SERVICES & FACILITIES ANNUAL REPORT - FY April 2012 to March 2013

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
Airborne Research & Survey Facility	Direct	via Swindon Office	1982	3 years

TYPE OF SERVICE PROVIDED:

The Airborne Research and Survey Facility (ARSF) is a unique NERC Facility providing high-quality data in support of high-impact research, survey, monitoring and training activities, making a major contribution to cross-sectorial integration. ARSF supports research across all seven of NERC's Science Priority Areas (Figure 1) and across all Research areas including Earth, terrestrial and freshwater, polar, atmospheric and marine science and science based archaeology. ARSF is classified as NERC "National Capability" but the customer base is predominantly from HEIs with a significant component of funding from NERC grant sources and commissioned research. ARSF has a world-leading reputation as the most popular facility in the EC-funded EUFAR (European Facilities for Airborne Research) project with the highest flight hours and the highest number of peer-reviewed applications. The facility has undergone fundamental changes in the past five years with a major upgrade or replacement of all remote sensing instruments, new atmospheric science capabilities and much improved

Figure 1 Dornier 228 showing instrument bays for ground viewing sensors.

Key benefits of the facility include:

- flexibility and responsiveness underpinned by its highly modified Dornier Do228 research aircraft (Fig 1), 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; the capability to operate anywhere in the world with supported projects in Australia (atmospheric chemistry), Svalbard (polar glaciology), Africa (geology and atmospheric chemistry) and Greenland (mass balance glaciology);
- provision of cutting-edge hyperspectral remote sensing instruments, integrated digital mapping camera, and airborne laser scanner;
- an Airborne Laser Scanner with state-of-the-art full waveform capability for topographic mapping;
- repeatable, high-quality, cost-effective means of monitoring highly dynamic environments at user-specified high temporal, spatial and spectral resolution;
- ability to mount additional new instrumentation on an opportunistic or thematic basis;
- the ability to cross-deploy remote sensing and atmospheric instrumentation to support atmospheric correction and new instrument development;
- provision of a dedicated data processing group that 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;
- promotion of awareness, application and technology of airborne research techniques among the wider user-community through regular workshops, and training to promote good practice in the use of remotely sensed data by the user community.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

- In 2012, the ARSF contributed to 48 publications including 26 in ISI journals and 7 PhDs, across a wide range of disciplines.
- The Facility supported 20 projects, including the direct support of two grants funded projects, the indirect support of another, the completion of two grade 9 projects and a large commissioned project in Easter Greenland.
- 34 applications for support by the ARSF included 5 successful research grant applications and 15 successful direct access applications, three of which were awarded a grade 9.

SCORES AT LAST REVIEW (each out of 5)			Date of Last Review:	March 2012
Need	**Uniqueness**	**Quality of Service**	**Quality of Science & Training**	**Average**
5	5	4.5	4.5	4.75

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
100%	1 x Pilot grade / B2-4 equiv (Head of ARSF/Chief Pilot) 2 x B6 (Co-pilot, Science/Ops Coordinator) 1 x temporary contract B6 (Instrument Operator)		

FINANCIAL DETAILS: CURRENT FY				
Total Resource Allocation £k	**Unit Cost £k** Unit 1	**Capital Expend £k**	**Income £k**	**Full Cash Cost £k**
873		730	c250	

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2011-12 967	**2012-13 873**	**2013-14 873**	**2014-2015 TBC**	**2015-2016 TBC**

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
Airborne Research & Survey Facility	12 (Chair Prof D Donoghue, University of Durham)	2	None

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2012/13)													
	10	**9**	**8**	**7** (§)	**6** (Reject)	**5** (Reject)	**4** (Reject)	**3** (Reject)	**2** (Reject)	**1** (Reject)	**0** (Reject)	**R***	**Pilot**
NERC Grant projects*		1									6		
Other academic		3	7	4							10		
Students**													
TOTAL		4	7	4							16		

PROJECTS COMPLETED (current FY – 2012/13)												
	10 (α5)	**9**	**8 (α4)**	**7**	**6 (α3)**	**5 (α2)**	**4**	**3 (α1)**	**2**	**1 (β)**	**0 (Reject)**	**Pilot**
NERC Grant projects*			1									
Other Academic		2	5 ◎									
Students**												
TOTAL		2	6									

