

The MFP System, an innovative airborne platform to monitor data of fluxes of gases and atmospheric pollutants

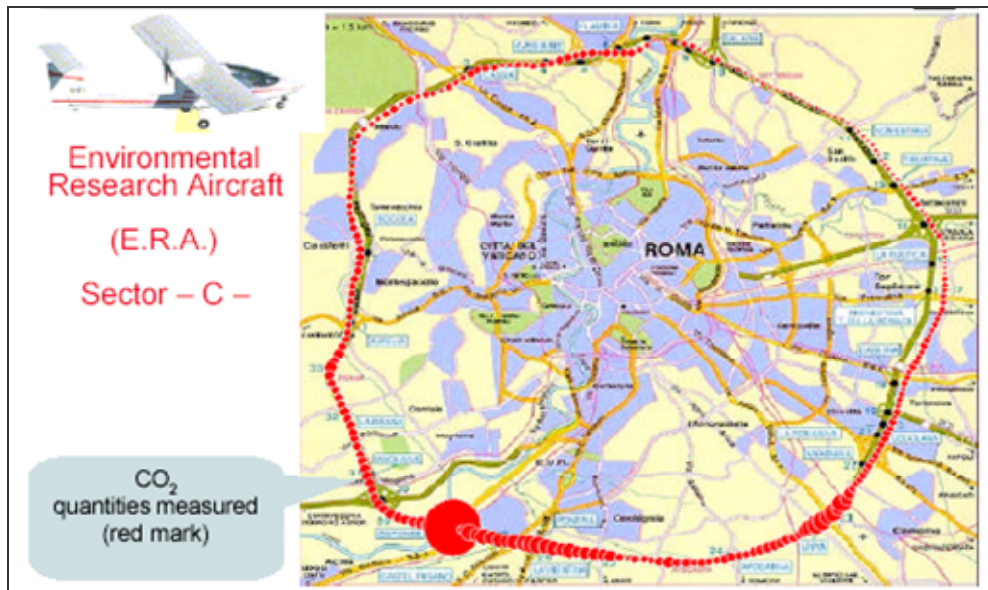
MFP is an innovative system for aerial monitoring of the green-house gas fluxes between the land and the atmosphere and atmospheric pollutants. The activity is performed by the Sky Arrow ERA aircraft, the first certified aircraft in USA and in Europe, capable of using airborne eddy covariance technique.

CarboEurope is a research project funded by the European Commission and whose aim is the study of the terrestrial Carbon Cycle. The MFP - Sky Arrow ERA, has been developed in the frame of CarbonEurope in collaboration with CNR-IBIMET in Florence and NOAA-ATDD (National Atmospheric Administration – Atmospheric Turbulence and Diffusion Division) in the USA in the 90's. The aircraft participated to several experimental campaigns worldwide for the measurement of gas fluxes exchanges and other atmospheric data.

The version developed at present by TERRASYSTEM is based on miniaturized electronic components of the last generation. These systems, featuring ease of use, cheapness and flexibility, were developed and have been constantly updated by TERRASYSTEM in close collaboration with a research team that involves Universities and Research Institutes. MFP systems developed by TERRASYSTEM has been installed on SkyArrow aircrafts of international Research Institutes as Alterra (Netherlands) and Istituto Agua e Aria (Argentina).

The objective of the technique is that of integrating data collected by ground monitoring networks with airborne regional information. Airborne sensors allow, in fact the:

- Measurement of significant sources of heat, water vapour, carbon dioxide and other green-house gases;
- Measurement of the wind, air temperature, water vapour and greenhouse gas concentrations for dynamics studies of the atmosphere;
- Integrated measurements of wind, turbulence and gas concentrations for atmospheric pollution monitoring.



Operating purpose

The system allows to carry out periodic monitoring of environmental pollution and its trend in specific areas such as: agricultural or urban zones, industrial sites etc.

