

**SERVICES & FACILITIES ANNUAL REPORT - FY April 2010 to March 2011**

<b>SERVICE</b> Airborne Research & Survey Facility	<b>FUNDING</b> Direct	<b>AGREEMENT</b> via Swindon Office	<b>ESTABLISHED as S&amp;F</b> 1982	<b>TERM</b> 5 years
---	--------------------------	--	---------------------------------------	------------------------

**TYPE OF SERVICE PROVIDED:**

Airborne remote sensing research and survey is a key component of the quantitative remote sensing of the earth and is an essential contributor to the development and validation of Earth-system models. The ARSF offers a high-quality, cost-effective means of sustained observation of terrestrial, freshwater, marine, cryospheric and atmospheric environments at high temporal, spatial and spectral resolution. The Facility supports a wide range of interdisciplinary environmental research across the spectrum of the NERC remit and scientific sectors, providing data that is increasingly important for fundamental research into the natural environment and its inherent physical, biological and chemical processes.



The flexibility and responsiveness of the Facility is due to its highly modified Dornier 228-101 research aircraft, with exceptional range, endurance and payload permitting the deployment of core and novel instrumentation in support of a wide range of science areas and applications. A dedicated ground-based data processing system provides users with a variety of products ranging from radiometrically-calibrated data to fully geometrically rectified images that allow direct comparison of multi-temporal surveys. Furthermore, training to promote good practice in the use of remotely sensed data by the user community, as well as promoting awareness, application and technology of airborne research techniques among the wider user-community is realised through regular workshops usually in collaboration with the Remote Sensing & Photogrammetry Society (RSPSoc).

**Key community benefits include:**

- Ability to operate in an international framework and support strategic research programmes;
- Provision of a fixed set of primary optical and digital remote sensing instruments capable of simultaneous data acquisition (analogue & digital cameras, hyperspectral imaging systems, LiDAR), and basic meteorological instruments;
- Operational flexibility; rapid opportunistic deployment and long-range self-sufficient campaigns;
- Repeatability of observations at user-specified spatial, temporal and spectral resolutions;
- Ability to mount additional new instruments on an opportunistic or thematic basis (e.g. various atmospheric sensors);
- A dedicated data processing service (ARSF-DAN) providing high levels of user-support and development.
- Close working relationship with the Facility for Airborne Atmospheric Measurements (FAAM).

**ANNUAL TARGETS AND PROGRESS TOWARDS THEM**

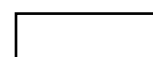
- In 2010, the ARSF contributed to 39 publications - 16 in ISI journals - across a wide range of disciplines.
- The Facility supported 31 projects, including three alpha 5 projects and 12 commissioned projects, including a series of National Contingency flights associated with the monitoring of the ash plume over the UK in the spring of 2010.

<b>SCORES AT LAST REVIEW (each out of 5)</b>				<b>Date of Last Review:</b>	March 2007
<b>Need</b> 5	<b>Uniqueness</b> 5	<b>Quality of Service</b> 3	<b>Quality of Science &amp; Training</b> 4.5	<b>Average</b>	4.37

<b>CAPACITY of HOST ENTITY FUNDED by S&amp;F</b>	<b>Staff &amp; Status</b>	<b>Next Review (March)</b>	<b>Contract End (31 March)</b>
100%	0.5 x B4 Head of Service 1 x Pilot grade / B2-4 equiv (Chief Pilot / Operations Manager) 1 x B5 (Instrument Specialist) 3 x B6 (Co-pilot, Instrument Ops, Sci/Ops Coordinator) 0.5 B7 Admin Officer	2012	2013

<b>FINANCIAL DETAILS: CURRENT FY</b>									
<b>Total Resource Allocation</b> £k	<b>Unit Cost £k @ 329 Flight Hours</b>				<b>Capital Expend</b> £k	<b>Income</b> £k	<b>Full Cash Cost</b> £k		
	<b>Unit 1 – Flight Hour</b> 4.0								
941					0	329.281	1313.88		
<b>FINANCIAL COMMITMENT (by year until end of current agreement) £k</b>									
<b>2008-09</b>	740	<b>2009-10</b>	840	<b>2010-11</b>	865	<b>2011-12</b>	874	<b>2012-2013</b>	905

