SERVICES & FACILITIES ANNUAL REPORT - FY April 2003 to March 2004

SERVICE	FUNDING BLOCK	AGREEMENT SLA	ESTABLISHED as S&F 1996	TERM 5 years - to March 2010
The NERC MST Radar Facility at Aberystwyth http://mst.nerc.ac.uk				

TYPE OF SERVICE PROVIDED:

The Mission of the NERC Mesosphere-Stratosphere-Troposphere (MST) Radar Facility is to provide high quality atmospheric data products in near real-time to the UK scientific community in support of environmental research. It arranges for peer review of projects thereby ensuring that only science of the highest quality is supported. It maintains an awareness of users' requirements so as to ensure that the service is fulfilling actual needs. It provides appropriate scientific and technical support to scientific customers in order to aid in the analysis and interpretation of the data.
It achieves these objectives by:

- operating and maintaining the MST radar system and a climate data logger (for measuring surface temperature, pressure, humidity, rain fall and solar radiation) at Capel Dewi, a wind measurement system at Frongoch Farm (3 km to the west of the radar site), and associated computer systems at the Rutherford Appleton Laboratory (RAL)
- monitoring and maintaining the quality of the data
- archiving the data with the NERC British Atmospheric Data Centre (BADC) within 24 hours of acquisition, thereby providing access for users through the internet
- investigating novel techniques in order to maximise the usefulness of the data products
- conducting research and development to ensure the Facility and its technology are state-of-the-art
- promoting the value of the data products, through seminars and presentations at conferences, in order to make them available to the widest possible audience
- maintaining a dedicated website
- holding one-to-one discussions with data-users
- executing commissioned work with the UK Met Office in order to supplement the annual budget

The NERC MST Radar is the UK's most powerful and versatile wind-profiling instrument. It provides continuous measurements of the three-dimensional wind vector over the altitude range 2 – 20 km, at resolutions of 300 m in altitude and 2 – 3 minutes in time. Moreover, under certain circumstances, it can provide information about atmospheric stability, turbulence and precipitation. It is therefore ideally suited for studying everything ranging from large scale weather systems down to small-scale atmospheric phenomena. Observations began in 1990, and have been made quasi-continuously since 1997. This provides an unparalleled opportunity to perform statistical studies, which would be extremely difficult to pursue by other means. It also means that the radar captures exceptional and unexpected events, whether or not observations have been requested. The Facility operates, and hosts, a number of other instruments, which provide complementary atmospheric data. This continually expands the range of scientific problems which can be addressed.

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 (January)	Contract Ends (31 March)
76%	Project Manager: Dr Stuart White 50% (Retired at end of FY) Project Scientist: Dr David Hooper 100% Site Manager: Mr Tony Olewicz 100% (University of Wales Aberystwyth contract)	2009	2010

FINANCIAL DETAILS: CURRENT FY						
Recurrent Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full cash cost £k
	Unit 1: Specific Project – NERC Funded	Unit 2: Specific Project – Non-NERC Funded	Unit 3: Pilot Project, Educational, or Teaching Use			
130.5	13.3	6.6	1.3	Nil	37.7	155.2

FINANCIAL COMMITMENT (by year until end of current agreement) £k							
2004-05 115.0	2005-06 122(?)	2006-07 125(?)	2007-08 130(?)	2008-09	133(?)	2009-10	137(?)

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NARFSC	5	1	Chilbolton Facility for Atmospheric and Radio Research

APPLICATIONS: DISTRIBUTION OF GRADES (Current FY — 2003/04)								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects		4						
Other academic		2						
Teaching/Educational	1 (applications in this category are not graded)							
Pilot	0 (applications in this category are not graded)							
TOTAL		6					1	
APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 years —2000/2001, 2001/2002 & 2002/2003)								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects		3.00						
Other Academic		1.67	0.67					
Teaching/Educational	2.00 (applications in this category are not graded)							
Pilot	5.33 (applications in this category are not graded)							
TOTAL		4.67	0.67				7.33	

PROJECTS COMPLETED (Current FY) – NOT APPLICABLE							
	α5	α4	α3	α2	α1	β	R*/Pilot
NERC Grant projects							
Other Academic							
Students							
Pilot							

USER PROFILE (current FY) **Combined non-Thematic and Thematic*

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	8	3	2		12					

USER PROFILE (per annum average previous 3 years) **Combined non-Thematic and Thematic*

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
20.33	1.33	6.00	2.33	0.33	12.67					

USER PROFILE (current FY)				
Academic	Centre/Survey	NERC Fellows	PhD	Commercial
19		0	3	1
USER PROFILE (per annum average previous 3 years)				
Academic	Centre/Survey	NERC Fellows	PhD	Commercial
16.0	0.33	2.67	3.00	1.00

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
			11				11	6	4	1

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
			8.00				8.00	6.33	1.33	0.33

Distribution of Projects (by science areas)

SBA	ES	MS	AS	TFS	EO	Polar
			100%			

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2003/04):
A major undertaking of the last year has been the preparation of the Facility's funding renewal application . This was submitted to NERC in December 2003. Renewal has been approved for the period 2005 – 2010.

