/blowing applied to the rear part of the airfoil.
•A wide and deep experimental investigation to highlight the practical advantages coming from suction/blowing implementation both for steady and unsteady cases with verification of cost effectiveness, in terms of power needs.

Test outline

The first experiment will be on a small scale model (21 cm in span and 40 cm in chord) and the second will be on a full span model (1.4 meter).
The Reynolds will be in both cases 750.000 with free stream speed close to 30 m/s. This is also the flight Reynolds number.
Both experiments will be performed with steady suction and oscillatory blowing for different frequency range (up to 150 Hz).



Reduced scale model



dimension: 400 mm(chord) 210 mm(span)
3 chamber 70 x 40 (mm)
input tube: 10 mm (internal diameter)
surface porosity: 0.25
surface hole diameter: 1.0 mm diameter

FLIGHT TESTS

Flight Instrumentation

"G97 Spotter" Ultralight Aircraft

Acquisition System, Radio Modem and GPS

Load Cell on command system

Potentiometer on control bar

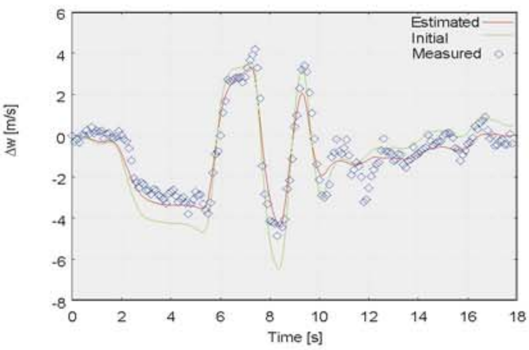
Pressure sensor

Inertial Platform

Pitot Probe with angle indicators

Studies have been performed to identify the sensors end the acquisition methods to obtain a complete, accurate, easy to use, low cost and low weight instrumentation tool. The equipment used in the flight tests consist basically of: data acquisition system; inertial platform (accelerations, angular rates, angles); pressure probes; probe for measuring the angles of attack and sideslip; potentiometers; load cell to measure command forces; propeller tachometer; GPS (position and ground velocity).

The data acquisition system (DAS) has been completely designed at DPA. The DAS allows the reading of 32 channels, 16 of which can be conditioned according to the user's needs, 8 dedicated to the DMU platform and the remaining 8 are used by potentiometers. The innovative probe to measure angles of attack and sideslip, in the process of being patented, has also been completely designed at DPA.

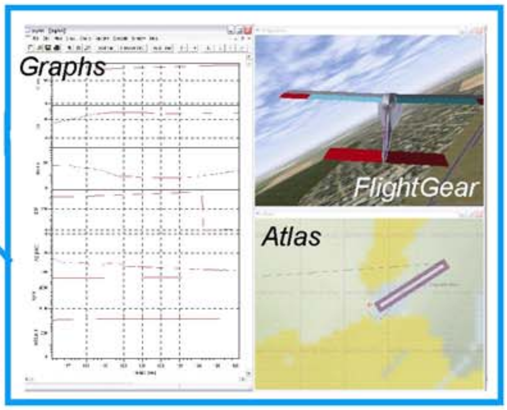


Aerodynamic & dynamic parameters estimation (MeMaV code)

The ADAG group has been working on the flight test campaign of G97 and P92 light aircraft. All aspects regarding JAR-VLA certification procedures have been object of research. Accurate and detailed analysis of flight test manoeuvres have been performed and comparison with numerical prediction has been done. It has been set up a complete procedure to estimate aerodynamic and dynamic characteristics, and performances of aircraft through flight tests. It has also been implemented a numerical code in Fortran language, named MeMaV, based on Maximum Likelihood Method applied to equations of aircraft motion (linear and nonlinear). Using this code it is possible to identify the aircraft aerodynamic derivatives from flight test data.

Ground Control Station (GCS)

Ground Control Station (GCS): transmission in real time of flight data and visual camera view; RPV Model control.



