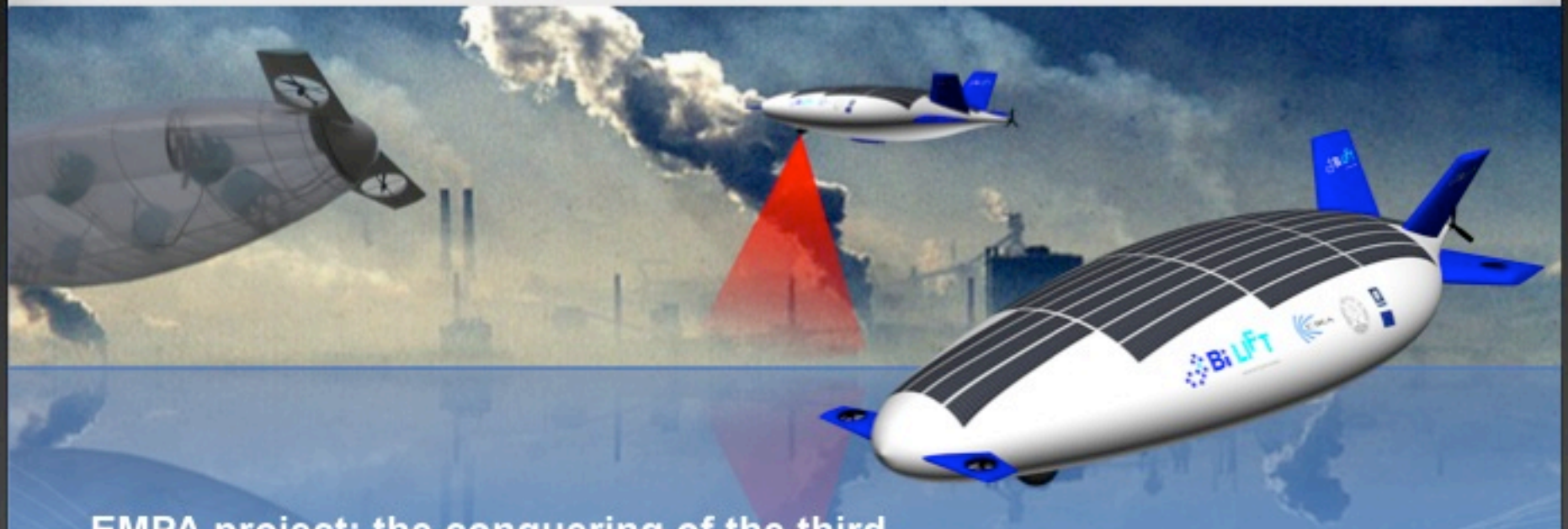

EMPA project: the conquering of the third dimension in the ambient air monitoring

M. Lega *- R.M.A. Napoli*- G. Persechino**- P. Schiano**

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NAQC 2009 – March, 2009 - Addison, Texas

Contents

- Introduction
- The past
- EMPA project
- Project Team
- Sensors and Missions
- Aerial Platform: Advanced Hybrid Airship
- Conclusions and Future perspective
- Acknowledgements

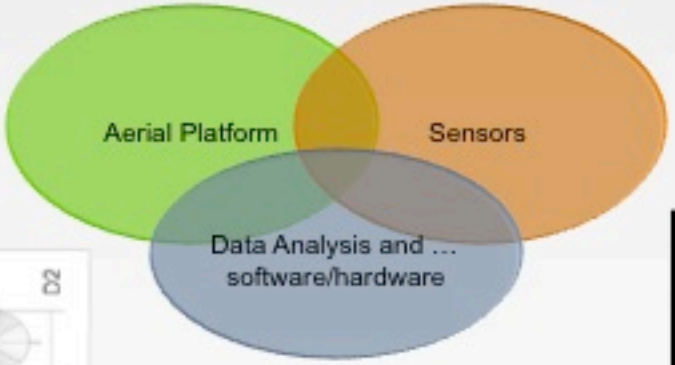
Introduction

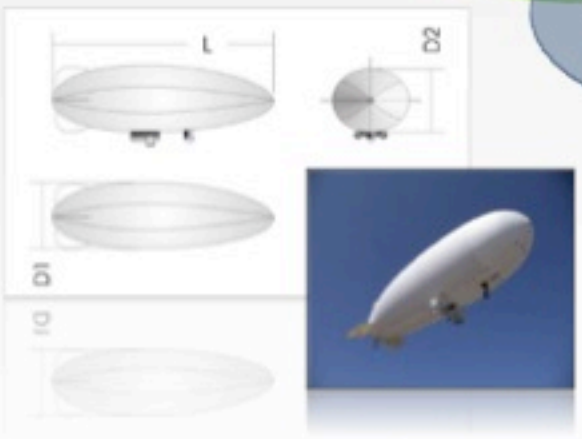
The analysis of the Remote Sensing data (satellite and ground-based) can't provide a consistent set to build a validated 3D-profile of pollutant concentrations and transport; in order to validate the model "source-path-target" we also need the data provided by a direct acquisition on the field at different altitude.