Applications for access to the data from the Facility were received in connection with 7 projects. Four of these were NERC funded. One of the applications related to an undergraduate project and one to a PhD studentship. Two of the projects requested that the MST radar be operated in a user-specified mode.

MST radar data were acquired for 98% of the available time. There were only two significant periods of data loss, each one lasting approximately 48 hours. Both were caused by problems which developed during a weekend, and so which were not noticed and rectified until the following Monday morning. In the first case a thunder storm caused a build up of static on the receiver interface board. In the second case a malfunction caused the radar beam steering unit to stick in one pointing direction. Neither problem could have been foreseen.

Surface meteorological data (i.e. temperature, pressure, humidity, rainfall, and solar radiation) were recorded without interruption throughout the year. There was a break in surface wind speed and direction measurements (made at Frongoch farm, 3 km to the west of the radar site) between 3rd and 14th April. This was caused by corrosion of an electrical connector (installed by the manufacturers of the equipment), which has now been replaced and thoroughly sealed. The data-logging PC (which runs under Windows2000) experienced considerable disruption during July and August after being infected by the MS-Blaster, and subsequently the Nachi-A, computer worms. This was despite the fact that the PC was running up-to-date anti-virus software. The Met Office suffered similar disruption on their GPS water vapour receiver PC at the radar site.

All MST radar observations made since 1st June 2003 have been reprocessed using new signal processing software, which has been written by the Facility's Project Scientist. The data have been made available through the British Atmospheric Data Centre in standard format files. The results have generally been very good, with increased altitude coverage compared to the observations processed by the old software. Although the new software is able to flag the data associated with sporadic interference events as being unreliable, it should be possible to make improvements in order to avoid data gaps. One source of interference is thought to be echoes from turbines on nearby wind farms. The problem is typically worst when the low-level wind speeds are largest, and hence when the turbines are rotating fastest. It only occurs at fixed ranges from the radar. This problem has been evident for 2 data sets, from pre June 2003, which have been specially reprocessed upon request from user scientists. In these cases the interference was removed by writing special processing routines based on a subjective inspection of the lowest-level data products. Although this method has proved to be effective, it is too time-consuming to be applied on a regular basis. Efforts are underway to find an objective solution to the problem.

Visualisation software, written by the Facility's Project Scientist, for inspecting the lowest-level data products has now been made available to user scientists. Since this shares code with the new signal processing software, it is now possible to see exactly how the higher level data products relate to the basic observations. This is particularly useful for studies of extreme weather events, which can give rise to strong surface winds, lightning strikes and heavy rain. Under such conditions the radar can temporarily malfunction, e.g. because of mains supply disruptions, physical damage to the antenna structure, or blowback along the transmitter ventilation channels. All of these can give rise to unusual looking radar data. However, unusual looking radar data might equally well be related to the exceptional nature of the atmosphere during extreme weather events. The new software can, in many cases, remove such uncertainties.

The NERC MST Radar Facility continues to be represented and promoted to the wider atmospheric community. Facility posters have been presented at the 10th International Workshop on Technical and Scientific Aspects of MST Radar, held in Peru 13-20 May 2003, and at the Royal Meteorological Society Conference, held at the University of East Anglia 1-5 September 2003. The Project Scientist has presented two science seminars and given two tutorials for new users at UK University Departments. He also gave a general presentation on MST radars at a meeting co-organised by NERC and the Particle Physics and Astronomy Research Council in September 2003. The aim of the Polar Atmospheric Science Seminar was to investigate the possibility of establishing a cross-council thematic programme in the area of overlapping interests.

The Project Scientist's article on atmospheric gravity waves (which are often observed by the MST radar) was published in the Autumn 2003 edition of Planet Earth. The Project Scientist has also attended training to become a Science and Engineering Ambassador. This is part of a national scheme which coordinates visits to schools by scientists and engineers as a way of encouraging more children to consider careers in these areas.

The Site Manager has carried out a health and safety assessment of the facility. No major causes for concern were found, but a number of improved procedures and safety measures have been identified. The Site Manager attended the NERC risk assignment course.

In November 2003, the Facility Manager, Project Scientist and Site Manager visited the Met Office's new 64 MHz wind-profiling radar in South Uist (Outer Hebrides). The Met Office's decision to invest in this type of technology, to replace the Stornoway radiosonde station, was based on their positive experiences with the NERC MST radar over the past 10 years.

SCIENCE SUPPORTED IN FY (2003/04):

MST radars, which operate at frequencies of around 50 MHz, are primarily sensitive to "clear-air" scattering from metre-scale irregularities of refractive index. They can also detect Rayleigh scattering from hydrometeors, although the signal strength is much weaker than that for the clear-air returns except under conditions of very heavy precipitation. Previous work in this field has largely been confined to tropical and low-latitude stations, where monsoon precipitation can be particularly intense. It was mentioned in last year's report that one study, using data from the Aberystwyth radar, was examining the role of precipitation in reducing the clear-air return signal strength. It has come as something of a surprise that hydrometeor returns can also sometimes be observed at Aberystwyth. This opens up the possibility of studying the precipitation directly.