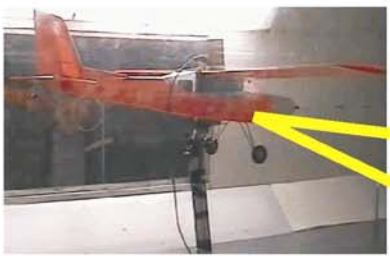
FlightGear, Atlas and Graphs interface integration

FlightGear instrument panel

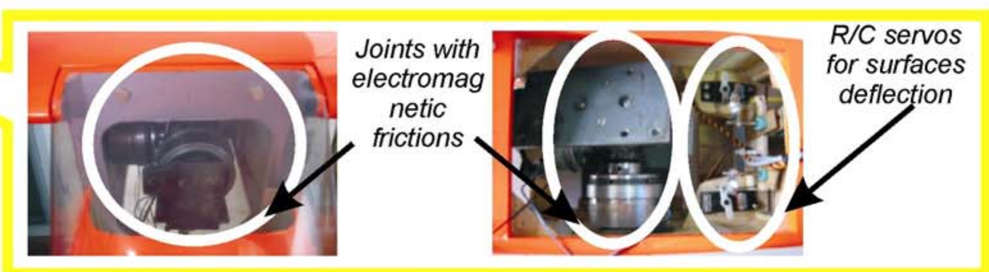
The ground station for the remote aircraft monitoring and control is an integrated system designed at DPA. It is housed in a compact rack and its dimensions are such that it can be easily transported by car and installed outdoor. Ground control station's subsystems are the following: a radio-modem, a GPS receiver, two PCs for data processing and visualization, a pedal joystick, a cloche, a radio digital remote control. The radio modem receives in real-time a large set of flight data, and a video signal. Flight data include aircraft position, linear and angular velocities, accelerations, aerodynamic control surface deflections, engine parameters. Flight data are recorded in flight by an airborne system, stored a magnetic support and sent to the ground station at a given rate. The analogic video signal is also sent to the radio-modem by an on-board video camera. Flight data are received in real-time and collected by a data-management software, which communicates with an instance of FlightGear (FG) flight simulator running on the first PC. The first PC is used here for the visualization of a panel of indicators via FG. A second instance of FG runs on the second PC. It shows the digital 3D terrain and virtual aircraft attitude, and is interfaced with a map visualization tool. Finally, the data-management software is interfaced with a plotting software for the scientific visualization of flight data.

Wind Tunnel Tests for Pitch Control of R/C Model Aircraft

- Experimental campaign for R/C model aircraft dynamic tests in the wind tunnel.
- Set up of a real-time control of a R/C model aircraft using wind tunnel tests and experimental data analysis.
- Matlab/Simulink control system design.

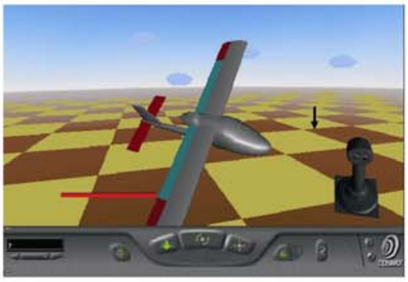


Wind tunnel test



FLIGHT DYNAMICS & FLIGHT SIMULATION

JDynaSim Simulator



JDynaSim simulator

The ADAG group has developed a flight simulator called ***JDYNASIM***, written in JAVA and available at http://www.dpa.unina.it/coiro/. Recently Flight Gear software system is being used to perform simulation of aircraft flights. Both codes read as input all the aerodynamic output curves of ***AEREO*** code, an *in house* developed numerical code to predict all aerodynamic, static and dynamic characteristics of propeller driven aircraft. ***AEREO*** is based on a mix of semi-empirical methodologies and more accurate lifting line methods. Comparison between flight simulation and flight tests results for some light aircraft has shown good agreement. Investigations on light aircraft longitudinal and lateral stability analysis have been carried out with detailed analysis of stall maneuver and all-movable horizontal tail behavior.

