Plane sailing

Project Coordinator **Professor Joachim Reuder** explains how Unmanned Aerial Systems could be a crucial tool in understanding our climate – and why this area of research must rise above existing boundaries

What is the main focus of this project and what circumstances brought about its development?

The main purpose of COST Action ES0802 'Unmanned Aerial Systems (UAS) for Atmospheric Research' is the Europe-wide coordination of present and future research on the development and application of UAS to provide a cost-efficient, trans-boundary method for monitoring the atmospheric boundary layer and underlying surface of the Earth.

We wish to promote UAS for research purposes and provide a platform for the scientific UAS community to discuss and disseminate specific requirements to enable corresponding UAS operations. The Action has been initialised by a handful of atmospheric scientists in Europe who presented a proposal for a COST Action to the European Science Foundation (ESF). It was selected as one of the 25 successful applications from more than 500 responses to the call and is in force for four years from November 2008.

Could you explain exactly what UAS are?

UAS are, in general, aircrafts without a pilot on board. Their size and weight ranges from a few centimetres and grams up to several tens of metres in wingspan and several tonnes of take-off weight. Almost every manned aircraft could, theoretically, be operated as a UAS by an onboard autopilot and a command pilot in a ground control station. At present, for atmospheric science purposes, the size range spans between the Small Unmanned Meteorological Observer (80 cm length and wingspan, 600 gram take-off weight) developed and operated by the University of Bergen, Norway and the Global Hawk (35 metre wingspan, maximum take-off weight 12,000 kg) operated by NASA and NOAA in the U.S. This COST Action is mainly focused on smaller UAS, with weights below 30 kg as this is the range of systems currently in use in Europe for environmental monitoring purposes.

What areas of atmospheric research is the project particularly interested in?

ES0802 has set its focus on the atmospheric boundary layer and selected several research topics, where a significant lack of knowledge has been identified and where we see a huge potential to distinctly improve our understanding, through measurement programmes based on relatively small and cost-efficient UAS. Examples are atmospheric boundary layer turbulence, the stable atmospheric boundary layer in Polar Regions, or the processes related to the entrainment zone on top of the boundary layer. Small UAS enable flexible measurement strategies and in situ observations, with unique repetition frequencies, for a detailed study of the relevant physical processes. This extended knowledge will be the basis for the improvement of our numerical models, used for weather forecast and future climate scenarios.

What has the project uncovered thus far about atmospheric boundary layer (ABL) and the underlying surface of the Earth?

As COST is funding networking activities and not scientific measurement campaigns; this work is done mainly by the individual participating research groups. One important shared issue the Action has addressed is the information exchange on sensors in use and the development of standards concerning calibration and data processing, enabling measurements of different UAS systems to be reliable and easily comparable.

Can you outline where some of the UAS are positioned and why?

Most of the small UAS are located at the research institutions developing and operating them – UAS deployments are always related to temporary measurement campaigns. First efforts for a multi-national and semi-operational use of UAS in the Arctic are in preparation, eg. through an initiative of the Arctic Monitoring and Assessment Program (AMAP), trying to realise a trans-boundary operation of scientific UAS across the whole Arctic.

What is the biggest challenge facing this COST Action?

One of the key messages I want to spread is that we already have a huge technical potential in operating our UAS systems for scientific purposes, but it is a really hard job to get the corresponding flight permissions from national or local authorities. It turns out this is the main stumbling block for further progress in the field of civil UAS operations. Raising awareness of this is a complicated matter which will take a great deal of time. ES0802 is currently working with relevant national and European authorities, towards a set of standardised and harmonised rules and regulations.

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Drone alone


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As our need for cost-effective and comprehensive climate data increases, the COST Action **Unmanned Aerial Systems for Atmospheric Research** aims to improve data sharing and coordination of European activities within this burgeoning field; work which could have a large impact on environmental monitoring

GIVEN THE INCREASING urgency for a comprehensive understanding of our changing climate, as well as the concordant need for sustainable development, committing the full range of tools to the challenge is critical. In the coming decades, the under-utilised field of Unmanned Aerial Systems (UAS) could present significant potential in closing the gap between established ground and satellite based climate measurements. More commonly associated with military reconnaissance, these 'drones' could actually fill an important niche and represent new realms of climate instrumentation.