The system also allows to measure pollutant fluxes on regional scale. This is possible by direct in-flight measurements of:

1. wind and turbulence at high frequency;
2. concentration of specific gases (CO₂, H₂O; options for CO, Nox, Sox);
3. other environmental parameters (radiation energy, temperature).

Further development of this system will lead to collect selected air samples, for post-flight laboratory testing and measurement.



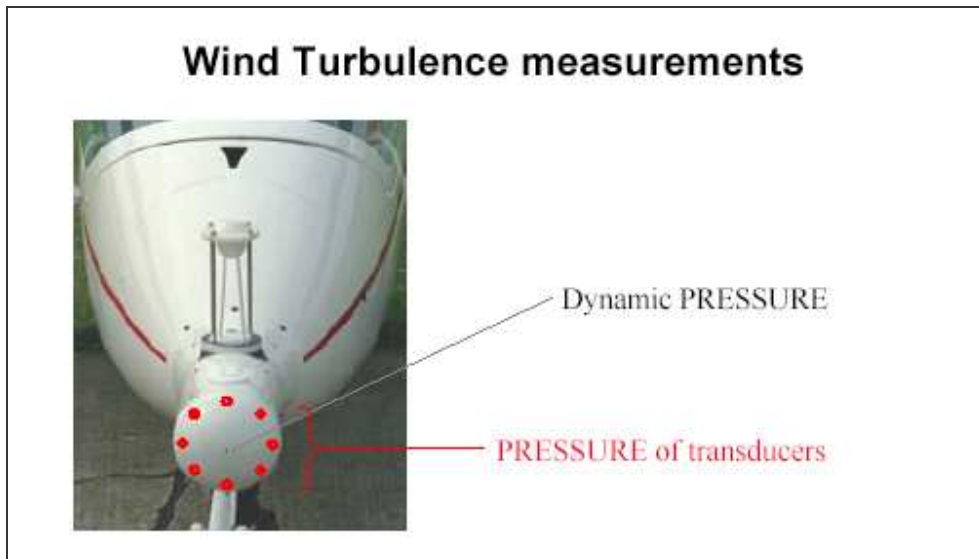
The system is composed of:

- Aerial platform;
- Station for the processing of data collected during the flight;
- Option for a GPS ground station to increase measurement accuracy.

The aerial platform is equipped with the following onboard mission devices which may be run by the pilot himself:

- BAT-Probe for wind and atmosphere turbulence (measurement collection of air samples);
- Vectorial GPS system, for aircraft attitude measurement;
- Infrared open path gas analysers (CO₂, H₂O);
- Laser Altimeter for measurement of the aircraft distance from the ground;
- GPS receiver to calculate the aircraft position and speed;
- Radiometers to measure both total (NET) and reflected (PAR) radiation;
- Temperature sensors to measure both air and surface temperatures.

Data processing is made by skilled personnel by means of dedicated software.



The wind and atmospheric turbulence measurement, calculated by means of aerial platform, is an operating possibility since a number of decades in the field of advanced scientific atmospheric research.