Flight Simulator

Under the activities of Regional Center of Competence in Trasportation System, it has been acquired a full-scale simulation system that will be both used for driving and flight research and activities. The simulator includes real cockpits, a motion system, and a large projection system. The motion system is able to be plugged to two different cockpits and the software is able to simulate either a car or aircraft.
The simulator is installed in Naples in the room belonging to CNR Istituto Motori. The cockpits are switched using a fork-lift truck. The used cockpit is safely plugged on the motion system adaptor plate.
The dynamics and the aerodynamics of simulated aircraft are obtained either from numerical analysis and/or wind tunnel test and/or flight test. The ADAG group manages the flight simulator and has developed software for the integration of proprietary prediction codes with FlightGear. Similarly, force feedback system is run by an *ad hoc* software manager that directly interfaces with FlightGear characteristic socket data exchange utilities.

Degrees of freedom (DOF)	6
Maximum Payload	1000 Kg
Surge range	0.923 m
Sway range	0.850 m
Heave range	0.495 m
Pitch range	+/– 25°
Roll range	+/– 25°
Yaw range	+/– 43°
Peak Velocity, Heave	+/– 0.484 m/s
Peak Velocity, Surge/Sway	+/– 0.718 m/s
Peak Rate, Pitch/Roll	50°/s
Peak Rate, Yaw	82°/s
Peak Acceleration, Heave	+/– 0.59 g
Peak Acceleration, Surge/Sway	+/– 1.3 g
Peak Acceleration, Pitch/Roll	600°/s/s
Peak Acceleration, Yaw	1100°/s/s
Weight	625 Kg

Software environment

The flight simulator is based on FlightGear software component. FlightGear is a civilian flight simulator comparable to Flight Simulator© from Microsoft. It is an open source project. The software is decomposed into various modules.

General architecture

The simulator is installed in a building divided into three areas: the simulator main room, the supervisor room, the briefing room. The platform is animated using a six degree of freedom motion platform.

Aircraft cockpit

The flight simulator cockpit consists in a generic cabin of a small aircraft. The cockpit structure consists in an aluminum "skeleton" and polycarbonate plans. The instrument panel consists in two tactile LCD screens: one screen displays the FlightGear flight panel; the second screen is used for engineering real time plots of flight parameters. The flight controls consist in: a Cirrus II Flight Console from Precision Flight Inc., a yoke, and rudder pedals. To simulate the ATC radio link, the trainee will have a headset with a microphone. The cockpit access is a rear door. The cockpit is equipped with swivel chairs.

Force feed-back systems

The yoke and the rudder pedals are also equipped with a force feedback system.

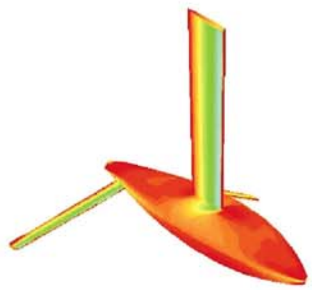
Internal view

Projection system

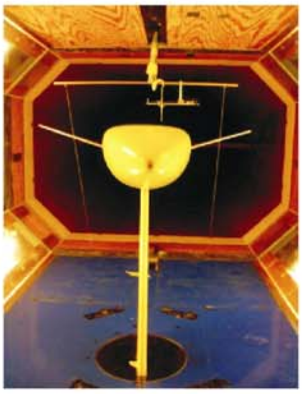
The external view images of the simulator is generated by three DLP projectors and projected on three screens in front of the cabin.