In order to accurately predict weather and simulate climatic conditions, UAS could fly in uncharted territory, thus offering trans-boundary, cost-efficient methods of gathering data with high temporal and spatial resolution, unique coverage in space and time. This could massively increase our understanding of the Atmospheric Boundary Layer (ABL) – which directly relates to human life and activity – and the surface-atmosphere exchange processes therein.

UAS come in many shapes and sizes – from the small and relatively simple, to the large and hugely complex, and everything in between. Likewise, the non-military and scientific developers of the technologies comprise a broad range of institutions and individuals. In November 2008, the COST programme of the European Science Foundation awarded Professor Joachim Reuder one of a small proportion of successful awards, in order to bring these disparate stakeholders together and begin fully exploiting the potential of UAS technology.

RELEVANT AND USEFUL

As Professor of Experimental Meteorology at the Geophysical Institute at the University of Bergen, Norway, Reuder is ideally placed to Chair COST Action ES0802. He has been developing remotely-controlled and autonomous UAS for atmospheric boundary layer research for 10 years, including the Small Unmanned Meteorological Observer SUMO. Building on a range of proven prototypes of varying sizes and complexities, and equipped with different instrumentation, the Action is promoting the conception and development of further prototypes intended for specific observational requirements.

By coordinating a forum at the European level, Reuder hopes to establish a safe and permanent operation of UAS for routine environmental monitoring purposes. As he points out, UAS is a crucial component of climate monitoring, as it offers an augmentation or alternative to missions which might put the lives of scientists at risk: "In general UAS are relevant and useful when they can provide a cost-efficient alternative to manned aircraft missions: UAS and manned scientific aircrafts are not competitors – each complements the other". These unmanned systems can venture into severe storms, volcanic eruptions and forest fires, into places where endurance beyond the human is needed, or to investigate phenomena which would be destroyed or disturbed by large manned aircraft.

LARGE POTENTIAL

To date, the vast majority of UAS has been developed in the military sector – with operations deployed for surveillance, reconnaissance and direct combat missions. However, civil applications of UAS could represent large potential in the fields of aerial photography for mapping purposes, control of pipelines or power lines, and the wide field of atmospheric and environmental monitoring that this Action aims to exploit. This could lead to benefits across the scientific and broader public, local authority and policy-making sectors, Reuder elaborates: "UAS will be important for security forces, civil protection groups and the affected public, by improved warning and monitoring of natural hazards, such as forest fires, volcanic eruptions and avalanches".

Through the enhanced coordination this Action brings, UAS present a more cost-effective means of seeing the bigger picture of the ABL and associated forecasting and modelling data. But the ecological benefits are delivered both through the message – the data – and the medium – the UAS themselves: "In terms of environmental friendliness," Reuder explains, "larger UAS have advantages against manned aircrafts, the sensors used in UAS are typically smaller and lighter than the systems on manned platforms". Those around 5 kg and below run on rechargeable batteries, are silent and do not create contaminating emissions.

SUMO

In particular, small UAS offer many features that ideally complement the pre-existing data from ground observation stations and ground or space based remote-sensing systems. Among these features are high resolution, in situ data, not reliant on similarity or propagation assumptions; real area-representative data at

user-defined altitude (even at ground level) in a short time; fast – or even instantaneous – data delivery, undisturbed by clouds, at a time defined by the operating scientists; as well as high flexibility and mobility.

With a view to developing unmanned systems to the very peak of their effectiveness, Reuder's own work in Bergen University – alongside his Chairmanship of the COST Action – has been focusing on the SUMO (Small Unmanned Meteorological Observer) project. SUMO is one example of a very small and lightweight UAS that helps close the gap between existing measurements from satellites, radiosonde stations and stationary meteorological measurement towers. Being tested in Iceland, SUMO aims to provide a controllable and recoverable radiosonde device, for ABL research which can be operated out of areas with minimal infrastructure. SUMO is intended to efficiently gain information that a manned mission would find much more challenging: "It is designed to perform auto-piloted missions to measure temperature, humidity, pressure and wind in the lowest 4 km of the atmosphere, up to a maximum distance of 10 km around its start location," Reuder explains.