Particularly it must be underlined, that the activities of direct acquisition on the field are essential both in the phase of the "discovery" of new phenomenologies, as well as in the validation of the numerical models but, above all, to allow rapid interventions in case of emergencies, allowing, in the time, also the definition of an evolutionary model for a strategic work of prevention and containment of the disasters.

The awareness to have to sample the "scenario / path" is known for a long time to the scientific community but, only the possibility and the facility to move in the studied matrix has determined its real application.

The past





Aerial Platform: mini UAV-LTA but with a conventional shape

EMPA project

Environmental Monitoring Performed by Advanced Sensors And LTA Platforms Supporting Urban And Suburban Early Warning Actions

In EMPA was developed an integrated system that, thanks to the joined use of **BiLift®** (advanced hybrid airship) aerial platforms and specific "payloads", will allow an "innovative" monitoring in urban and suburban areas also to support actions of "early warning".

The choice of the aerial platform has been done by verifying the particular correspondence of it to the requisites of a mission and, at the same time, appraising the same one like efficient "amplifier" of what is measurable from the sensors positioned on the ground in “pure” configuration.

Project Team

CIRA (Italy)
Italian Aerospace Research Center

PARTHENOPE (Italy)
University of Naples - Department of Environmental Sciences

CNR-IBP (Italy)
Italian National Research Council - Institute of Biochemistry of the Proteins

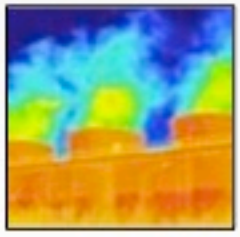
UMD (USA)
University of Maryland - Department of Atmospheric and Oceanic Science

UCSD (USA)
University of California, San Diego - Department of Structural Engineering

Sensors and missions: IR camera + ULM

FLIR P660

- 640 x 480 Infrared Detector
- Thermal Sensitivity: <45 mK
- Highest accuracy +/- 1% or +/- 1°C
- Dynamic Details Enhancement (DDE)
- Built-in Geographic Positioning System (GPS)
- WLAN remote control and display
- 3.2 Megapixel visible light camera
- Target illuminator for low-light areas



with contribution of FLIR SYSTEMS TECNAM

ENGINE		
Manufacturer	Rotax	
Model	912ULS2	
Power	100 hp	
Number of Cylinders	4	

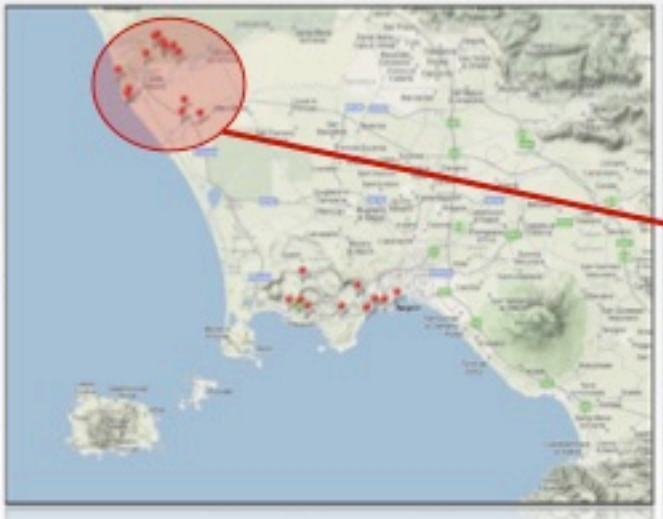
DIMENSIONS		
Wing Span	26.5 ft	8.7 m
Wing Area	133 sq/ft	12.4 sq/m
Fuselage Length	21.3 ft	6.5 m
Fuselage Height	8.2 ft	2.5 m
LH-RH Cabin Door	in	m
• Height	33	0.83
• Width	30	0.76