Max Yoke Force (pitch up / down)	+/– 400 N
Max Yoke Torque (roll left / right)	+/– 40 Nm
Max Pedal force (yaw left / right)	+/– 400 N

SAILBOAT APPENDAGE ANALYSIS

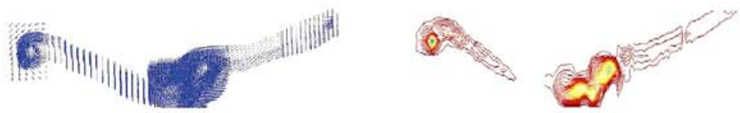


Numerical data - Pressure coefficient distribution



WINGLET POSITION	Alfa [deg]	CL	CD_i	CD_f	CD_{tot}	Percentual Advantage from Nowinglet
No winglets	3	0.312	0.0110	0.011	0.0233	-
Aft position	**3**	**0.300**	**0.0060**	**0.013**	**0.0199**	**15%**
Mid position	3	0.295	0.0080	0.013	0.0217	8%
Forward position	3	0.296	0.0086	0.013	0.0221	6%

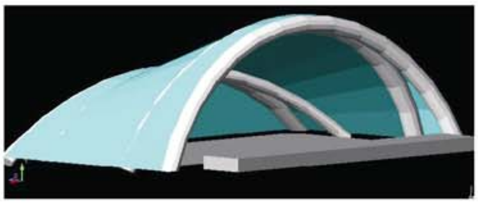
Lately particular attention has also been devoted to sailboat complete appendages (fin-bulb-winglets). Specific and detailed numerical and experimental investigations have been performed on the winglet influence on the global performances of the appendage.
A preliminary study has been carried out on some fin-bulb-winglet configuration in order to have a first optimization of some geometrical parameters and to investigate the winglet influence on the fin-bulb-system.
A detailed numerical study has been carried out on many different configurations to establish geometry to be tested in wind tunnel.
The first experimental test has then been performed at Chalmers University Wind Tunnel with active participation of our group. A second test is programmed in our wind tunnel.
The experimental data treatment has been performed developing some specific numerical codes useful to derive the aero/hydrodynamic coefficients of interest. In particular the measured velocities as well as the derived vorticity and streamlines contours of the appendage wake have been evaluated to compute induced drag of the whole system.



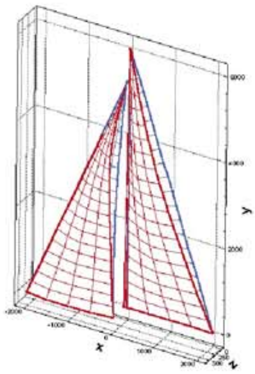
Experimental data - Measured velocities in the appendage wake and vorticity contour

3D SAILS

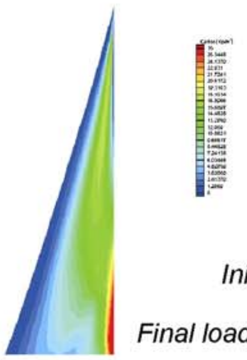
Aero-Structural deformation of a sail system under aerodynamic load



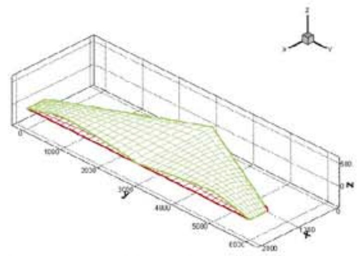
Covering of a hockey field



Initial shape (blue), final shape (red)



Final load distribution



Initial shape (red), final shape (green)

The ADAG group, in the last years, has been involved in the investigation of fabric's behaviour under aerodynamic loads. First investigations have regarded inflatable structures.
The complexity of the subject, due principally to the not negligible interaction between the structure and the aerodynamics in the case of sail behaviour, has induced the development of a numerical code, named ISTIA, to predict both structural and aerodynamic loads for a complete sail rig.
The code has been validated with experimental results performed in our wind tunnel on a sail model. This was a simple triangular sail and a laser scan system has been used to measure the three-dimensional sail shape under aerodynamic load.

