The European Fleet for Airborne Research (EUFAR) provides a resource network for both experts and novices in airborne research, making available aircraft equipped with specialist instruments for in-flight experimentation. **Dr Jean-Louis Brenguier** outlines the progress and future developments

The sky's the limit for EUFAR researchers

The FAAM BAe-146 offers the largest scientific pay-load in the European fleet (3-4 tons), with an endurance of 5.5 hours and a sampling speed of 100-150 m/s. FAAM is operated by the MetOffice and NERC (photograph copyright RALPH WEIGEL)

EUFAR has made a significant contribution to European integration over the past 10 years, with the support of the European Commission (DG Research-Infrastructures division) having helped it evolve into a unique collaborative network in the field of airborne research. Servicing a sustained level of integration has always been the intended objective, whilst giving European researchers access to the facilities they need to achieve their research goals, regardless of the nationality of either the user or infrastructure operator. There is little doubt that the European research community benefits enormously from the highly efficient and cost effective technology base provided by EUFAR when attempting to overcome a wide range of scientific problems in the fields of environmental and Geo-sciences.

What can EUFAR accomplish?

EUFAR was born from the need to overcome the fragmentation of communities of users and operators in Europe, an issue which had become a constraint on the development of airborne research activities.

Accessing national or 'home' facilities has traditionally been relatively easy for users, largely because such facilities are often subsidised by national authorities. However, accessing aircraft operated outside the users own country has typically been far more difficult, even when the aircraft itself was better suited to the objectives of the experiment. For researchers from countries which were not operating any aircraft, the only opportunities to participate in airborne campaigns were as an invited participant, and rarely as the principal investigator. National research priorities were consequently driven by the type of research aircraft available. For the operators, developments in infrastructures and instrumentation were decided at the national level, usually without consideration of similar facilities already available in other European countries.

However, the situation has evolved significantly since, with successive EC funded projects in FP5 (Framework Programme 5), FP6 and now in FP7 addressing the issue. By pooling European resources in airborne environmental and Geo-sciences, EUFAR

- facilitates access to a large and diverse fleet of aircraft and a complete panoply of state-of-the-art airborne instruments,
- fosters a culture of cooperation between operators, and
- collects information on activities, scientific impact and user needs for an integrated approach to infrastructure developments.

The integration of European research infrastructures is a long term enterprise and the network itself is continuously evolving. It has already grown into a highly advantageous culture where operators participate in collaborative activities. EUFAR keeps essential continuous feedback alive, and strengthens networking activities that link scientific users of the infrastructures with operators and research funding institutions. For instance, it enables eminent scientists to provide recommendations to the operators on the long term development of their activities, and for expert users to provide recommendations to operators and research funding institutions on good practice and future challenges. Furthermore, it allows operators to provide users with a coordinated access to the infrastructures, education and training opportunities, and a unique gateway to the database for airborne measurements. The initiative also provides the research funding institutions with technical solutions for the future development of the fleet and a sustainable management structure for EUFAR. Operators will develop standards and protocols for a better quality of service. Finally, the activity on e-communication provides all the actors with efficient collaborative tools, from a unique public portal to secured workflows for the activities of the working groups.

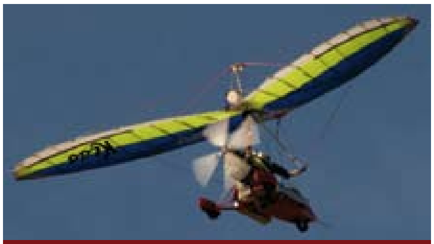
EUFAR thus combines, in a closely coordinated manner, nine networking activities, transnational access to 26 installations, and joint research activities. Although the majority of the funding comes from the European Commission, the aircraft operators and expert scientists involved in EUFAR make a significant contribution to the project and the pursuit of its goals.

Gathering airborne data

The contribution of instrumented aircraft to environmental and Geo-sciences is well recognised and appreciated by the research community. Indeed, an aircraft is the most efficient tool for sampling a large variety of atmospheric parameters in situ, and on scales spanning from the micro to the continental scale. In the atmosphere, the focus is on phenomena that are difficult to precisely document from the ground or from satellite, i.e. small scale winds, turbulence, microphysics of clouds and aerosols, local radiative balance and the chemistry of gases and aerosol particles.

For observations of the surface, the focus is on high spatial and spectral resolution, if possible from low levels so as to avoid the kind of atmospheric fluctuations that can affect satellite measurements.

Moreover, aircraft field experiments complement ground and satellite observations in that both the latter provide long-term, continuous monitoring of the atmosphere, but are limited to air masses flowing over the ground sites, and to the satellite's swath or field of view. An aircraft, by contrast, allows the scientist to target a specific atmospheric phenomenon, to follow it while it is moving in the atmosphere, and to sample its properties in situ, hence validating the retrieval techniques for ground and satellite remote sensing.



The FZK-ENDURO (DE) is the smallest aircraft of the fleet, with a scientific payload of 80kg and an endurance of 5 hours at a sampling speed of 25 m/s.