PROPELLER	
Manufacturer	Tonini
Model	GT
Number of Blades	2
Type	Fix

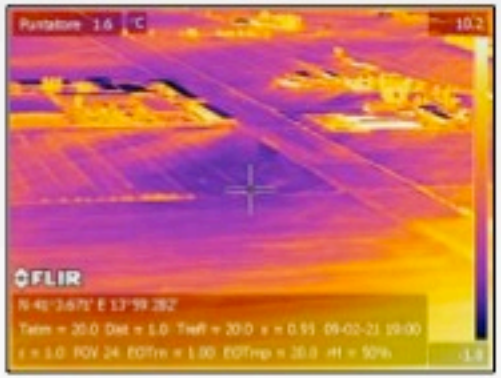
DESIGNED WEIGHT and LOADING	lb	kg
Designed MTOW	1320	600
Limit Loads	+4 / -2 g	
Ultimate Loads	+6 / -3g	
Baggage Allowance	44	20

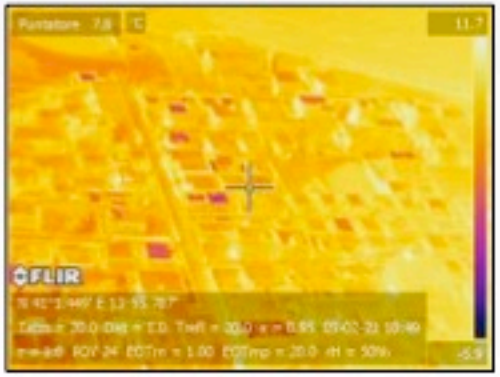
PERFORMANCE (450 KG) 100 hp		
Speed	Kts	Km
○ Max Sea Level Gross weight	127	235
○ Cruise 75% power	116	215
○ Vne	146	270
Stall Speed	Kts	Km
○ Flaps Down, power off	35	65
Rate of Climb at Sea Level	1200 ft/m	
Service Ceiling	14,600 ft	4500 m

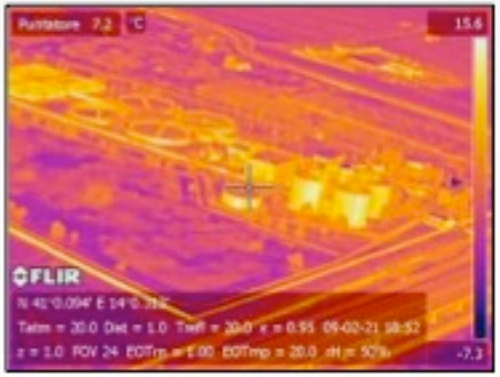
Sensors and missions: IR camera + ULM



Sensors and missions: IR camera + ULM



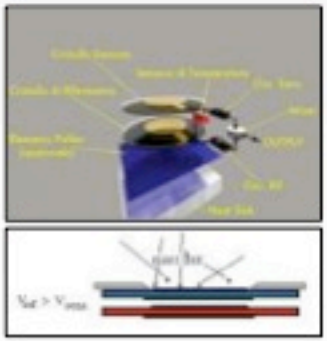




Sensors and missions: QCM + TB

Novaetech - Quartz crystal microbalance

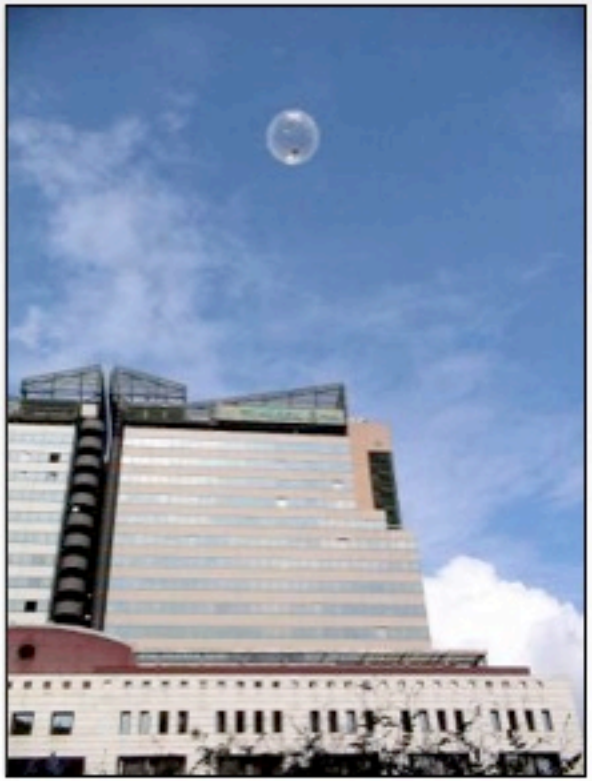
Power supply: 5 (VDC)
PM min size : 0.1 (μm)
Pump Flux : 4.68 (l/min)
Efficiency: 0.40
Data acquisition: real time
Pc link: USB 2.0