RENEWABLY ENERGY

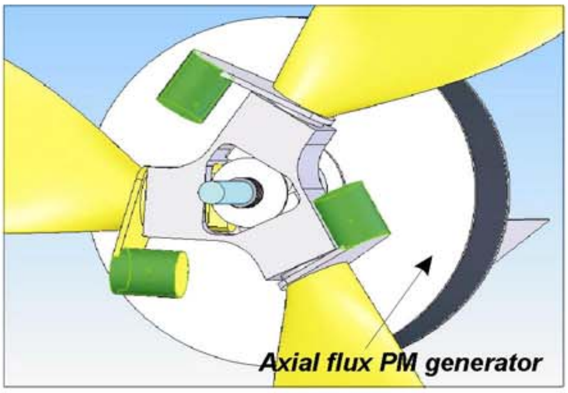
Horizontal Axis Wind Turbine Design (5kW Wind Turbine Project)

The complete design of a 5 kW wind turbine prototype has been carried out starting from wind tunnel and free-air tests on a small model. The design has regarded rotor's aerodynamics and structure as well as the axial flow PM generator ad hoc designed. The rotor's blade shape has been obtained starting from blade's airfoil geometry. Five different airfoil's geometries have been employed in the blade.

The wind turbine has been designed to work at optimum condition in a wide range of wind speed having its maximum at a relatively low wind speed compared to current market available models. Over speed control has been obtained by an in-house designed passive centrifugal control system that keeps the rotor at the nominal working condition. Structural and dynamic analysis of the rotor blade (fibreglass construction) has been performed. The whole turbine has been built and particular attention has been paid to the production process in order to lower the final turbine cost.

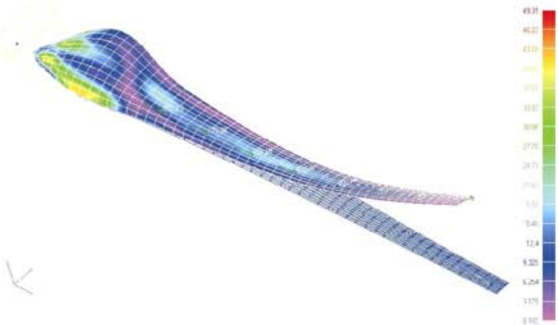
Full scale turbine's prototype under test

Maximum dimensions of the 5 kW wind turbine	
Number of blades	3
Rotor radius	2.8 m
Above ground height	18 m

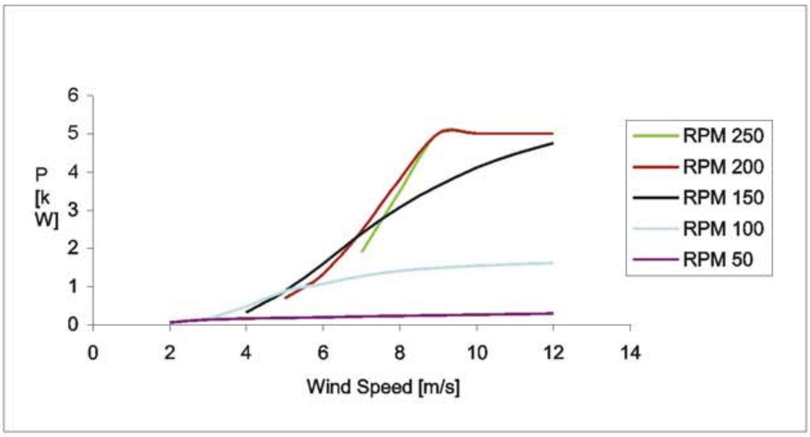


Passive centrifugal pitch control (toward stall)

Small turbine: wind tunnel test



Structural & dynamic analysis of the rotor blade (fibreglass)