<b>STEERING COMMITTEE</b>	<b>Independent Members</b>	<b>Meetings per annum</b>	<b>Other S&amp;F Overseen</b>
Airborne Research & Survey Facility	1 (Chair Prof D Donoghue, Univ Durham)	2	None



**APPLICATIONS: DISTRIBUTION OF GRADES (current FY - 2010/11) \*  $\alpha$ 3/ $\alpha$ 2 applications not funded & thus not supported by ARSF**

	$\alpha$ 5	$\alpha$ 4	$\alpha$ 3	$\alpha$ 2	$\alpha$ 1	$\beta$	R*/Pilot	Reject
NERC Grant projects*	1	2						1
Other academic		4	1				1	3
Students**								
Pilot								
<b>TOTAL</b>	1	6	1	0	0	0	1	4

**APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years — 2007/2008, 2008/2009 & 2009/10)**

	$\alpha$ 5	$\alpha$ 4	$\alpha$ 3	$\alpha$ 2	$\alpha$ 1	$\beta$	R*/Pilot	Reject
NERC Grant projects*	0.7	3.6	1.8			0.1	0.7	1.2
Other Academic	0.7	5.7	3.4	0.8	0.4	0.2	1.3	2.5
Students**								
Pilot							1.3	
<b>TOTAL</b>	1.4	9.3	5.2	0.8	0.4	0.3	3.3	3.7

**PROJECTS COMPLETED (current FY – 2010/11)**

	$\alpha$ 5	$\alpha$ 4	$\alpha$ 3	$\alpha$ 2	$\alpha$ 1	$\beta$	Pilot
NERC Grant projects*		2					
Other Academic	2	7 ***					
Students**							
Pilot							4
<b>TOTAL</b>	2	9					4

An additional 4 projects were supported but not completed. Of these, 2 were partially supported and 2 projects were withdrawn / relocated (due to access restrictions).

**USER PROFILE of Projects completed - funding type (current FY – 2010/11)**

Grand Total	Infrastructure				PAYG					
	Supplement to NERC Grant *	Student NERC	Other	NERC C/S	Other	NERC Grant*	Student NERC	Other	NERC C/S	Other
27					15	0	0			12

**USER PROFILE - funding type (per annum average previous 3 financial years — 2007/2008, 2008/2009 & 2009/10)**

Grand Total	Infrastructure				PAYG					
	Supplement to NERC Grant *	Student NERC	Other	NERC C/S	Other	NERC Grant*	Student NERC	Other	NERC C/S	Other
23	4.4	8.9	4.4	2.7	18.1	0.4	0	0.3	1.1	0.8

**USER PROFILE – user type (current FY – 2010/11)**

Academic	Centre/Survey	NERC Fellows	PhD	Commercial
22	3	0	3	1

**USER PROFILE - user type (per annum average previous 3 financial years — 2007/2008, 2008/2009 & 2009/10)**

Academic	Centre/Survey	NERC Fellows	PhD	Commercial
21.9	3.9	0.5	6.9	0.46

**OUTPUT & PERFORMANCE MEASURES (current year)**

Publications (by science area & type) (calendar year 2010)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
4	7	2	3	15	4	4	39	16	21	2

Distribution of Projects supported (by science areas) (FY 2010/11)						
SBA	ES	MS	AS	TFS	EO	Polar
0.8	2.5	1.6	2.5	10	7.5	2.1

**OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)**

Publications (by science area & type) (Calendar years 2007, 2008 & 2009)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
1.3	8.1	2.4	3.0	11.6	5.5	1.8	34	14.3	19.9	1.8

Distribution of Projects (by science areas) (FY 2007/2008, 2008/2009 & 2009/2010)						
SBA	ES	MS	AS	TFS	EO	Polar
1.4	5.6	2.5	2.2	14.5	2.2	2.3

**Distribution of Projects by NERC strategic priority (current FY – 2010/11)**

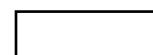
Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
2.2	0.7	14	1.9	1.10	4.10	3

\* Combined Responsive Mode and Directed Programme grants.