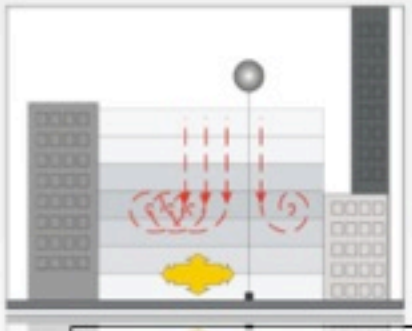
with contribution of novaetech

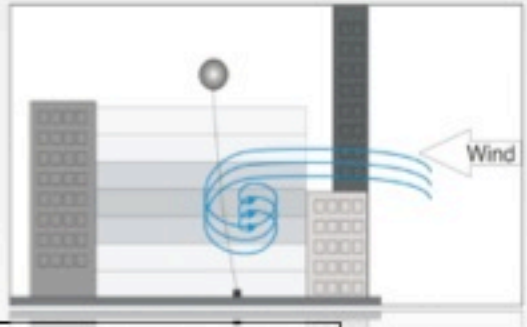
"Ready to fly" prototype

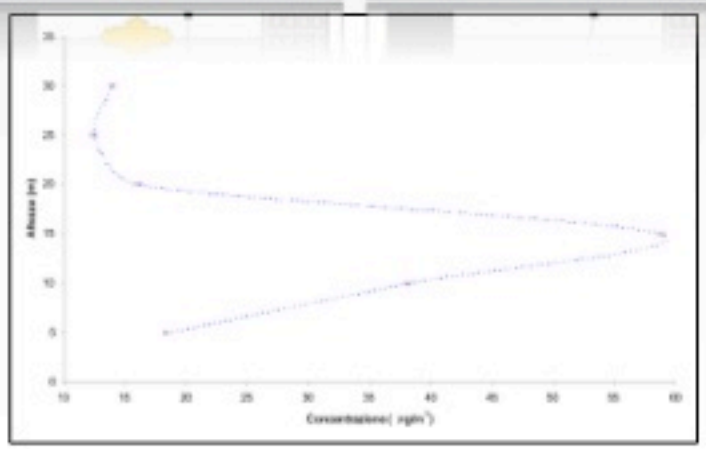
Sensors and missions: QCM + TB

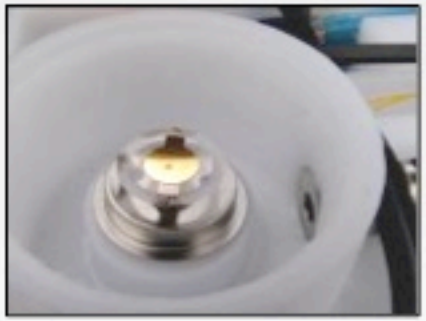


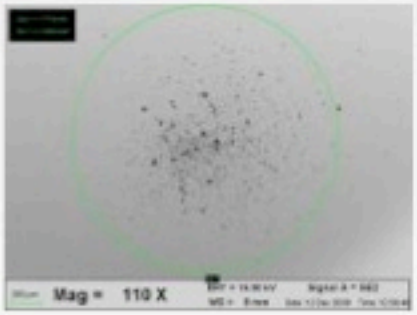
Sensors and missions: QCM + TB

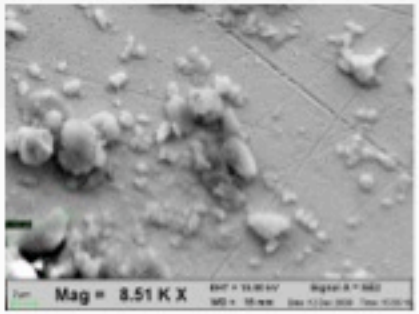


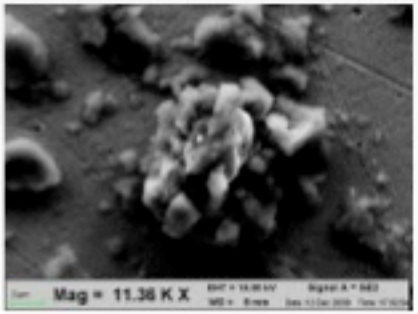












Sensors and missions: MPU

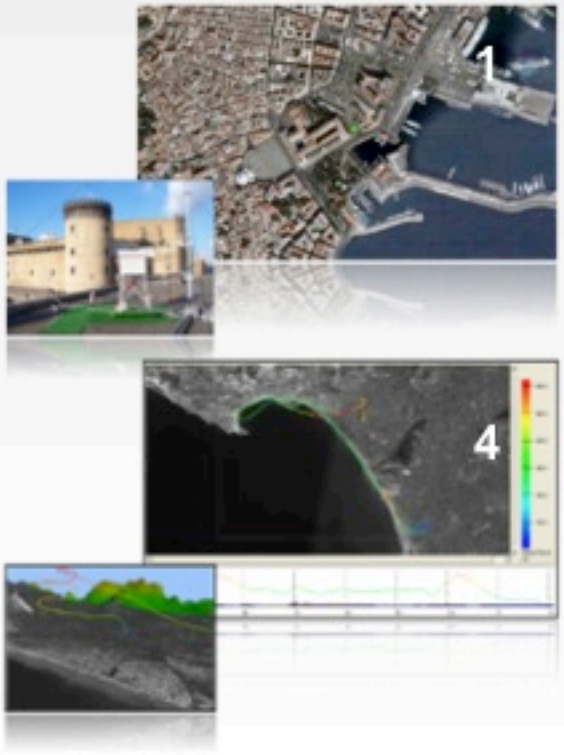
The proposed multi-parametric unit is a device manufactured by UNITEC (ETL) and customized in our lab to permit the transportation on an aerial platform. It is