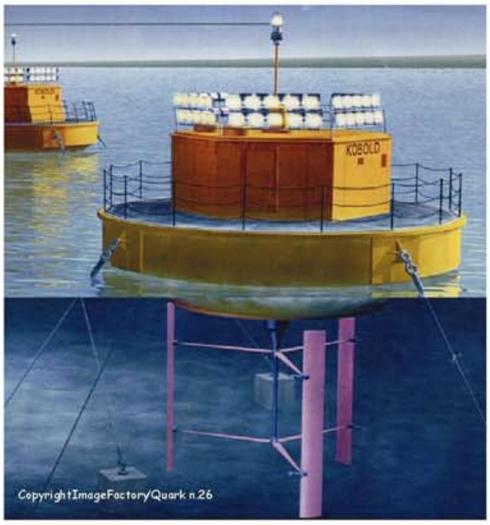
Power in function of wind speed and RPM

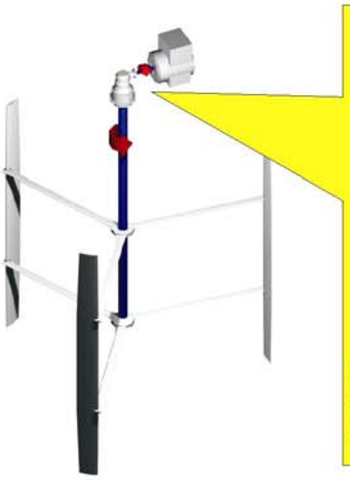
Vertical Axis Turbine to Exploit Tidal Currents

The KOBOLD turbine

From 1998 to 2003 the ADAG group has been involved in the development of the first prototype in the world of vertical axis hydro turbine, able to produce electrical energy from tidal currents: the KOBOLD turbine. This turbine is covered by an international patent PCT n. WO 2005/024226 A1. At present, the turbine is moored in Strait of Messina for the test phase.

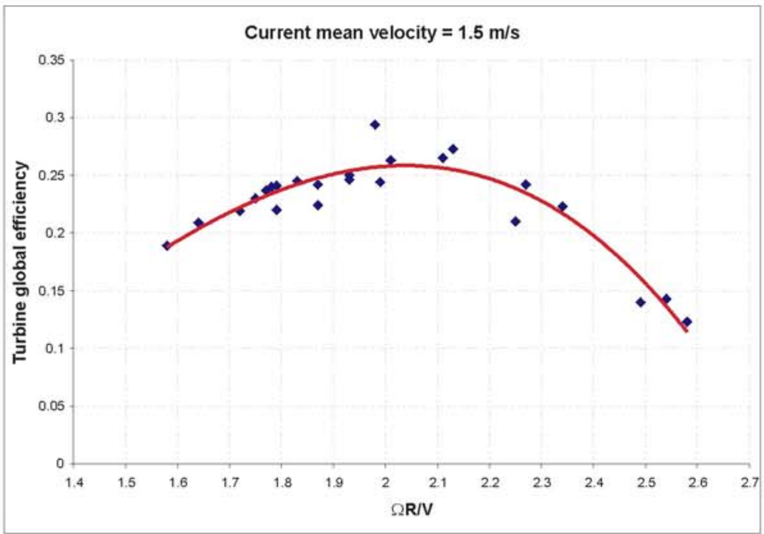
The ADAG group developed the whole hydrodynamic and structural design of the rotor both numerically and experimentally. In the last two years the group has developed the MYTHOS turbine that has higher global efficiency thanks to an innovative blades design and to the optimization of other components such as electrical PM generator directly driven by the main shaft. The whole research project is aimed to lower the construction and maintenance costs.





Buoy inside:
multiplier (1), torque-meter (2), electric generator (3), control panel (4)

Main plant dimensions		
Turbine	Diameter	6 m
	Blade span	5 m
	Chord	0.4 m
	N° of blades	3
Floating platform	Diameter	10 m
	Depth	2.5 m
	Draft	1.5 m
Mooring	N° anchoring blocks	4
	Blocks weight (concrete)	350 kN each
	Chain	70 mm
	Water depth	18/25 m



Measured global efficiency of KOBOLD turbine

Patents, Selected Publications and Invited Lectures

International patent: PCT n. WO 2005/024226 A1.