The heaviest rain is associated with convective events, the study of which was also a highlighted as a new area of research in last year's report. This work has benefited from combining observations made by the MST radar with those made by the Met Office's boundary-layer wind-profiler, which was operated at the radar site between 1999 and 2002. These profilers operate at frequencies of around 1000 MHz and so are highly sensitive to hydrometeor returns, the strength of which increases in proportion to the 4^{th} power of radar frequency. Therefore, although they routinely detect clear-air returns from the lowest 2 km of the atmosphere, returns from higher altitudes tend to be associated exclusively with precipitation. The vertical velocities observed by the wind-profilers, under such conditions, relate to the fall speeds of the hydrometeors. On the other hand, the vertical velocities observed by MST radars relate to the air motions and show the up and down drafts associated with the convection. Simultaneous observations with radars operating at two widely separated frequencies therefore offer far greater potential than observations made with either radar alone.

The increased understanding of the signatures of convection and precipitation, as observed by the MST radar, has allowed observations made by the Aberystwyth radar to be used for validation purposes in two modelling-based studies. One study focuses on the transport of boundary layer air, which lies within the lowest 1 – 2 km of the atmosphere, into the free troposphere above. The boundary layer is typically distinct from the free troposphere and so is relatively rich in gases which are released exclusively from ground-level. The project aims to determine which dynamical processes are most important for mixing boundary layer air into the free troposphere, where this mixing actually occurs, and how rapidly the boundary layer is ventilated by fronts. Convection is known to be one of the processes which gives rise to such ventilation. The second study focuses on mesoscale rain bands associated with mid-latitude fronts. These can lead to heavy rain and damaging winds. Both upright and slantwise convection are known to play a role in their formation and one of the aims of the study is to determine the relative importance of these two mechanisms. The MST radar observations have shown a very clear signature of precipitation in one of the case studies examined so far.

Since the Aberystwyth MST radar is operated on a continuous basis, it is able to capture infrequently occurring and unpredicted extreme weather events. A good example of an extreme phenomenon is a sting jet – a region of very strong winds which occurs in the rear of a cold front as air wraps around a surface cyclone. Such an event, observed on 27^{th} October 2002, caused widespread damage across the UK and was responsible for major power supply disruptions in the east of England. A case study of this event is combining observations made by the MST radar with those made by the UFAM (Universities Facility for Atmospheric Measurement) boundary-layer wind-profiler, which happened to be in operation at a field campaign in Cardington (in the east of England) at the time.

One of the projects which required the MST radar to be operated in a user-specific mode was concerned with testing a novel technique for deriving turbulence information from the raw radar data, which are not typically stored. An earlier evaluation of this technique had made use of the raw data acquired as part of the Egrett campaign, which was conducted during summer of 2000. The traditional technique for deriving turbulence parameters becomes less reliable with increasing wind speed. Few occurrences of suitable conditions could be found during the Egrett campaign period and so the results of the study were inconclusive. The Project Scientist recommended that the new observations be made during a period of low-level easterly winds. As expected, these conditions gave rise to turbulence generation, through mountain wave breaking, in a region of low wind speeds.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

Now that funding for the Facility has been secured until 2010, a capital funding application has been submitted to NERC for an upgrade of the existing equipment at the radar site, and for the installation of new instruments. The existing radar control and data acquisition system is not sufficiently flexible to allow the full versatility of the radar to be exploited. Moreover, these applications are run on a PC under Windows NT, which is no longer supported by Microsoft. The problems with computer viruses experienced by the data-logging PC during the last year have highlighted the fact that operating systems should be kept up-to-date. It is planned to transfer these tasks to a Linux PC, which will allow for better security and networking potential. The software will be rewritten so that the radar can be operated in a much more flexible way.

The capital funding application also proposes the installation of a laser ceilometer (which gives a measure of the altitude of the cloud base) and a sky-pointing camera at the radar site. These will allow an extension of the convection and precipitation studies, which have already benefited from the availability of complementary surface rainfall and boundary-layer wind-profiler data. The new instruments will also be of direct value to a study which aims to better understand the influence of humidity fields on MST radar return signal strength. Similar studies conducted by the Met Office, and using a boundary-layer wind-profiler, have shown that the observed and predicted signal strengths were often poorly matched under conditions of broken cloud. This was attributed to large differences in humidity structure existing between the cloud and inter-cloud regions, hence the need for a sky-pointing camera in order to be able to differentiate between these regions.

A plan has also been initiated to upgrade the internet connection to the radar site from 56 kbps to 2 Mbps. This will be particularly important with the increasing number of Facility owned and guest instruments (such as the UFAM mobile boundary-layer wind-profiler) in operation at the radar site.