SERVICES & FACILITIES ANNUAL REPORT - FY April 2011 to March 2012

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
The NERC MST Radar Facility at Aberystwyth http://mst.nerc.ac.uk	Block	SLA	1996	5 years

TYPE OF SERVICE PROVIDED:

The Mesosphere-Stratosphere-Troposphere (MST) Radar at Aberystwyth is the UK's most powerful and versatile wind-profiling instrument. It is unique in being able to provide continuous measurements of the three-dimensional wind vector over the altitude range 2-20 km at high resolution (typically 300 m in altitude and a few minutes in time). It can also provide information about atmospheric stability, turbulence, humidity and rainfall. Its data are therefore ideally suited for studying everything from small-scale atmospheric phenomena through to large-scale weather systems. There is no alternative source of comparable data for many of the projects which it supports.

The mission of the Facility is:

- To operate the MST radar on behalf of the UK atmospheric science community
- To operate, and host, instruments whose observations complement those made by the MST radar
- To participate in appropriate NERC-funded field campaigns
- To support facility users with analysis and interpretation of the data

During the past year, the Facility has supported projects which address 5 of the 7 NERC priority themes: (1) Climate System, (2) Sustainable Use of Natural Resources, (3) Natural Hazards, (4) Environment, Pollution and Human Health, and (5) Technologies. It has supported two NERC-funded field campaigns.

Data from the Facility have demonstrable economic, social and practical impacts. Real-time wind-profile data are used operationally by the Met Office for the purposes of numerical weather prediction This is undertaken through a commercial contract, which provides 33% of the Facility's budget. Page 4 gives details of a research project that has lead to more-fuel-efficient aircraft landing procedures being used at UK airports.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

The MST Radar has maintained was operated for 99.1% of the available time, exceeding the target of 98.0%.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review:		2009
Need	Uniqueness	Quality of Service	Quality of Science & Training	Average
4.5	5.0	4.5	4.0	4.5

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
67 %	Project Manager: Dr Jon Eastment - 10% Project Scientist: Dr David Hooper - 100% Site Technician: Mr Les Dean - 30%	2014	2015

FINANCIAL DETAILS: CURRENT FY						
Total Resource Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full Cash Cost £k
	Unit 1	Unit 2	Unit 3			
130.28	General user support £1.89k	Guest instrument/campaign support, £18.0k		0.0	63.0	261.81

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2011-12 130.3	2012-13 131.0	2013-14 131.0	2014-2015 131.0	2015-2016 -

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NARFSC	5	1	CFARR and EISCAT

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2011/12)													
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**R***	**Pilot**
NERC Grant projects*		**1**											
Other academic			**1**				**1**						**1**
Students					**1**								**1**
TOTAL		**1**	**1**		**1**		**1**						**2**

PROJECTS COMPLETED (current FY – 2011/12)												
	10 (α5)	**9**	**8 (α4)**	**7**	**6 (α3)**	**5 (α2)**	**4**	**3 (α1)**	**2**	**1 (β)**	**0 (Reject)**	**Pilot**
NERC Grant projects*												
Other Academic												**1**
Students			**1**		**1**	**1**						

Project Funding Type (current FY – 2011/12) (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**		
16	**4**	**5**	**2**		**4**					**1**
Project Funding Type (per annum average previous 3 financial years - 2008/2009, 2009/2010 & 2010/2011)											
Grand Total	**Infrastructure**					**PAYG**					
	Supplement to NERC Grant *	**PhD Students**		**NERC Centre**	**Other**	**NERC Grant***	**PhD Student**		**NERC Centre**	**Other**
		NERC	**Other**				**NERC**	**Other**		
15.67	**2.67**	**2.67**	**4.00**		**5.0**					**1.33**

User type (current FY – 2011/12) (include each person named on application form)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
8			**7**	**1**
User type (per annum average previous 3 financial years - 2008/2009, 2009/2010 & 2010/2011)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
8.33			**6.0**	**1.33**

OUTPUT & PERFORMANCE MEASURES (current year)										
Publications (by science area & type) (calendar year 2011)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
			7				**8**	**4**	**2**	**2**

Distribution of Projects (by science areas) (FY 2011/12)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
16				**16**			

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)										
Publications (by science area & type) (Calendar years 2008, 2009 &2010)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
			8.0				**8.00**	**3.67**	**3.33**	**1.00**

Distribution of Projects (by science areas) (FY 2008/2009, 2009/2010 & 2010/2011)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
15.67				**15.67**			