\*\* Most projects are funded by direct access, grant awards or commissioned science. No projects have a studentship as their primary funding.

\*\*\* including an on-going project that records measurements during all flights and will do so year after year.

**NOTE:** All metrics should be presented as whole or part of whole number NOT as a %



## OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2010/11):

### Output and performance measures:

- Of the 17 NERC applications submitted for the 2011 flying season 8 were Consortium, Standard or Urgency grants; 2 were successful and 4 are pending their final grade. The 9 remaining applications were via direct access, four of which were accepted for support (4 x  $\alpha 4$ , 1 x  $\alpha 3$ , 1 x pilot/R\*).
- During the 2010/11 FY 31 projects were supported (including three  $\alpha 5$  projects), 28 of which were completed (including two  $\alpha 5$  projects). 14 projects were supported by direct access, 2 in support of Urgency grants, 12 were commissioned and 4 were pilots or trials instigated by the facility for internal research.

### Major campaigns:

- Monitoring of the atmospheric ash plume over the UK that resulted from the eruption of Eyjafjallajökull (Iceland), see science case 1. After a rapid configuration for atmospheric science the ARSF flew six days of National Contingency flights accumulation over 32 and a half hours of flying. The rapid response of the ARSF was achieved due to the versatility of the aircraft and the dedication of the air crew. It allowed essential data to be collected early in the event and fed the data that reconfigured and validated the Met Office models used to identify safe flying conditions in UK airspace.
- During the summer of 2010 a remote sensing campaign was focused around Lake Balaton, Hungary, completed an  $\alpha 5$  graded project and three EUFAR funded projects. The core project was investigating water quality, specifically the presence of algal blooms (see science example). Other projects were monitoring shore line vegetation, archaeology and geology.

### Data processing/delivery:

Average time (from delivery of data to the DAN to despatch to the PI) was 121.76, 186.39, 127.16 & 96.05 days for Specim Eagle, Hawk, LiDAR and RCD, respectively. Unresolved problems in 2010 with Specim Eagle and Hawk sensors (timing errors requiring manual correction) and the Leica LiDAR (roll problems requiring manual processing) severely increased processing time. Staff effort averaged 10.23 days /project (5.61, 4.51 & 0.62 for Hyperspectral, LiDAR, RCD data, respectively) with the remaining time spent waiting for the completion of automated processing stages and the availability of other data inputs and logistical limitations (hardware and labour) of processing many projects. These problems required all staff to undertake processing meaning that virtually no development was undertaken. TABI data are being processed by the instrument's owners, the Technical University of Athens, as part of the access agreement.

### Facility development

- A CAPs probe, Thermo 49i, atmospheric sampling manifold and support infrastructure for atmospheric monitoring have been fitted (or are being fitted) to the Dornier. These developments enhance the facilities capability to support atmospheric research and potentially assist in the atmospheric correction of remotely sensed data.
- The versatility and performance of the ARSF have established it as the most requested remote sensing platform in EUFAR.
- Strong links established in the UK science community, the European science community and other collectors of hyperspectral and full-wave form LiDAR have resulted in invitations for ARSF staff to chair conference sessions and participate in expert groups (technical and scientific). Interest by the general public has been enhanced by scientific participation with secondary schools and our Invitation to appear at air shows in the UK and in Europe.

### ARSF publicity and training:

- The biennial ARSF workshop will be held prior to the RSPSoc Annual Conference (hosted by Bournemouth University in September 2011).
- The ARSF were strongly represented at the International Conference on Airborne Research for the Environment (ICARE), Toulouse, France. This representation was in several of the expert working groups, the static display and participation in a EUFAR funded calibration / validation exercise for multipsectral and hyperspectral instruments.
- The ARSF-DAN represented the ARSF at the EARSEL conference early in 2011 and Dr Choi presented observations resulting from the in-house calibration of the ARSF's hyperspectral instruments.