1. C. de Nicola, D.P. Coiro, V. Losito, " *An efficient multi methods computer code for the prediction of the inviscid and viscous flow over multi-component airfoils*", AIAA paper 88-3564, in AIAA CP888, AIAA NFDC Congress, Cincinnati, Ohio, U.S.A., July 1988.
2. C. de Nicola, D.P. Coiro, V. Losito, *" Prediction of Aerodynamic Characteristics of High Lift Multi-Element Airfoil*s ",in Boundary Elements X, Vol. 2, edited by C.A. Brebbia, 1988.
3. D.P. Coiro, C. de Nicola, " *Prediction of Aerodynamic Performance of Airfoils in Low Reynolds Number Flows* ",Low Reynolds Number Aerodynamics Conference, NotreDame, Indiana, U.S.A., June 1989, also published in "Low Reynolds Number Aerodynamics" edited by T.J.Mueller, Springer-Verlag, 1989.
4. D.P.Coiro, C. de Nicola, " *Low Reynolds Number Flows: The Role of The Transition*", X Congresso Nazionale AIDAA, Pisa, Ottobre 1989, also published on Aerotecnica, Missili e Spazio, Novembre-Dicembre, 1989.
5. D.P. Coiro, P. de Matteis, M. Amato, " *An Euler/Boundary Layer Interaction Method for Transonic Flow Calculations Around Airfoils* ", X AIDAA National Congress, Pisa, Ottobre 1989.
6. D.P. Coiro, M. Amato, P. de Matteis, " *Numerical Prediction of Transonic Viscous Flows Around Airfoils Through an Euler/Boundary Layer Interaction Method*", AIAA paper 90-1537, AIAA 21st Fluid Dynamics, Plasma Dynamics & Lasers Conference, Seattle, WA (U.S.A.) -June 18-20, 1990, published on Aeronautical Journal, Vol. 96, Number 954, April 1992.
7. D.P. Coiro, P. de Matteis, M. Amato, " *Wake Effects on the Prediction of Transonic Flows Around Airfoils With an Euler/Boundary Layer Interaction Approach*", AIAA paper 90-3061, AIAA 8th Applied Aerodynamics Conference, Portland, OR (U.S.A.), August 20-22, 1990, published on Journal of Aircraft, Vol. 29, Num. 3, May-June 1992.
8. D.P. Coiro, " *Convergence Acceleration Procedure for a Viscous/Inviscid Coupling Approach for Airfoil Performances Prediction* ", XI AIDAA National Congress, Forli', Italy, October 1991.
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12. D.P. Coiro, P. Dini, " *Stall and Post-Stall Performance Prediction of Advanced Wind-Turbine Airfoil*s ", XII AIDAA National Congress, Como, Italy, July 1993.
13. D.P. Coiro, F. Nicolosi, " *Design of Natural Laminar Flow Fuselages* " ICAS Congress, California, USA, September 1994, in final phase for the publication on Aeronautical Journal.
14. D.P. Coiro, F. Nicolosi, *" Design and Optimization of Glider Components* ", OSTIV Congress, Omarama, New Zealand, January 1995 -also in Technical Soaring Journal, Vol. 19, n. 2, April 1995.
15. P. Dini, D.P. Coiro, S. Bartolucci, " *Vortex Model for Airfoil Stall Prediction Using an Interactive Boundary-Layer Metho*d ", ASME Conference, Houston, Texas, USA, January 1995.
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20. D.P. Coiro, F. Nicolosi, A. Amendola, D. Barbagallo, L. Paparone, S. Beccio, P. Castelli, S. Limone, ", *Experiments and Numerical Investigation on a Multi-Component Airfoil Employed in a Racing Car Wing,* " SAE Congress, Detroit (USA), February 1997.

