SERVICES & FACILITIES ANNUAL REPORT - FY April 2005 to March 2006

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 (to March 2010)

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 precipitation. It is therefore ideally suited for studying everything from small-scale atmospheric phenomena through to large-scale weather systems. Wind-profile data are supplied to the Met Office, for numerical weather prediction purposes, through a commercial contract. Upper-air input from the Aberystwyth area has been found to have a significant impact on improving longer range forecasts.

The Facility operates and hosts additional instruments whose observations complement those made by the MST radar. The Met Office operates a GPS water vapour receiver at the site, and has previously operated a boundary-layer wind-profiler there. The NERC Universities' Facility for Atmospheric Measurement (UFAM) boundary-layer wind-profiler and ozone lidar are operated at the site in-between campaigns.

The mission of the Facility is:

- To operate the radar on behalf of the UK atmospheric science community
- To operate, and host, instruments whose observations complement those made by the MST radar
- To facilitate the analysis and interpretation of the data

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

1	Target	Install a new concrete instrument area, together with the new laser ceilometer, next to the radar site bungalow by early May 2005.
	Progress	Delivery of the ceilometer was delayed by the manufacturer until May 2005. The instrument platform was constructed (in stages) during June and completed at the beginning of July. The ceilometer was mounted on the platform and began operations at the beginning of August.
2	Target	Install new radar control and data acquisition system by December 2005.
	Progress	The new acquisition system was completed and tested at the beginning of December 2005.
3	Target	Introduce operational multi-peak MST radar signal processing by September 2005.
	Progress	The operational processing scheme (which delivers data to the Met Office) was introduced at the beginning of January 2006.
4	Target	To operate the MST radar for a minimum of 98% of the available time
	Progress	The radar was in operation for 98.0% of the available time.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review: January 2004		
Need	Uniqueness	Quality of Service	Quality of Science & Training	Average
5.0	5.0	4.5	4.5	4.75

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review	Contract Ends
74%	Project Manager: Dr Sam Pepler 25% (not NERC funded) Project Scientist: Dr David Hooper – 100% Site Manager: Mr Tony Olewicz – 100% (UWA contract)	(January) 2009	(31 March) 2010

FINANCIAL DETAILS: CURRENT FY							
Total Resource Allocation £k	Unit Cost £k				Capital Expend £k	Income £k	Full Cash Cost £k
	Unit 1 NERC funded Specific	Unit 2 Non-NERC Specific	Unit 3 Pilot/Educational	Unit 4 Guest Instrument Support			
124	10.3	5.2	1.1	20.1	41	39	148.6

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2005-06 124	2006-07 123	2007-08 127	2008-09 133	2009/2010 138

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

APPLICATIONS: DISTRIBUTION OF GRADES (Current FY — 2005/06								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects		**1**						
Other academic		**1**						
Students (non PhD)	Applications in this category are regarded as Pilot projects and are not graded						**1**	
Pilot	Applications in this category are regarded as Pilot projects and are not graded						**2**	
TOTAL		**2**					**3**	

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 years —2002/2003, 2003/2004 & 2004/2005)								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects		**1.67**	**0.33**					
Other Academic		**2.33**	**0.67**				**0.67**	
Students (non PhD)	Applications in this category are regarded as Pilot projects and are not graded						**1.67**	
Pilot	Applications in this category are regarded as Pilot projects and are not graded						**0.67**	
TOTAL		**4.00**	**1.00**				**3.00**	

PROJECTS COMPLETED (Current FY) – Not applicable for this Facility							
	α5	α4	α3	α2	α1	β	R*/Pilot
NERC Grant projects							
Other Academic							
Students							
Pilot							

USER PROFILE (current FY)										*Combined non-Directed and Directed*
Grand Total	**Infrastructure**					**PAYG**				
	Supplement to NERC Grant *	**Student Total**	**Student NERC**	NERC C/S	Other	**NERC Grant***	**Student Total**	**Student NERC**	**NERC C/S**	**Other**
23	7	5	2		10	**Supply of data to the Met Office (counts as 1 user) under a commercial contract**				

USER PROFILE (per annum average previous 3 years)										*Combined non-Directed and Directed*
Grand Total	**Infrastructure**					**PAYG**				
	Supplement to NERC Grant *	**Student Total**	**Student NERC**	NERC C/S	Other	**NERC Grant***	**Student Total**	**Student NERC**	**NERC C/S**	**Other**
21.33	**6.00**	**4.67**	**2.33**		**9.67**	**Supply of data to the Met Office (counts as 1 user) under a commercial contract**				