Project Funding Type – *for projects supported* (current FY – 2012/13) (select one category for each project)											
Grand Total	**Infrastructure**					**PAYG**					
	Supplement to NERC Grant *	**PhD Students**		**NERC Centre**	**Other**	**NERC Grant***	**PhD Students**		**NERC Centre**	**Other**
		NERC	**Other**				**NERC**	**Other**		
20	1	0	0	0	14 ◎	1	0	0	2	2
Project Funding Type (per annum average previous 3 financial years - 2009/2010, 2010/2011 & 2011/2012)										
Grand Total	**Infrastructure**					**PAYG**				
	Supplement to NERC Grant *	**PhD Students**		**NERC Centre**	**Other**	**NERC Grant***	**PhD Student**		**NERC Centre**	**Other**
		NERC	**Other**				**NERC**	**Other**		
24.3	1.3	1.7	2	0.3	16	0	0	0	0	7.3

User type (current FY – 2012/13) – *for projects supported* (include each person named on application form)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
84	**6**	**2**	**6**	**2**
User type (per annum average previous 3 financial years - 2009/2010, 2010/2011 & 2011/2012)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
48.3	2.3	0	8.7	2.7

OUTPUT & PERFORMANCE MEASURES (current year)										
Publications (by science area & type) (calendar year 2012)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**ISI Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
4	**7**	**1**	**7**	**19**	**6**	**4**	**48**	**26**	**15**	**7**

Distribution of Projects - supported (by science areas) (FY 2012/13)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
20	0.7	6.65	0	4.2	4.25	3.65	0.55

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)										
Publications (by science area & type) (Calendar years 2009, 2010 &2011)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
2.3	8.3	1.3	3.7	18.3	4.3	4	42.3	18.3	22.3	3.3

Distribution of Projects (by science areas) (FY 2009/2010, 2010/2011 & 2011/2012)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
24.3	1.7	16.5	0.7	2.1	11.5	3.4	2.4

Distribution of Projects supported by NERC strategic priority (current FY 2012/13)							
Grand Total	**Climate System**	**Biodiversity**	**Earth System Science**	**Sustainable Use of Natural Resources**	**Natural Hazards**	**Environment, Pollution & Human Health**	**Technologies**
20	0.75	3.3	1.35	3.2	6.9	4.5	0

**Either Responsive Mode or Directed Programme grants*

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

◎ Includes an on-going project that records measurements during all flights and will do so year after year.

§ Maybe supported to a limited extent in no additional transit is incurred (i.e. if it is near or on the transit to or from a project with a higher grade.

NOTE: All are presented as whole or part of whole number NOT as a %

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2012/13):

Of the 34 applications submitted for the 2013 flying season (the highest number in ten years), seven were NERC research grant applications (one of these was successful) one was an EPSRC grant (successful) and another was from BBSRC (successful) and the remaining twenty five were via direct access. Of the direct access applications, fourteen were accepted for support (3 x grade 9, 7 x grade 8 & 4 x grade 7), ten were rejected. During FY2012/13 20 projects were supported. Of these ten projects were completed. The completed projects including one grade 9 project in Santorini (Greece), a NERC BESS grant funded project in the North of London, a direct access project supporting the large NERC grant funded ClearfLo project over London and a large commissioned project in Eastern Greenland. Due to poor weather in the UK, those projects that were completed were either overseas (Ethiopia and Greece) or were research grant focused projects near (or over) London.

Major campaigns: The focus for 2012 was geology. There were three main overseas campaigns. These explored structural geology, mineral sequences and volcanic structures.

- A Spring deployment to the Greek islands completed a two geology related projects, one graded 9.
- A Summer deployment to Eastern Greenland completed a large collaborative geology related project between BGS and GEUS.
- An Autumn deployment to Ethiopia completed three geology related projects, one graded 9.

Data processing/delivery: In 2012 5.6TB of data (excluding full waveform LiDAR) were collected and processed; this compares to 3.4TB in 2011 and 4.3TB in 2008 (the next highest-volume year). A significant part of this was obtained late in the year (in November in Ethiopia). Delivery of 2012 primary sensor data was completed up to flight day 251 (7th September 2012) by 12th February 2013. Delivery of remaining 2012 hyperspectral data was delayed, after the calibration of the Eagle sensor was found to have changed significantly over the flying season; after resolution data delivery was completed by 5th May 2013. Delivery of all 2012 LiDAR data was completed by 4th April 2013.

Data archiving: 49 flights were archived at NEODC between April 2012 and April 2013 (seven of these are still awaiting download). Of these, 34 were from 2011, 8 were from 2012 and 7 were from 2010.

Software developments: The Airborne Processing Library (APL) has been improved APL following user feedback, including a new method for mapper cubic interpolation and efficiency improvements. The command line LIDAR processing utility is in the final stages before alpha release to test in tandem with Leica's processor. The prototype GRIMM portal now contains all collected data from 2011 and 2012, but needs some tidying and further testing on multiple browsers before release. The Linux based LIDAR Analysis GUI has been released open source and is available via github.

ARSF helpdesk: During the year there were 104 external discussions with 58 unique users.