21. D.P. Coiro, P. Dini, " *The Prediction of Aerodynamic Stall Over Wind-Turbine Airfoils*, " International Conference on fluid and thermal energy conversion '97 Yogyakarta, Indonesia, July 1997.
22. Coiro D.P., Nicolosi F., Boermans L.M.M., Woldendorp S., " *Testing High Lift Airfoils at Low and Moderate Reynolds Numbers*, " ICEFM III Congress -Moscow, June 1997.
23. Coiro D.P., Nicolosi F., " *Aerodynamics, Dynamics and Performance prediction of Sailplanes and Light Aircraft*, " XXV OSTIV Congress, St. Auban, France, July 1997, published on Technical Soaring Journal,2000, 24(2).
24. Nicolosi F., Coiro D.P., "*Fuselage Design and wing integration for Sailplanes and Light Aircraft*," XIV AIDAA National Congress, Napoli, Italy, 20-24 October 1997.
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28. Coiro D.P., Madonna M., "*Investigation of Turbulence Effect on Dynamic Behaviour of Aircraft through Use of* ***JDynasim****: a Platform Independent Simulation Software,*" First International Conference on Engineering Design, Prague, May 1999, published on Acta Polytechnica, J. of Advanced Engineering Design, Vol. 40, N. 1/2000.
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30. Giordano V., Coiro D.P:, Nicolosi F., "*Reconnaissance Very Light Aircraft Design. Wind-Tunnel and Numerical Investigation*". EHAE 99 Conference, Prague, Sept. 1999. Published on Journal for theoretical and applied mechanics Czech Republic.
31. Giordano V., Coiro D. P., Nicolosi F., Di Leo L.,"*Design and Aerodynamic Optimization of a NewReconnaissance Very Light Aircraft through Wind-Tunnel Tests*", AGARD Symposium on Aerodynamic Design and Optimization of Flight Vehicles in a Concurrent Multi-Disciplinary Environment, Ottawa, Canada, October 1999.
32. Malpede S.M., Vezza M., Coiro D.P., "*Load Distribution along a Sail-Mast*," 3rd ISEA International Conference on The Engineering of Sport, Sydney, 9-12 Giugno 2000 published on "The Engineering of Sport", eds. A.J. Subic, S.J. Haake, Black well, 2001, ISBN0632055634.
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38. Coiro D.P., Nicolosi F., "*The ENERMAR Project*", IATICE 2002 Conference and Exhibition, Melbourne, Australia, April 2002.
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41. Coiro D.P., Nicolosi F., Scherillo F. and Maisto U., "*Numerical and Experimental Aeroelastic Analysis of Sails*," High Performance Yatch Design Conference, Aukland, New Zealand, December 2002.
42. D.P. Coiro , F. Nicolosi , A. Moroso , N. Soprano "*Exploitation of Marine Tidal Currents: Design, Installation and Experimental Results for the Patented Kobold Vertical Axis Hydro Turbine*", Poster-International Conference OWEMES 2003, 10-12 April 2003, Naples.

43. Coiro D.P., "*RPV and Light Aircraft Aerodynamics, Performances and Flying Qualities Estimation, Simulation and Flight Tests*", **invited lecture** at: DINCON 2003, International Conference on System Identification, San Paolo, Brasil, 18-23 August 2003.
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48. Coiro D.P., "*Numerical and Experimental Activities on the Aero-Structural Behaviour of Sails and on the Hydrodynamics of Lifting Surfaces*", **invited lecture** at Chalmers University of Technology, Department of Naval Architecture and Ocean Engineering, Gothenburg, Sweden, January 12th 2004
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56. **Invited Seminars**: Coiro D.P., "*1) Harvesting tidal current energy: scientific and technological aspects; 2) Economics of harvesting tidal current energy*" at MIT, Massachussets Institute of Technology, Boston, February 2005.
57. Coiro D.P., Nicolosi F., De Marco A., Melone S.. and Montella F., "Dynamic Behavior of Novel Vertical Axis Tidal Current Turbine: Numerical and Experimental Investigations," ISOPE Conference, Seul, June 2005
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