USER PROFILE (current FY)				
Academic	**Centre/Survey**	**NERC Fellows**	**PhD**	**Commercial**
20			**2**	**1**

USER PROFILE (per annum average previous 3 years)				
Academic	**Centre/Survey**	**NERC Fellows**	**PhD**	**Commercial**
16.67		**1.00**	**3.00**	**1.0**

OUTPUT & PERFORMANCE MEASURES (current FY)

Publications (by science area & type)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
							5	**3**	**2**	

Distribution of Projects (by science areas)						
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
			100%			

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

Publications (by science area & type)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
							9.33	**6.00**	**2.67**	**0.67**

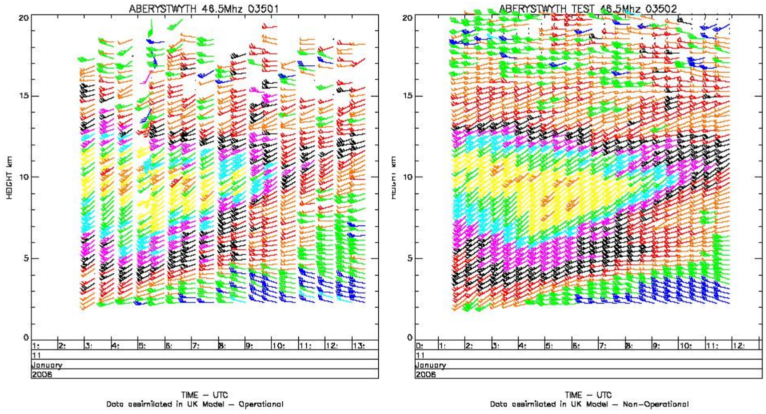
Distribution of Projects (by science areas)						
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
			100%			

Distribution of Projects (by NERC strategic priority)				
Earth's life support systems	**Climate Change**	**Sustainable Economies**	**Underpinning Science**	**Specific Research**
	11	**8**	**5**	**3**

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2005/06):

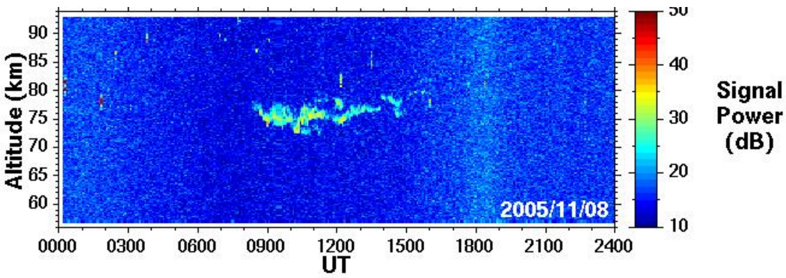
Introduction of a new operational signal processing scheme

Wind-profile data from the original (left panel) and new (right panel) signal processing schemes. Plots courtesy of the Met Office.



The most significant development of the past year has been the introduction of a new operational MST radar signal processing scheme in January 2006. Validation of the data is being undertaken in collaboration with the Met Office, who compare MST-radar-derived winds against their model fields. At present data from the new scheme (right-hand panel) are regarded as being under test and so are being sent to the Met Office in parallel with data from the original processing scheme (left-hand panel). The new processing scheme has improved data quality noticeably at all altitudes and most obviously so above 14 km. The altitude up to which wind-profile data are provided for at least 80% of the time has risen from 17.4 to 18.3 km. It is anticipated that the Met Office will switch over to the new processing scheme for operational assimilation (into numerical weather prediction models) in August 2006.

An example of an unexpectedly persistent and highly-structured mesospheric echo layer.



The reintroduction of mesospheric observations

In keeping with the requirements of the majority of the data users, the MST radar is operated predominantly in the ST (stratosphere-troposphere) mode, i.e. covering the approximate altitude range 2-20 km. Nevertheless, the radar is also capable of making M (mesosphere) mode observations, covering the approximate altitude range 56 – 94 km. This region of the atmosphere is too high to be reached by aircraft and too low for satellite transits and so remains little-studied. Even the MST radar returns tend to be weak, sporadically occurring, and from layers of thin vertical extent. However, no systematic attempt had ever been made to characterise the occurrence and nature of these echoes and no M-mode observations were made at all after 1999. In order to fill this gap in knowledge, M-mode observations were reintroduced in April 2005, interlaced with the continuous ST-mode observations (M-mode observations had never before been made for more than a few hours at a time). Amongst other things, this has revealed that echo layers can be much better defined, more persistent and more structured than previously thought. M-mode observations are set to continue.

The new laser ceilometer (left) and the RAL cloud radar (right).