Systems status: Eagle and Hawk processing: the navsync timing error was present in all 2012 data resulting in significantly longer processing times. Specim are investigating differences in their two current methods of time stamping, although this is not expected to fix our problem. LIDAR processing: the roll error was present in 2012 data, later becoming more of a general boresighting issue with noticeable differences in pitch. This problem also means significant additional time for processing. RCD processing: further steps were taken to make the processing more automated, reducing the amount of time needed for initial QC.

ARSF publicity and training: For the first time ARSF-DAN ran a three-day data processing workshop at Plymouth Marine Laboratory in February 2013. Invitations were sent initially to users who had had data collected in 2012 or for whom it was anticipated in 2013. Fourteen delegates attended from the UK and Europe. Subsequent user feedback was overwhelmingly positive, with ARSF staff praised for their knowledge, helpfulness and enthusiasm. Delegates rated the usefulness of the course as 4.2/5 and the impact on their science as 3.7/5 (5 being the best rating).

Cited references (average IF of 26 publications = 3.1)

- Al-Moustafa, T. (2012) Mapping fuel moisture content in upland vegetation using airborne hyperspectral imagery. Remote Sensing of Environment, 127, 74-83. (**IF=5.3**)
- Simonson, W.D., Allen, H.D. & Coomes, D.A. (2012) Use of an Airborne Lidar System to Model Plant Species Composition and Diversity of Mediterranean Oak Forests. Conservation Biology, 26(5), 840-850. (**IF=4.7**)
- Waddicor, D.A., Vaughan, G., Choularton, T.W., Bower, K.N., Coe, H., Gallagher, M., Williams, P.I., Flynn, M., Volz-Thomas, A., Patz, H.-W., Isaac, P., Hacker, J., Arnold, F., Schlager, H. & Whiteway, J.A. (2012) Aerosol observations and growth rates downwind of the anvil of a deep tropical thunderstorm. Atmospheric Chemistry and Physics, 12, 6157-6172. (**IF=5.5**)

SCIENCE HIGHLIGHTS:

Overview: Publications during 2012 followed previous years in covering a number of thematic areas such as terrestrial science the cryosphere, atmospheric science, EO and geology, as well NERC science priority areas including Climate, Earth systems science, Biodiversity and Environment and human health.

SCIENCE EXAMPLES

Atmospheric Science over London (James Lee, University of York)

During the summer of 2013 we completed 50 hours of flying of this system over London and SE England on the NERC Airborne Research and Survey Facility's Dornier-228 aircraft and successfully made highly time resolved measurements of benzene, toluene, isoprene, nitric oxide and nitrogen dioxide (figure 2). The figure below show a typical flight track coloured by NOx missing ratios (in pptv), overlaid on the National Atmospheric Emissions Inventory (NAEI) total NOx emission estimate for London (1km x 1km grid squares in Tonnes km^{-2} yr^{-1}). The next step in this project is to use these concentration measurements together with the three dimensional wind vector data obtained with the ARSF AIMMS-20 turbulence probe on the aircraft to calculate the surface emission flux rates of these compounds using the eddy covariance method. We are confident that our measurement data are sufficiently high quality and our understanding of the eddy covariance mathematics is sufficiently robust that within the next six months we will have VOC (benzene and toluene as representative anthropogenic compounds and isoprene as a representative biogenic compound, and NO_x) fluxes from London and rural SE England. This will be a unique dataset that should allow some validation of the NAEI estimates for these species.