Distribution of Projects by NERC strategic priority (current FY 2011/12)							
Grand Total	**Climate System**	**Biodiversity**	**Earth System Science**	**Sustainable Use of Natural Resources**	**Natural Hazards**	**Environment, Pollution & Human Health**	**Technologies**
16	**6.33**	**0.00**	**0.50**	**1.00**	**3.83**	**1.00**	**3.33**

**Either Responsive Mode or Directed Programme grants*

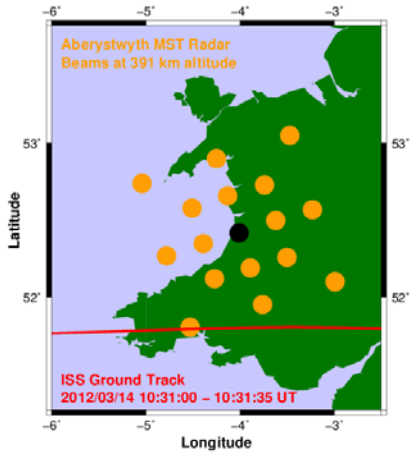
NOTE: All metrics should be presented as whole or part of whole number NOT as a %

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2011/12):

Radar Renovation

During March 2011, the MST radar underwent its first major renovation in a 20 year lifetime. At the time of the 2010-2011 annual report, the Facility's Project Scientist had already demonstrated that this had lead to an impressive 29% increase in useful coverage for wind-profiling purposes. A subsequent, more-detailed analysis of the data has shown that the ageing of the original radar components unexpectedly affected the data quality as well as the coverage.

In order to measure the wind, the radar's beam must be cycled through a variety of pointing directions every few minutes. Although it was not realised at the time, the old components were losing much more signal when the radar beam was directed at an off-vertical angle than then when it was directed towards the vertical. For rather subtle reasons, this lead to wind speeds being slightly over-estimated. The effect was sufficiently small that it was not noticed at the time. However, it became immediately apparent when a statistical comparison of the pre- and post-renovation data was carried out. This result has proved to be of interest to other operators of ageing radars.



Map showing a specific orbit of the International Space Station (red line) passing through one of the MST radar's fixed beam pointing directions (orange circles).

Detecting Low Earth Orbit Objects

Owing to the rapidly-increasing use of the near-Earth space environment, there is a growing need for space agencies to be able to track the objects within it. This is primarily motivated by the threat of collisions between operational spacecraft (including satellites and manned vessels) and orbital debris or defunct spacecraft. A dedicated space surveillance radar network already exists for this purpose. Nevertheless, owing to the ever-increasing number of objects to be tracked, there is interest in how radars which were designed for other purposes might contribute to this effort.

The MST Radar Facility has previously been involved in a paper study of its potential for this type of work. Since then, the NERC-funded Chilbolton Facility for Atmospheric and Radio Research (CFARR) has successfully tracked a variety of near-Earth objects using one of its atmospheric radars. Unlike the CFARR radar, whose beam can be steered towards any given direction, the MST radar only has a limited number of fixed beam pointing directions. The International Space Station has been identified as a suitable test target. The most northerly extent of its orbit commonly passes over the southern British Isles. It occasionally passes through one of the MST radar's beam pointing directions. It's not yet clear whether or not the radar return signal will be detectable. Changes will have to be made to the radar's data acquisition software so that the receiver signal can be analysed at the shortest possible time intervals. The space station is expected to pass through the beam in less than a couple of seconds. Atmospheric targets are usually detected from signals which have been accumulated over a comparatively-long period of 21 seconds.

SCIENCE HIGHLIGHTS:

Field campaigns supported by the Facility

During the final 3 months of 2011, the Facility supported two inter-related field campaigns - DIAMET and TROSIAD. The aim of DIAMET is to improve our ability to forecast extreme weather events. The strongest winds and heaviest rainfalls can often be confined within relatively small regions of large-scale storm systems. Although our ability to predict the large-scale patterns has improved in recent years, it is much more difficult to forecast the localised regions where the storm damage is often concentrated. The campaign is a collaboration between several NERC-funded University groups and the Met Office. The campaign relied on the instrumented NERC/Met Office FAAM aircraft as well as on a number of ground-based instruments, including the MST radar. The TROSIAD campaign focussed on a single type of small-scale atmospheric phenomenon (convection) and on the role that a large-scale phenomenon (stratospheric intrusions) has in either promoting or inhibiting it. During the course of the campaign, 45 meteorological balloons were launched from the MST radar site during 5 intensive observation periods.