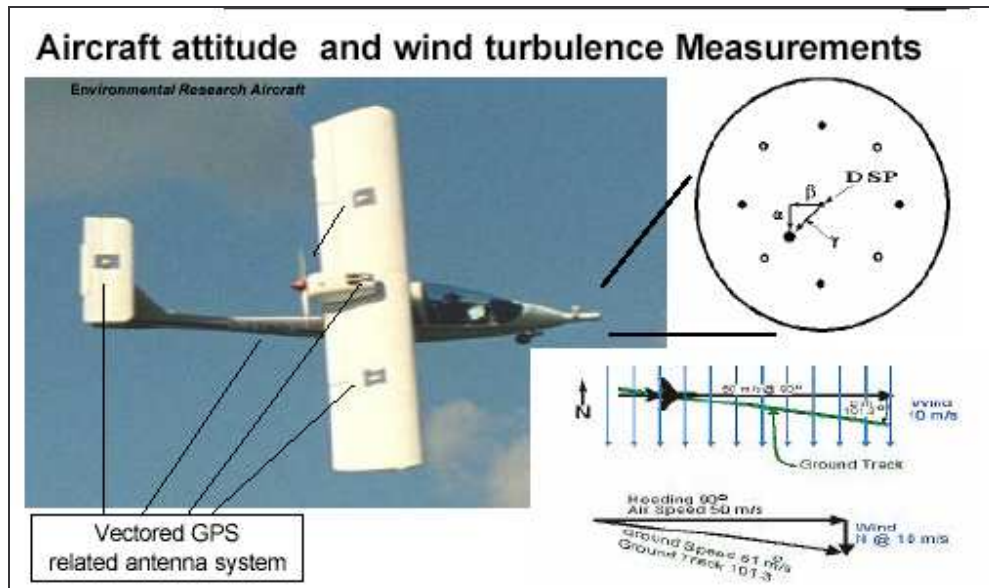
The advent of a new generation sensors featuring compact size, limited power consumption, low cost and extremely rapid response times, has made it possible to outfit small-scale aircraft, thus offering consistent advantages in terms of cost, simplicity of operation and quality of measurement.

To measure turbulence, this aircraft uses the BAT (Best Atmospheric Turbulence) probe, developed jointly by NOAA and ARA (Airborne Research Australia).

In 1998, the company Iniziative Industriali Italiane SpA, became aware of the potential offered by the Sky Arrow, for environmental research and began studying how to combine the NOAA-ARA sensor units with the aircraft.

The result was the creation, in 1999, of the Sky Arrow ERA (Environmental Research Aircraft), the first aircraft certified both in Europe and the United States to perform environmental measurements with MFP (Mobile Flux Platform) instrumentation.

CNR IBIMET has promoted the introduction of this technology in Europe as well, through the RECAB project, (Regional Assessment and Modelling of the Carbon Balance of Europe – part of the CarboEurope initiative), whose goal is to assess the carbon balance on European scale. The subject aircraft has played a key role in determining the carbon fluxes, latent and sensible heat fluxes at the regional scale.



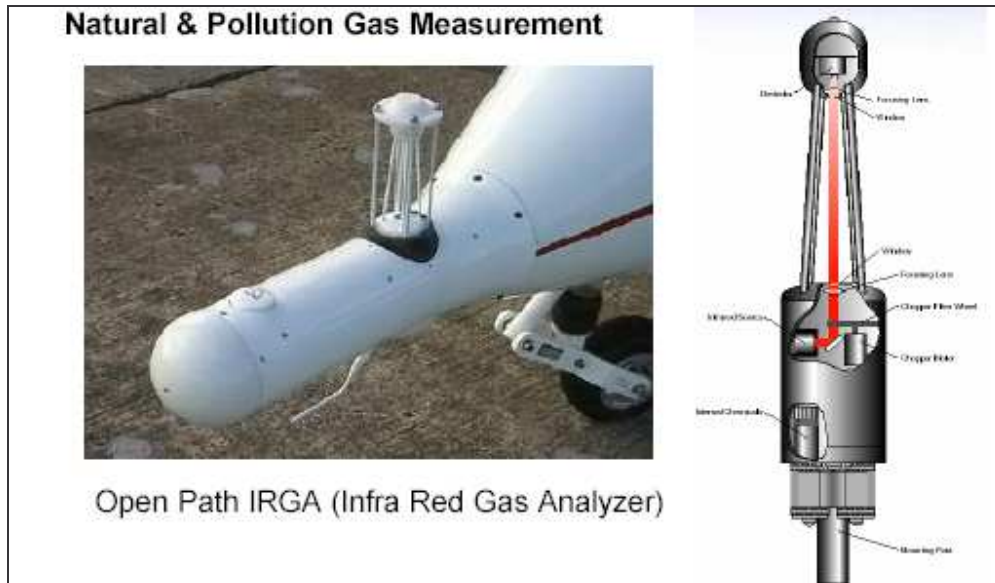
The primary purpose of the MFP technology is high frequency wind measurement compared to the ground reference system, as with a ground-based sonic anemometer.

