SERVICES & FACILITIES ANNUAL REPORT - FY April 2002 to March 2003

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 2005

TYPE OF SERVICE PROVIDED:

The Mission of the NERC Mesosphere-Stratosphere-Troposphere Radar (MSTR) 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 MSTR 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 at Capel Dewi, near Aberystwyth in West Wales, is a 46.5 MHz pulsed Doppler radar ideally suited for studies of atmospheric winds, waves and turbulence. It is run predominantly in the ST mode for which such radars are unique in their ability to provide continuous measurements of the three-dimensional wind vector over the altitude range 2 – 20 km at resolutions of a few minutes in time (typically 2-3) and a few hundred metres in altitude (typically 300). Additionally, under certain circumstances the radar returns can give information about the atmospheric static stability (thus allowing monitoring of the altitude and sharpness of the tropopause), humidity fields and turbulence (of at least moderate intensity). The extensive data-set of high-resolution observations from the NERC MST Radar, which covers a period of more than 10 years, offers the potential for studies to be made of atmospheric phenomena ranging from the micro and meso scales through to the synoptic and seasonal scales and beyond. The Radar is the most powerful and versatile wind-profiling system in the UK.

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

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status		Next Review	Contract Ends
76%	Head of Facility: Dr Stuart White	50%	(January)	(31 March)
	Project Scientist: Dr David Hooper	100%	2004	2005
	Site Manager: MrTony Olewicz	100% (UWA contract)		

FINANCIAL DETAILS: CURRENT FY						
Recurrent Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full cash cost £k
	Unit 1	Unit 2	Unit 3			
125.2	14,375	7,118	1,438	Nil	34.0	138.0

FINANCIAL COMMITMENT (by year until end of current agreement)				
2003-04 £130.5k	2004-05 ?	2005-06	2006-07	2007-08

Unit 1: Specific Project – NERC Funded
Unit 2: Specific Project
Unit 3: Pilot Project , Educational, or Teaching Use

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NARSFC	5	1-2	Chilbolton Radar Facility

APPLICATIONS: DISTRIBUTION OF GRADES (Current FY — 2002/03)								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects		1						
Other academic		4	2					
Teaching/Educational	3 (applications in this category are not graded)							
Pilot	1 (applications in this category are not graded)							
TOTAL		5	2					
APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 2 years —2000/2001 & 2001/2002; no data pre-2000)								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects	1.00	3.50						
Other Academic	0.50	0.50	0.50					
Teaching/Educational	3.50 (applications in this category are not graded)							
Pilot	4.00 (applications in this category are not graded)							
TOTAL	1.50	4.00	0.50					

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		NERC C/S	Other	NERC Grant*	Student		NERC C/S	Other	
		Total	NERC				Total	NERC		
19	2	6	3		9					

USER PROFILE (per annum average previous 2 years; no data pre 2000)											*Combined non-Thematic and Thematic
Grand Total	Infrastructure					PAYG					
	Supplement to NERC Grant *	Student		NERC C/S	Other	NERC Grant*	Student		NERC C/S	Other	
		Total	NERC				Total	NERC		
23.50	1.50	5.50	2.50	0.50	14.50					

USER PROFILE (current FY)				
Academic	Centre/Survey	NERC Fellows	PhD	Commercial
12		3	4	1
USER PROFILE (per annum average previous 3 years)				
Academic	Centre/Survey	NERC Fellows	PhD	Commercial
19.00		1.00	2.50	1

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
			10				10	9	1	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
			7.33				7.33	5.67	1.33	0.33

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

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2002/03):

During the last year 10 Supporting Scientific Cases have been submitted as applications for access to the MST Radar Facility datasets through the British Atmospheric Data Centre. Of these 4 were from researchers for specific projects, 2 were from PhD students, 1 was for a pilot project, 2 were for teaching use, and 1 was for an undergraduate project.

The MST Radar acquired data for 98% of the projected time for the year. Surface meteorological data (i.e. temperature, pressure, humidity, rainfall, and solar radiation) were recorded at 10 minute intervals without interruption for the whole year. Wind speed and direction data from the wind-sensor at Frongoch, 3 km to the west of the radar site, were acquired at 1 minute intervals for all but one week of the year. Quick-look plots and data files were, for the most part, made available through the British Atmospheric Data Centre (BADC) website within 24 hours of the acquisition of the data. Specific requests for data were typically taken care of within 24 hours.

Considerable progress has been made with the processing and management of MST radar data. Particular emphasis has been placed on a new method of data reliability flagging. The existing method relies on rejecting all data which fail to meet a threshold signal-to-noise ratio. Although this method is reasonably effective, it fails to reject strong spurious signals, such as those arising from aircraft echoes. Moreover it rejects a significant number of weak but apparently reliable signals. This effectively limits the maximum observable altitude, for wind-profiling purposes, to around 16 or 17 km. The new reliability flagging system is based on the continuity of horizontal velocity components as a function of time. In addition to improving the quality of the low-level data products, it can significantly increase the altitude coverage for higher-level data products; wind-profile information is regularly available up to 20 km. This is achieved because the number of beam pointing directions used in the standard mode of operation (typically more than 5) is larger than the minimum required for wind-profiling purposes (3). The availability of reliability flagging allows the redundancy to be adaptively exploited in order to maximise the altitude coverage. The Met Office have expressed an interest in receiving samples of wind-profile data processed using the new algorithms as soon as they become routinely available.