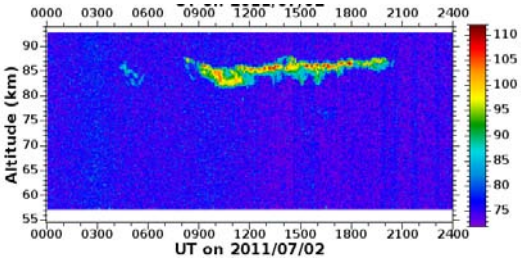
Noctilucent clouds shine light on a remote and relatively-unstudied region of the atmosphere. Image courtesy of David Hooper.

Long-term changes in a remote region of the atmosphere?
During the past year, research has begun into a remote region of the atmosphere, which is expected to show long-term changes as a result of human activity.

The mesosphere is the layer of the atmosphere between altitudes of approximately 50 and 90 km. Ice crystals can form in its uppermost part (at middle and high latitudes) as a result of exceptionally cold temperatures during the midsummer months. These crystals remain illuminated long after the Sun has set from the lower atmosphere. They can be seen during twilight hours as Noctilucent (literally "night-shining") Clouds (NLCs). Regular clouds are typically confined to the lowest 10 km of the atmosphere. Both the brightness and frequency of occurrence of NLCs are thought to have increased over the past century. It remains to be established whether or not this is a result of human activity.

Ice crystals, albeit of smaller sizes than are responsible for NLCs, are known to also play a role in the occurrence of the Mesosphere Summer Echoes (MSEs) observed by MST radars. Consequently, the researchers are combining radar data with observations made by a member of the amateur NLC-spotting community. This is starting to reveal details which were not apparent from either dataset in isolation. The NERC MST radar has been systematically observing MSEs since 2005. In connection with this project, the Facility's Project Scientist has been interviewed for BBC Radio 4's "Material World" programme - http://www.bbc.co.uk/iplayer/console/b015crkj - and for a NERC "Planet Earth" podcast - http://planetearth.nerc.ac.uk/multimedia/story.aspx?id=1181.

Proven impact of Facility-supported research
One of this year's publications - Ren et al. (2011) - made use of MST radar data as part of a project to design improved aircraft landing procedures. This lead to flight trials being undertaken at the UK's East Midlands Airport. The new procedures proved to be significantly quieter and more-fuel-efficient than traditional ones and hence resulted in lower emissions. As a result they are starting to be adopted for operational purposes, e.g. at Birmingham International Airport in the UK. This publication was highlighted on NERC's Science Impacts Database - http://sid.nerc.ac.uk/details.aspx?id=336 - which serves to demonstrate the ways in which NERC-supported science has had a beneficial impact on society.



One of the Mesosphere Summer Echoes (green, yellow and red colours) seen by the NERC MST Radar during the 2011 season.

Publications from 2011 which were supported by the Facility

1. Box, S., Bishop, C. M., and Hunt, H. Stochastic six-degree-of-freedom flight simulator for passively controlled high-power rockets. J. Aerosp. Engrg., 24(1):31-45, 2011.
2. Lawson, J., Vaughan, G., and Schultz, D. M. Classifying fronts in data from a VHF wind-profiling radar. Atmos. Sci. Lett., 12(4):375-380, 2011.
3. Redi, S., Aglietti, G. S., Tatnall, A. R., and Markvart, T. Dynamic response to turbulence of tethered lighter-than-air platforms. J. Aircraft, 48(2):540-552, 2011.
4. Ren, L., Reynolds, T. G., Clarke, J.-P. B., Hooper, D. A., Parton, G. A., and Dore, A. J. Meteorological influences on the design of advanced aircraft approach procedures for reduced environmental impacts. Meteorol. Apps., 18(1):40-59, 2011.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK
The work on detecting low earth orbit objects will continue during the forthcoming year, once the necessary changes have been made to the data acquisition software. A proven novel capability could help to attract new Facility users. An automatic Noctilucent Cloud camera will be set up in time for the 2012 summer season. This will help with the ongoing investigations into the mesosphere. Moreover, it is possible that we will see additional unusual phenomena in this part of the atmosphere. The period since the MST radar began making systematic mesospheric observations has been characterised by low solar activity. However, this is expected to change over the next couple of years as we pass through a period of peak solar activity. It is possible that we will see the impacts of "space weather" events in the form of extra-ordinary mesospheric echoes.