Since in this case we have a moving platform, the wind speed, relative to the ground reference is calculated by means of two different measurements: the air speed, relative to the aircraft, and the aircraft speed, relative to the ground.

The aircraft and ground coordinate systems are related to the three angles describing aircraft attitude in the space. As a result, measurements of the relative wind, through the BAT probe, are subsequently corrected for the aircraft motion relative to the earth.

These corrections are based on high-frequency, attitude (defined by the three angles of orientation in space: Pitch, Roll, Heading) and speed (defined by the three spatial components) measurements of the aircraft which the BAT system is integrated to.

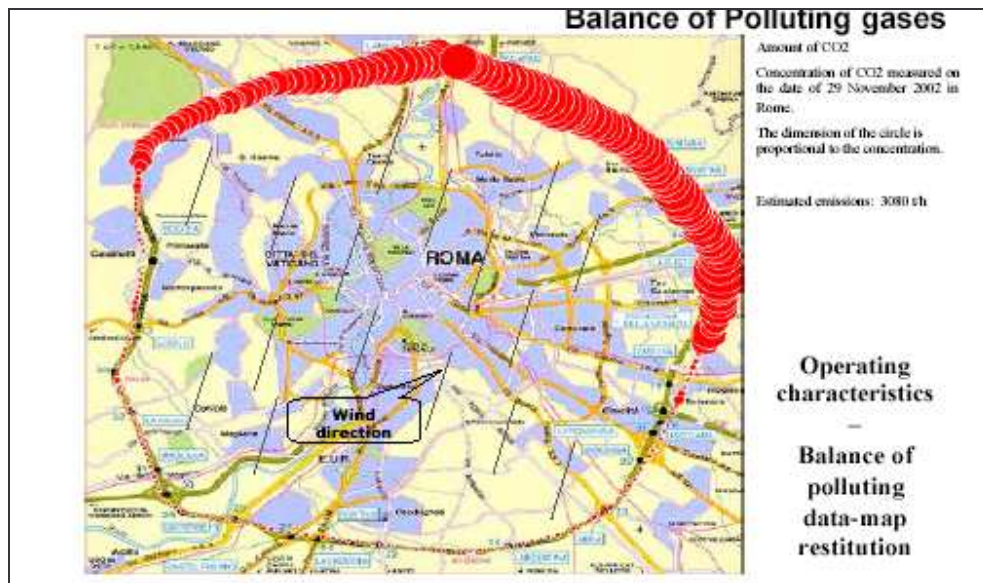
Both the attitude and the speed measurements rely on the GPS and on the three-axes accelerometers installed on the aircraft.



The gas analyser is one of the aircraft main instruments. It is capable of measuring, the concentration of carbon dioxide (CO₂) and water vapour (H₂O) in the atmospheric layer, in which turbulence is measured, at a frequency of 20Hz (20 measurements per second).

The instrument is projected to work for 20,000 hours, the rough construction enables it to work in any environmental condition.

The sensor head has a 12.5 cm open path, with 1 cm diameter single pass optics. Reference filters centered at 3.95 μm and 2.40 μm provide for attenuation corrections at non-absorbing wavelengths. Absorption at wavelengths centered at 4.26 μm and 2.59 μm makes it possible measurement of both CO₂ and water vapour concentrations with high accuracy.



The diagram shows the concentration of carbon dioxide in the atmosphere at different heights around the city of Rome during rush hours of a week day.

With the Sky arrow aircraft it was possible to measure the quantity of carbon dioxide emitted in Rome an autumn working day: over 3,000 tons per hour.