## SCIENCE HIGHLIGHTS – Publications & Projects supported ( *impact factor*):

**Lee. J. D. et al.** (2010). Reactive Halogens in the Marine Boundary Layer (RHAMBLe): the tropical North Atlantic experiments. *Atmospheric Chemistry and Physics*, 10, 1031-1055. (4.8)

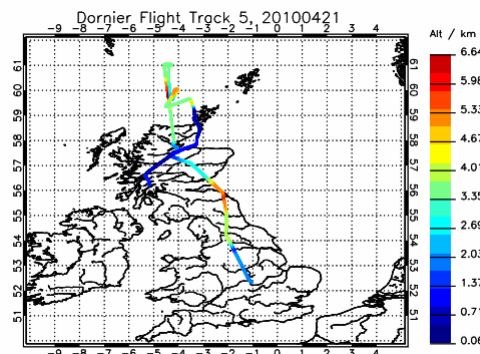
**Bateson. L. et al.** (2010). The application of remote-sensing techniques to monitor CO<sub>2</sub>-storage sites for surface leakage : method development and testing at Latera (Italy) where naturally produced CO<sub>2</sub> is leaking to the atmosphere. *International Journal of Greenhouse Gas Control*. 2, 388-400. (3.7)

**Grebby. S. et al.** (2010). Lithological mapping of the Troodos ophiolite, Cyprus, using airborne LiDAR topographic data. *Remote Sensing of Environment*. 114, 713-724. (3.6)

## Monitoring volcanic ash plumes over the UK

Allen. G.

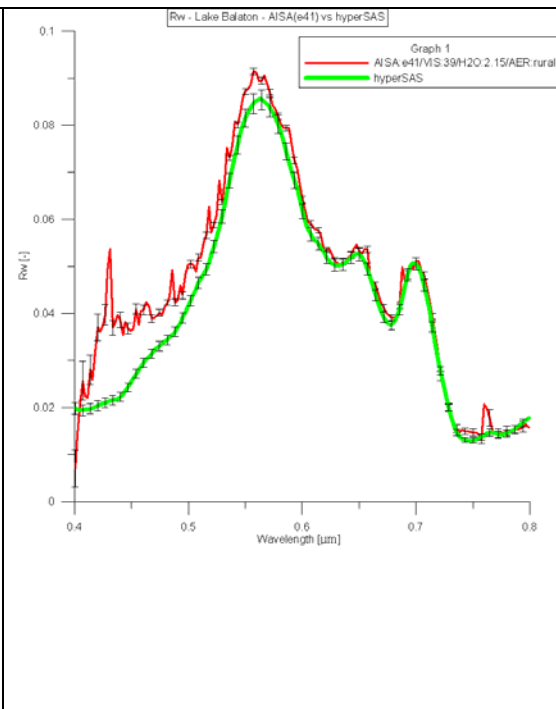
A total of five missions were flown between the 16<sup>th</sup> & the 21<sup>st</sup> of April 2010. The aircraft was fitted with a suite of aerosol instruments and a Teco SO<sub>2</sub> analyser. Extremely high particle mass concentrations were measured on the 21<sup>st</sup>. These appeared to be related dynamically with high measured concentrations of SO<sub>2</sub>. Additionally, there was evident dislocation of the concentrated SO<sub>2</sub> plume from the measured particles. The former was not visible to the human eye, although the latter may be. Furthermore, high concentrations of SO<sub>2</sub> imply high concentrations of sulphuric acid, a powerful oxidising agent. However, the high concentrations of SO<sub>2</sub> were highly localised & constituted a vertically thin layer.



## Remote sensing and bio-optical properties of phytoplankton blooms in Lake Balaton, Hungary

Tyler, A.N., Lyman, C.A., Hunter, P.D., Groom, S., Vicente, V., Kovács, W.A., Preston, T., Présing, M. Raymaekers, D.