A HIGHLY INTERDISCIPLINARY EFFORT

At present the network of this Action spans 19 European countries, an interdisciplinary consortium which covers the most important aspects of the development and use of UAS for atmospheric research. As Reuder explains: "The project is, from its beginning, designed as a highly interdisciplinary effort, illustrated by the four different working groups (WGs) installed by the Action". The first covers all aspects of airframes, propulsion, autopilot and ground control stations. WG2 deals with specific requirements of UAS sensors: as size, power consumption constraints, and standardised calibration procedures. Atmospheric scientists are dealing with the real world application of UAS in WG3, selecting relevant scientific issues to address and to develop and define the optimal mission strategies for the corresponding UAS operation. Finally, WG4 is dedicated to the crucial legal and regulatory issues connected to scientific use of UAS.

Through twice-yearly meetings of all COST members, their network has a chance to share skills, knowledge and experience face to face. With this strong collaborative work, Reuder believes an operational feed into the global observing systems is only a matter of time: "This will take place more or less automatically, if regulatory issues are solved, pinpointing the need for international standardisation of rules and regulations. I am sure UAS will revolutionise Earth Observation in a similar way to satellites during the past decades," he enthuses.

30 YEARS FROM NOW

Through the advancement of all relevant fields, from material science, battery technology, electronic miniaturisation and communications technology, UAS are becoming ever more efficient and sophisticated. While civil and scientific applications for these technologies are in their infancy compared to military uses, approaches are developing which could lead to great progress. Universities are developing their own systems for cost-effective sensor carriers for their projects, while other, mainly larger, UAS are being adapted and optimised from military systems. Bringing these systems – such as the NOAA Global Hawk, adapted from military technology – and lending their knowledge and experience to the development of new prototypes is at the core of this COST Action.

Reuder believes that a key element of international cooperation in this field must be through policy, not least in the integration of general air traffic allowing UAS to circulate freely. Once this challenge is overcome, he believes the sky is the limit for the role of UAS in atmospheric measurements and climate related environmental monitoring: "I am sure that 30 years from now, UAS will be seen the same way we are presently looking at satellites in revolutionising our observational capabilities for environmental monitoring," he concludes.

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INTELLIGENCE

UNMANNED AERIAL SYSTEMS IN ATMOSPHERIC RESEARCH - COST ACTION ES0802

OBJECTIVES

To coordinate unmanned aerial systems research to provide a cost-efficient, trans-boundary method for the monitoring of the atmospheric boundary layer and underlying surface of the Earth.

PARTNERS

Technical University Braunschweig; **University of Applied Sciences Ostwestfalen-Lippe**; **University of Applied Sciences Bremen**; **University of Stuttgart**; **Eberhard Karls University of Tuebingen**; **University of Heidelberg**; **German Space Agency (DLR)**; **Karlsruhe Institute of Technology**, Germany • **University of Bergen**; **ALOMAR Andøya Rocket Range**; **Northern Research Institute**, **Norut AS**; **Norwegian Institute for Air Research**; **Luftfarttilsynet**; **Robot Aviation AS**, Norway • **British Antarctic Survey**; **The University of Sheffield**; **University of Birmingham**; **University of East Anglia**, **University of Reading; UK Civil Aviation Authority**, UK • **Ecole Nationale l'Aviation Civile**; **CNRS**, **Meteo France**; **University of Toulouse**, France • **Stockholm University**; **Swedish Space Corporation**; **Lund University**, Sweden • **Ben-Gurion University of the Negev**; **Israel Aerospace Industries Ltd**, Israel • **University of Iceland**; **Institute for Meteorological Research**, Iceland • **Instituto Nazionale di Geofisicy e Vulcanologia**; **ERS-Srl**, Italy • **Technical University of Denmark**; **Aalborg University**, Denmark • **CIRES, University of Colorado**; **NASA**, USA • **Zurich University of Applied Sciences**, Switzerland • **University Politehnica of Bucharest**, Romania • **Warsaw University**, Poland • **University of the Balearic Islands**, Spain • **Finish Meteorological Institute**, Finland • **University College Dublin**, Ireland • **Politechnico do Porto**, Portugal • **The Cyprus Institute**, Cyprus • **VITO**, Belgium

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