Plane facts

Using aircraft for airborne research does not equate to a one-size-fits-all strategy which is why collaboration of resources is vital. For instance, altitude matters when considering the aircraft technology. Propellers are generally used at levels below 9 km. Jets are limited to 15 km. Above 15 km, specific propulsion systems are required (stratospheric aircraft). Pressurisation of the cabin is necessary for working above 4 km. Both propulsion and pressurisation impact the cost of the installation and of the flight. Indeed, certification rules are more severe on a high level jet than on a non-pressurised light aircraft. The sampling speed is also an issue. Light aircraft have a limited pay-load, but they can be flown at a speed as low as 30 m/s, which is very good for sampling small scale turbulence with minimum perturbation. A jet is normally operated at about 100-200 m/s. This allows to rapidly cover large areas, but the airflow perturbation is a constraint (for particle sampling for instance). For instrumented aircraft, the highest altitude is below 20 km and the focus is on the chemical composition of the stratosphere. The lowest is just above the forest canopy with light aircraft when the focus is on the surface fluxes of sensible and latent heat and of the various chemical compounds (CO, CO_2, Ozone, etc)

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The number of scientists involved in airborne experiments in Europe, however, is still limited. The reason is that airborne operations are complex, due to the limitations imposed by air traffic control and by the aircraft's flying capabilities. Thus the training of young scientists, at Masters and PhD level, is crucial for the development of airborne activities. These airborne activities are more commonly developed in the U.S. as opportunities for training there are frequent and access is provided to a large suite of instrumented aircraft. EUFAR is currently working to improve this situation by facilitating access to all European aircraft, and by organising training sessions for young scientists. It is also expected that coordination at the European level will further smooth the process so that users will be able to obtain funding and gain access to the aircraft of their choice.

What's next?

The most challenging development the EUFAR project currently faces is the construction of a heavy-payload and long endurance turbo-prop for research in the troposphere (Hercules C-130

The young scientists of the first EUFAR training course in Iasi (RO) on side of the SAFIRE ATR-42 aircraft (FR). SAFIRE is operated by CNRS, Météo-France and CNES

type aircraft). Such an aircraft is considered by the users to be the main priority in terms of the overall development of the European fleet.

The COPAL project (Community Heavy-Payload Long Endurance Instrumented Aircraft) has been submitted to the ESFRI (European Strategy Forum for Research Infrastructures) roadmap and selected by the Commission for a Preparatory Phase project. With an allocation of 1 million Euros, the European Commission supports a feasibility study to precisely evaluate the costs for the procurement, modification, instrumentation, certification and operation of such an aircraft by a European consortium.

Additionally, the definition of a legal structure for the management and operation of a community aircraft will a key step towards ensuring the sustainable future of the EUFAR project. Beyond COPAL, EUFAR will consolidate and extend the networking activities in the seventh framework programme, with the integration of the remote sensing community, the development of a European airborne database, the establishment of standards and protocols for data acquisition and processing, and also the development of education and training activities. Trans-national access will be offered to a broader suite of aircraft and instruments, including hyperspectral imagers. It is planned that four joint research activities will start in FP7; these activities will be aimed at improving the quality of humidity measurements; the construction of a modular turbulence pod; the construction of a novel particle spectrometer; and the development of processing techniques and software for hyperspectral measurements of the earth's surface. The evolution of this world-class collaborative system looks set to further advance the essential studies and experiments that can only be carried out through the challenging but rewarding process of airborne research. ★

EUFAR outcomes in FP6

Over the past three years (2005-2007) seven EUFAR expert meetings have been organised. Some 73 applications for trans-national access have been evaluated and 43 selected for a total amount of 377 hours of research flying. In June 2007, the first EUFAR training school was organised in the Romanian city of Iasi on boundary layer studies. No less than 27 young scientists attended theoretical courses. They designed five scientific experiments, planned the corresponding mission with the SAFIRE ATR-42 (FR) crew, participated actively in the flight, and processed the collected data to validate their hypothesis. A similar training session was organised in April 2008 in De Bilt (NL) on aerosols and clouds, with 20 young scientists using the FAAM BAe-146 (UK). The data base on the European fleet summarises the activities of the aircraft (in flight hours and immobilisation days) since 1997, with information on the research topic and the geographical location of the field experiments. The data base on the scientific impact of airborne activities now includes more than 1,600 references to peer reviewed publications, with information on the research field, the geographical location of the experiment, and the aircraft used. The EUFAR public web site provides information on airborne instrumentation available, on aircraft performance, and their utilisation planning; on the activities of the expert working groups and their reports; on publications related to airborne research; on the sources of funding, and also on opportunities to join existing field experiments. Today, more than 1,000 European scientists are registered to the web site and contribute to EUFAR activities.

At a glance

Project Title

EUFAR – EUFAR is an integrated infrastructure initiative of the 6th framework programme of the european commission.

Project Partners

Météo-France (FR) Coordinator
Geophysica-EEIG (IT)
ESF (EU)

DLR (DE)	FUB (DE)
NLR (NL)	METAIR (CH)
Enviscope (DE)	ISAFoM (IT)
INSU-CNRS (FR)	FZK (DE)
MetOffice (UK)	MISU (SE)
NERC-ARSF (UK)	MPI-C (DE)
INTA (ES)	NUIG (IE)
TAU (IL)	UNIMAN (UK)
GTK (FI)	IFT (DE)
AWI (DE)	ANM (RO)
TU-BS (DE)	NERC-BGS (UK)

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Dr. Jean-Louis Brenguler is leading Experimental Research at the Meteo-France National Research Centre. His research activities are dedicated to cloud physics and aerosol/cloud interactions with climate. Since 1979, he has been actively involved in airborne field experiments and coordinated European projects on clouds and climate change. He has been coordinating the EUFAR network since its origin in 2000 (FP5, FP6 and FP7) and the COPAL project (FP7) for the construction of a European heavy-payload and long endurance research aircraft.

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EUFAR European Fleet For Airborne Research