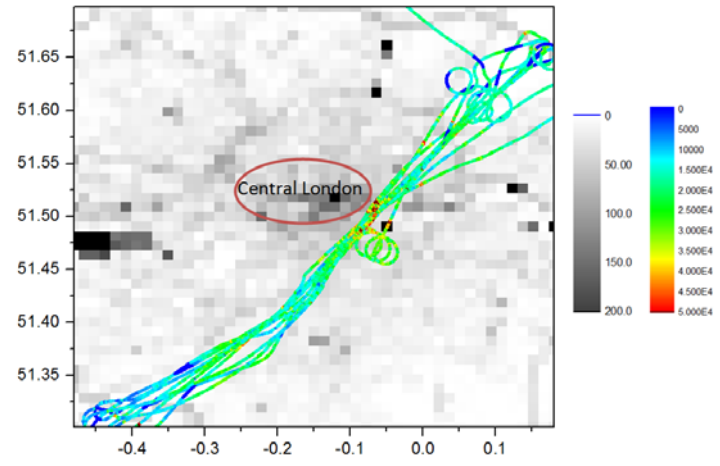

Figure 2. Typical flight track coloured by NOx missing ratios

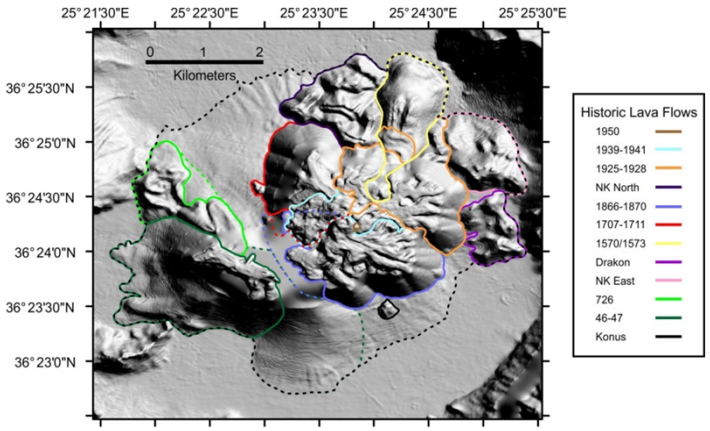

Figure 3. Lava flows on Santorini, Greece

Airborne LiDAR investigations on Santorini, Greece, reveal the prior eruptive history of an intra-caldera volcano.

(Michelle Parks[1], Paraskevi Nomikou[2], Steve Carey[3], Lara Kalnins[1], Dimitrios Papanikolaou[2], Tamsin Mather[1], David Pyle[1], Tony Watts[1]. University of Oxford[1], University of Athens[2], University of Rhode Island[3])

Quantitative analysis of high-resolution lava flow morphology can improve our understanding of past effusive eruptions by providing insight into eruptive processes and rheological properties of erupted magmas. We report the results of a new ARSF LiDAR survey of Santorini in May 2012, which provided a dataset with an average point density of 2.1 points per m^2. The new DEM has been used for topographic corrections in ongoing high resolution InSAR work (using TerraSAR-X; Parks et al., *Nature Geoscience* 2012). Hyperspectral data collected at the same time will augment ongoing work on CO_2 emissions from the summit area of the Kameni islands (Parks et al., *EPSL* 2013).

Prior volcanological studies of the Kameni islands have neglected the considerable volume of this edifice that is underwater. We combined the new 2012 LiDAR dataset with a high resolution multibeam bathymetric grid to map both onshore and offshore features around the Kameni islands (Figure 3). We use the updated lava flow outlines to revise estimates of the lava volumes for each of the historic flows, and for previously unidentified submarine flows and cones. This significantly improves our analysis of the relationship between eruption volumes and pre-eruption repose intervals, which will be of great value in the lead up to future episodes of unrest on Santorini.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

Operational Changes: Changes in NERC's operation of the facility to an integrated fleet of aircraft managed by British Antarctic Survey (BAS) will allow access to other aircraft (e.g. access to the Dash 7 for long or remote surveys in the European summer months) within the fleet and may yield access to a Z/I Imaging DMC (Digital Mapping Camera) currently operated by BAS.

Science Activities: The support of large research grants and commissioned, collaborative science will continue to define the facilities activities in 2014. Foremost in these is the support of a NERC research grant to Malaysia but several funded projects in the UK will also require a commitment of flight time. The trend for more grant funded projects (from NERC and other funding groups) continues to increase.

Planned hardware developments to support UK science: Delivery of a Specim Owl and a Specim Fenix is scheduled for the end of 2013/14. The Owl will return the facility's lost capability to collect thermal data but will provide this via a multispectral sensor rather then the previous broad band sensor. The Fenix will maintain a VNIR and SWIR capability after the loss of sensitivity of the Eagle identified in the last calibration.

Non-mandatory Output & Performance Measures; utilisation, allocation of capacity etc.

Targets & Milestones: From 01-04-12 to 28.04.13, aircraft and crew were on standby 164 days for 248.37 flying hours. The aircraft was stood down between 09.12.12 and 31.01.13 (52 days) for maintenance. 14 further days were required for maintenance (5 of which were scheduled).

Allocation of Capacity (Decimal flight hours/percent):

Science/Commissioned Research	Instrument		Applications Develop	Training / Maintenance	TOTAL
195.82/80.4	**Test**	**Develop**	0	38.44/15.8	243.52
	9.26/3.8	0			

Allocation of Flying Effort by Sector (Decimal flight hours/percent):

Science	R&D	Crew training / Maintenance	Commissioned
142.62/58.6	9.26/3.8	38.44/15.8	53.2/21.8

Allocation of effort by Project:

α-Grading/ Number supported	α5 (9/10) / 2	α4 (8/7) / 14 ◎	α3 (6/5) / 0	α2 (4/3) /0	α1 (2/1) /0	Pilot *0*	Commis-sioned / 4
Average Project Flight-time *Hrs:min*	*11:11*	*8:35*					*13:18*