based on thick film technology for the continuous measurement of CO, NOx, O3, added to air temperature, relative humidity. The system has a built-in data logger and a GSM modem.

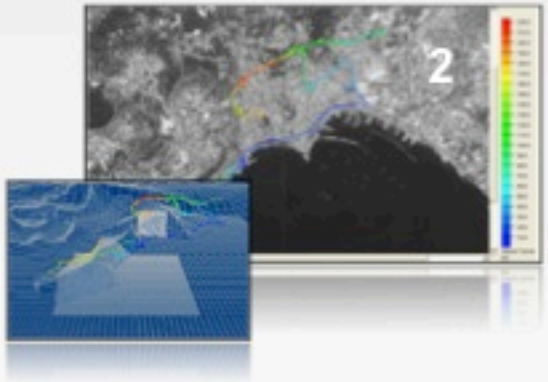
Principle of measurements :
CO, NOx, O3: thick film sensors
Relative humidity: capacitive sensor with thermostated polymer interacting with platinum electrodes
temperature: high precision sensor on integrated circuit

Ranges :
CO : 0-100 mg/m^3 (relevability limit: 0.1 mg/m^3)
NOx : 0-1000 g/m^3 (relevability limit : 2 ppb)
O3 : 0 - 500 g/m^3 (relevability limit : 20 g/m^3)
Air temperature : -20 +80 °C
Relative humidity : 0 −100%