Mass populations of cyanobacteria are an increasingly global phenomenon because of eutrophication and climate change and can have serious ecological and socioeconomic consequences in freshwaters. There is currently much interest in the use of satellite remote sensing for routine, near real-time monitoring of cyanobacterial blooms in lakes, but currently standard algorithms for the retrieval of phytoplankton pigments lack the robustness needed for operational use. The development of analytically-based inversion algorithms should greatly improve uncertainties in pigment retrievals but this approach requires detailed knowledge of the inherent and apparent optical properties (IOPs/AOPs) of lake waters. Lake Balaton presents an ideal arena for such work because of the range and complexity in its bio-optical properties. IOP and AOP measurements, concomitant with ARSF (AISA Eagle and Hawk) and MERIS image acquisition, were made at a total of 38 stations. A total of 101 flight lines were flown across Lake Balaton and the adjoining wetland Kis Balaton in support of an  $\alpha 5$  graded project during a 14 day campaign. The data will subsequently be used to validate algorithms for the retrieval of chlorophyll *a* phycocyanin in optically complex waters following on from previously published work in British lakes.



## FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

### Science Activities:

Increased user-drive and demand for support of large-scale international projects is a function of demonstrated Facility capability and flexibility. Key examples are listed below.

**Atmospheric:** The standard ARSF atmospheric instrument suite has been developed for aerosol monitoring and will be used in the support of projects in the current and future flying seasons (e.g. in support of the ClearFlo experiment). These measurements will be supplemented with cloud physics measurements on dedicated atmospheric missions. In the future these data are also intended for use for the atmospheric correction for remotely sensed data.

**Earth:** A series of NERC grant and BGS commissioned surveys should yield valuable quality geological data from Greenland. These data will inform science teams of surface structure and also allow the extrapolation of sub-marine geology.

**EUFAR:** Trans-national Access demand by European researchers remains high due to the attractiveness of the core RS instrument suite and the flexibility of ARSF support. Three EUFAR funded projects have already been supported in 2011 and a project based in Svalbard is due to be supported in the summer of 2011. The ARSF combination of hyperspectral and LiDAR instruments remains popular with European users. However, EUFAR's framework 7 funding is coming to an end and discussions are on-going as to the provision of support for airborne research under framework 8.

### Planned hardware developments to support UK science:

- The facility have developed its cloud physics capability to support atmospheric science but would also benefit from atmospheric chemistry monitoring instruments. A gas box remains a high priority.
- User interest and scientific justification for a long infrared wavelength spectrometer have been confirmed by ARSF working groups and EUFAR demand. Such an instrument would measure in the thermal emission wavelengths and provide data on surface temperature, mineralogy and emissivity.

### Non-mandatory Output & Performance Measures

**Targets & Milestones:** From 01-04-10 to 01.04.11, aircraft and crew were on standby for 153 days and flew 328.6 flying hours. The aircraft was stood down between 11.11.10 and 12.02.11 (93 days) for maintenance. 36 further days were required for maintenance.

### Allocation of Capacity (Decimal flight hours/percent):

Science/Commissioned Research	Instrument		Applications Develop #	Train / Maintenance	TOTAL
	Test	Develop			
257.3/78.3	26.1/7.9	7.7/2.4	16.9/5.1	20.6/6.3	328.6

### Allocation of Flying Effort by Sector (Flight hours/percent):

Science	R&D #	Crew training / Maintenance	Commissioned
118.9/36.2	50.7/15.4	20.6/6.6	138.4/42.1

### Allocation of effort by Project:

$\alpha$ -Grading/ Number supported	$\alpha 5/3$	$\alpha 4/12$	$\alpha 3/0$	$\alpha 2/0$	$\alpha 1/0$	Pilot/4 #	Commissioned/12
Average Project Flight-time Hrs:min	14:44	6:14	0	0	0	4:14	11.53

# this includes two full-waveform LiDAR trial projects.