Operation of complementary instruments

The MST radar provides more than just wind-profile data and a number of studies are concerned with the extraction of additional information from the radar returns. Simultaneous observations made by complementary instruments are invaluable in this regard. In July 2005 the Facility began operating a NERC-funded laser ceilometer (upright instrument to the left of the image), which measures cloud base altitudes. Additional information about the vertical extent of the clouds has been provided by a pre-prototype cloud radar (short instrument to the right of the image) which is being developed by the Millimetre-Wave Technology Group of the Rutherford Appleton Laboratory. For the first time the combined information has revealed that the MST radar is (occasionally) capable of detecting structures associated with clouds.

Upgrade of the MST radar control and data acquisition system

The original radar control and data acquisition system was designed for a WindowsNT computer by a member of staff who retired in 2001. Since this could no longer be actively maintained by current members of staff, it became necessary to build a replacement system. At the same time changes were implemented to allow more flexible operation of the radar. This work has been funded by NERC.

SCIENCE HIGHLIGHTS:

Convective Storm Initiation Project (CSIP)

The aim of CSIP is to establish the mechanisms which give rise to the localised initiation of convective activity, which ultimately leads to heavy rainfall and possible flooding. The bulk of the summer-2005 phase of the field campaign was centred around the Chilbolton Observatory in southern England. Nevertheless, the MST radar, which is located near Aberystwyth in West Wales, played a role in providing details of the large-scale upper-air conditions. These can either encourage or inhibit the growth of convection. Attention has so far been focussed on one case for which the convection was largely inhibited. However, the descent of dry upper-level air behind a cold front, as seen by the radar, gave rise to an isolated thunderstorm.

Cumulus (convective) clouds seen above the MST radar.

Convectively-generated gravity waves

The effects of convection are not limited to the region in which the updrafts and downdrafts are active. Gravity waves (also known as buoyancy waves) can transfer energy from the top of the convective region to the top of the atmosphere – many tens of kilometres above. Since this mechanism is thought to play an important role in the general circulation of the atmosphere, it has received considerable attention at tropical locations, where convection is most common. Interest is gradually spreading to mid-latitude locations and Aberystwyth MST radar data are being used for two such studies. The first challenge has been to distinguish convectively-generated gravity waves from the more commonly-occurring mountain waves, which are generated by the flow of air over the Welsh hills. Several clear cases have been identified for which the wave activity is clearly of convective origin.

Distinctive cloud formations indicating mountain wave activity, which is caused by air flow over the Welsh hills.

The Silent Aircraft Initiative.

Three projects are making use of MST radar wind-profile data for novel aircraft applications. One of these, "The Silent Aircraft Initiative" aims to discover ways to dramatically reduce aircraft noise to the point where it would be virtually unnoticeable above the background noise level at the perimeter of a typical urban airport. The project is under the Cambridge-MIT Institute, a collaboration between the University of Cambridge and the Massachusetts Institute of Technology (MIT), and includes an extended community of representatives from all parts of the civil aerospace/aviation industry. The ultimate goal is to produce a technically-feasible and economically-viable novel aircraft design, such as the blended wing-body shown to the right. An intermediate goal is to design improved take-off and landing procedures which reduce noise, fuel burn and emissions for conventional aircraft. Developing these new procedures has required detailed assessments of the wind profiles around candidate airports. MST radar observations are the only source of data with sufficiently high altitude- and time-resolution for the modelling needs.

A design concept being considered by the Silent Aircraft Initiative. Image courtesy of the Cambridge-MIT Institute.

Refereed publications from 2005:

1) K. A. Browning. Observational synthesis of mesoscale structures within an explosively developing cyclone. *Q. J. R. Meteorol. Soc.*, 131:603-623, 2005.

2) D. A. Hooper, A. J. McDonald, E. Pavelin, T. K. Carey-Smith, and C. L. Pascoe. The signature of mid-latitude convection observed by VHF wind-profiling radar. *Geophys. Res. Lett.*, 32:doi:10.1029/2004GL020401, 2005.

3) S. Varadarajan, K. Jithendra Reddy, and G. Ramachandra Reddy. Wind profile detection of atmospheric radar signals using wavelets and harmonic decomposition techniques. *Atmos. Sci. Lett.*, 5:52-161, doi:10.1002/asl.78, 2005.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

- Retire remaining legacy hardware and software which cannot be actively maintained by existing members of staff..
- Move towards automating the operation of the MST radar.
- Adopt the improved MST radar signal processing scheme for operational use (once the Met Office and University users are satisfied with the data quality)
- Increase Facility promotion activities as a way of expanding the user base.
- Renovate storage shed at the radar site.