with contribution of UniTec

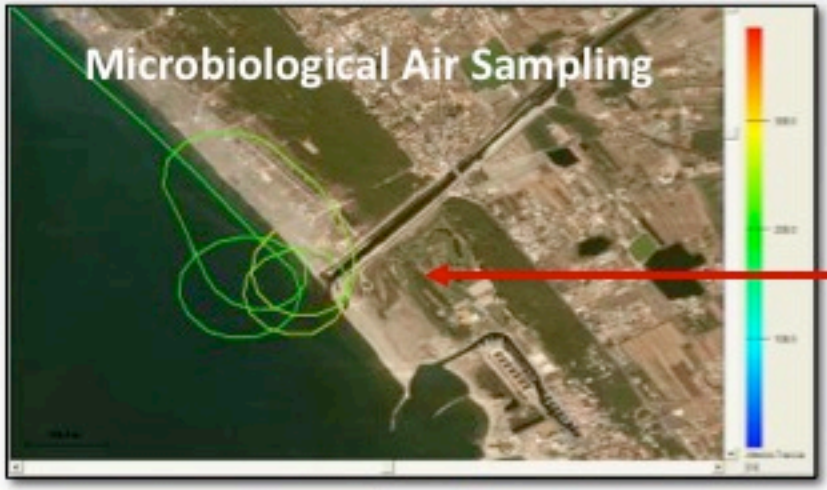
Sensors and missions: MPU





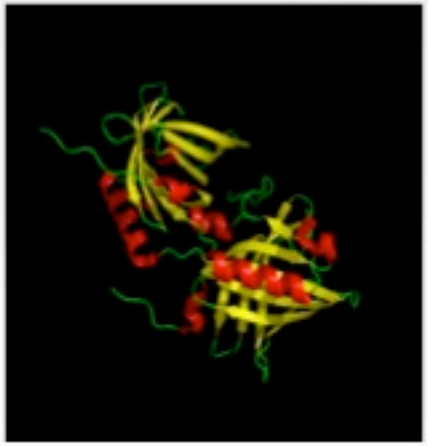
1) "Fixed point"
2) "Dynamic", short range by ground vehicle
3) "Dynamic", long range by ground vehicle
4) "Dynamic", long range by aerial platform

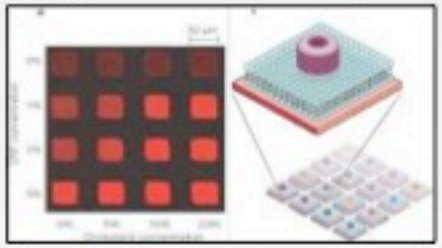
Sensors and missions: SAS + ULM

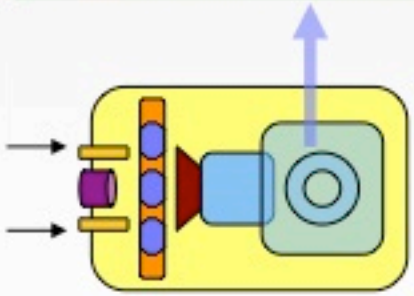


Sensors: biosensor

Activity developed in cooperation with the **Italian National Research Council (CNR)**: Prof. M. Rossi - Dott. S. D'Auria

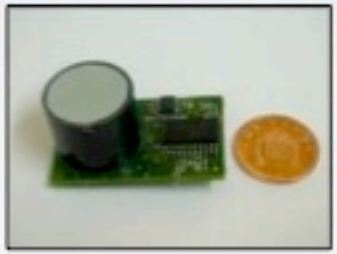


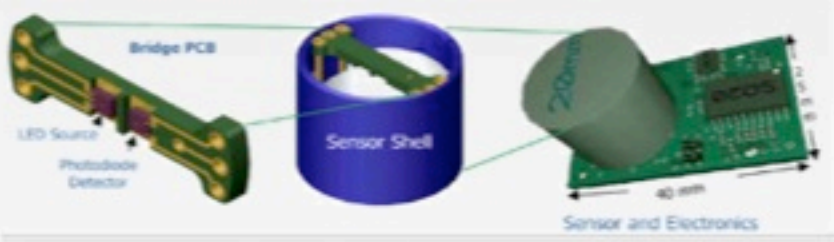




with contribution of Consiglio Nazionale delle Ricerche

Sensors: CO2





Noise at zero (30s integration)	10 ppm
Temperature range	-25C to +55C
Supply Voltage	4.7V to 5.5V (std) 3.3V to 5.5V (low)
Average Power Consumption	<100mW
Peak Supply Current	200mA
Range	0 to 20% (up to 100% available)
Output	TTL level RS232 + Analogue Output
T90	< 4secs
Zero Drift	Recommend re-zeroing once 2-3month

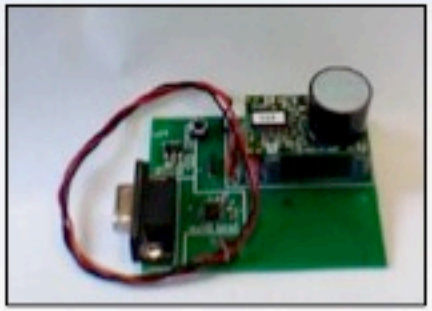
Plus:

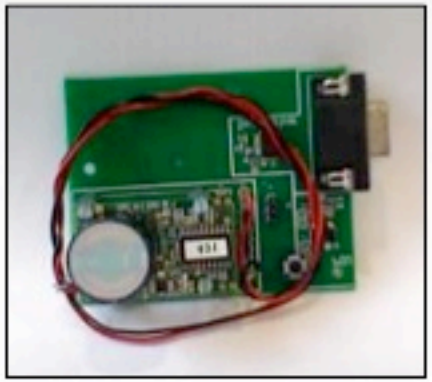
-Simple Design

-No Moving parts

-Large aperture for rapid diffusion

- Optical filtering built into chipset





"Ready to fly" prototype

with contribution of AIR MONITORS

Sensors: Gyro-Pod + EOS

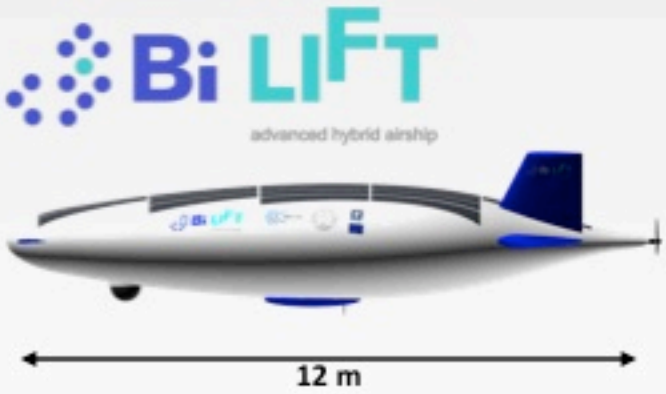
Carbon-fiber gyro-stabilized pod

Electro-optical sensors: HD digital camera, IR camera, …

+ ….

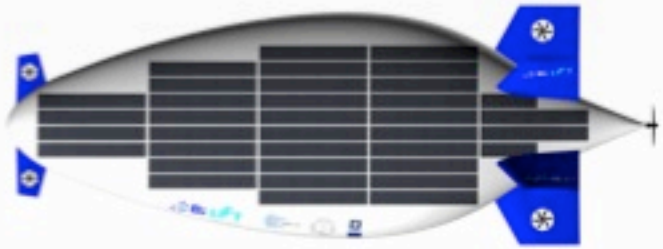
Aerial Platform: Advanced Hybrid Airship

SPECIFICATIONS	
Length	12 m
Width	4.5 m (Dmax) – 2.20 m (Dmin)
Max Speed	50 Km/h
Payload	20 kg
Max weight (w/o helium)	60 Kg
Endurance	> 4 hours
Max. Altitude	1000 m
Control	RC/RPV/UAV



Plus:

- "Zero" emissions
- High maneuverability al low speed
- Easy handling
- Vertical take-off and landing
- Low cost management



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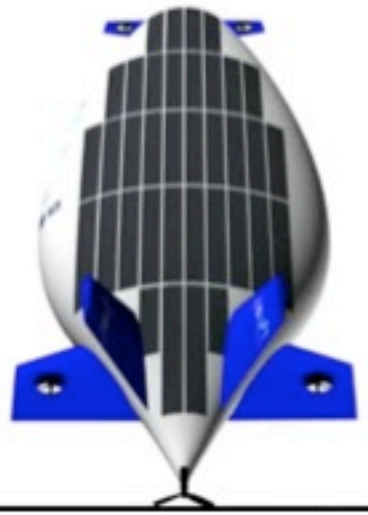
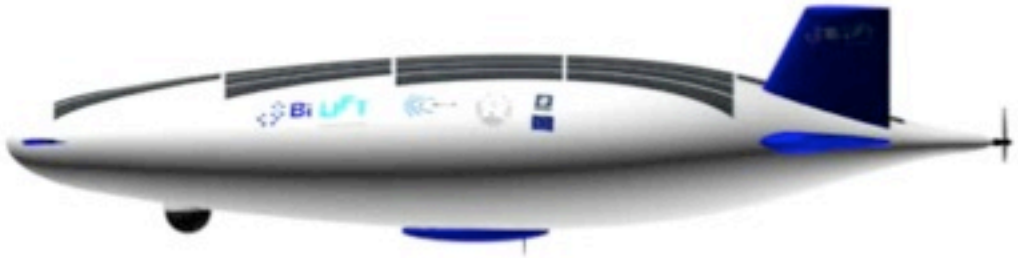


Aerial Platform: Advanced Hybrid Airship

Thin flexible solar panel based amorphous silicon

High power brushless electric motor

5 electric motors powered by LiPo Batteries + Solar Panels

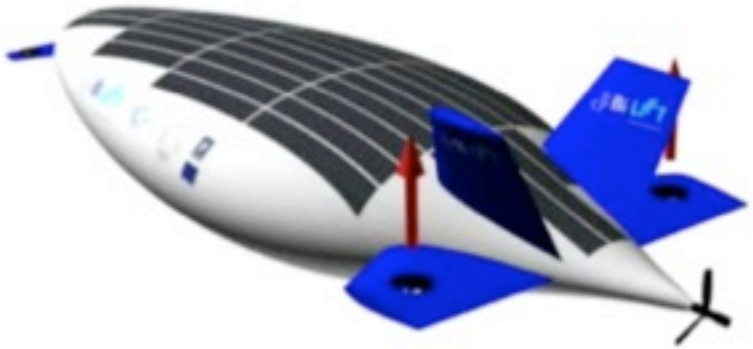


Aerial Platform: Advanced Hybrid Airship

Trust Vectoring for hi maneuverability at low speed

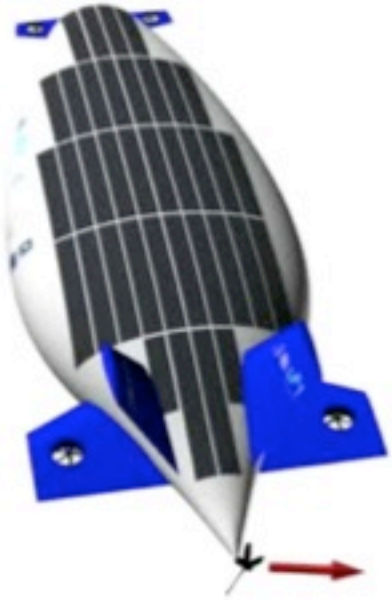
Aerial Platform: Advanced Hybrid Airship

Trust Vectoring for hi maneuverability at low speed



Aerial Platform: Advanced Hybrid Airship

Trust Vectoring for hi maneuverability at low speed



Aerial Platform: Advanced Hybrid Airship

First flying prototype

Aerial Platform: Advanced Hybrid Airship

First flying prototype

Conclusions and Future perspective

We customized and tested all selected sensors (payload) to permit the data acquisition to be carried onboard aerial platforms.

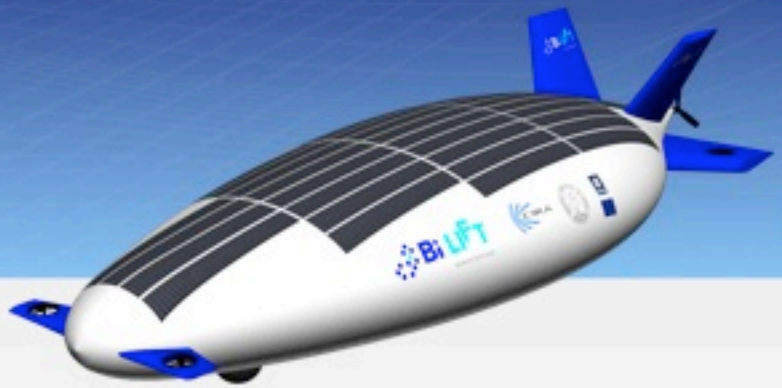
The "payload" was composed of an array of sensors finalized to the measurement of environmental parameters and was customized to be hosted on board of the aircraft and includes: IR camera, Biosensors, Particulate Mass measurement (based on a piezo-crystal inertial micro-balance), a multi-component air quality monitor device (based on “thick film” sensors), HD Digital Cameras, GPS, Data Logger, GSM modem and/or WiFI network for remote data link/handling.

Conclusions and Future perspective

The selected aerial platform is of UAV hybrid LTA (Lighter than Air) type and will allow the exploration of three-dimensional spaces without altering the measurement parameters, returning geo-referenced data, guaranteeing minimal invasion and maximal safety for the operational context.

The choice of a specific platform that float in the "air" matrix, besides, not only represents a key element for the environmental investigations for the interest of the phenomenologies that happen in it (because "scenario/path") but, also because privileged point of view for phenomena in action in the other matrices.

Acknowledgements



CIRA Centro Italiano Ricerche Aerospaziali

Università degli Studi di Napoli PARTHENOPE

Consiglio Nazionale delle Ricerche

UNIVERSITY OF MARYLAND

UCSanDiego

Assessorato all'Università e Ricerca Scientifica, Innovazione Tecnologica e Nuova Economia, Sistemi Informativi e Statistica

Assessorato all'Agricoltura e alle Attività Produttive

with contribution of

FLIR SYSTEMS

novaetech

TECNAM

UniTec

AIR MONITORS