To coincide with the introduction of new signal processing routines, standardised file formats have been defined in collaboration with the staff of the BADC. The original file formats reflect the relatively limited storage capacity available in the early years of the radar project (c. 1990). They are difficult to understand for a first-time user and cannot be interpreted without reference to external metadata. The new files are written using the self-descriptive NASA-Ames format which has been adopted for many datasets stored by the BADC. This step will radically improve the current accessibility and will ensure long-term utility of the data.

The most significant developments to take place at the radar site during the last financial year have been those in connection with the new University Facilities for Atmospheric Measurements (UFAM) instruments. A variety of instruments have been acquired by a consortium of 6 UK university departments on behalf of the entire UK atmospheric science community. The instruments are intended primarily for use in field campaigns although those owned by the University of Wales Aberystwyth (a mobile boundary-layer wind-profiler and a mobile ozone lidar) will be operated at the MST radar site whilst not otherwise engaged. The boundary-layer wind-profiler covers the approximate altitude range 200 – 3000 m and therefore both fills-in and overlaps with the wind information provided by the MST radar (2 – 20 km). However, both instruments provide more than just wind information and owing to the large difference in operating frequencies (1290.0 and 46.5 MHz, respectively), they give slightly different views of the atmosphere. The availability of such complementary information has proved to be particularly useful in connection with precipitation studies.

Some of the content on the Facility's website (http://mst.nerc.ac.uk) has been generalised over the past year so that it can serve the anticipated needs of an increasing wind-profiling community. In addition to the new UFAM boundary-layer wind-profiler at the MST radar site, a similar UFAM instrument is currently under construction at the Chilbolton radar facility. Although the mode of operation of the latter is significantly different to that of the other two instruments, the relevant radar return mechanisms and signal processing techniques are similar in all 3 cases. The MST Radar Project Scientist has provided valuable assistance to the UFAM instrument scientists responsible for both of these instruments in relation to signal processing and data analysis.

The MST radar facility continues to be represented and promoted to the wider atmospheric community. Facility posters have been presented at the UTLS/COSMAS workshop, held at the University of Bristol 8-11 July 2002, and at the UWERN Annual Conference, held at the University of Essex 9-11 September 2002. Seminars promoting the facility have been given at the University of Salford and at the University of Bath. It is noteworthy that the latter case was through the Department of Electronic and Electrical Engineering, which is not an immediately obvious candidate for such a seminar. The group is interested in the effects of refractive index structures on the propagation of radio waves in the lowermost region of the atmosphere. Such structures also have an effect on the radar returns observed by the MST radar and boundary-layer wind-profiler, hence the interest.

The Project Scientist has had four abstracts accepted for the forthcoming international MST Radar workshop to be held in Peru in May. One of these relates to a poster promoting the NERC MST Radar Facility. The other three relate to research and development work; two of these involve collaboration with UK scientists at the Universities of Reading and of Aberystwyth.

The Project Scientist has also made a start on Science Communication Activities. An article on atmospheric gravity waves, which are commonly observed by the MST radar, has been submitted for the autumn 2003 issue of NERC's publication "Planet Earth". A short presentation on the radar was given to a group of A-level students visiting the Rutherford Appleton Laboratory. It is intended that activities in this area will increase during the forthcoming year.

A number of Health and Safety issues have been addressed during the last financial year including collation all the relevant Health & Safety and site security information. An incident log-book, for H&S and security matters, has also been introduced at the radar site.

A 2-year extension to the contract with the Met Office for the supply of quasi-continuous wind data for 2003/04 and 2004/05 was agreed and ratified.

SCIENCE SUPPORTED IN FY (2002/03):

A number of studies over the past year have focused on the interaction of normally distinct regions of the atmosphere, often through the effects of gravity wave activity. Gravity waves are known to play a number of significant roles within the atmosphere and consideration of them in global circulation models is essential in order to reproduce realistic results. However, since the waves span a large range of spatial scale sizes, and since a significant proportion of these fall below the resolution of the models, it is necessary to parameterise them statistically. Therefore, although it is known that gravity waves of different scale sizes are able to interact, this is typically demonstrated by inference. However, a recent case study using observations made by the NERC MST radar gives direct evidence of a mountain wave/inertia-gravity wave interaction event. Mountain waves extract energy from the low-level wind and transport it to higher regions of the atmosphere. The energy is typically returned to the background flow where the waves encounter a critical layer, i.e. where the wind vector has rotated more than 90º relative to the low-level flow direction. It is common to observe mountain wave breaking at critical layers related to changes in the synoptic-scale winds. However, for the case in question the necessary rotation is only achieved where the wind vector is modulated by inertia-gravity wave activity in the lower-stratosphere.

Investigations into tropopause erosion by mountain wave breaking, mentioned in last year's report, are on-going. Tropopause erosion is significant because it can give rise to mixing between the otherwise distinct upper-tropospheric and lower-stratospheric air masses. A second mechanism by which tropospheric and stratospheric air masses can be mixed is through convectively generated turbulence; this has the subject of a study making use of data from the Dynamics and Chemistry of Frontal Zones campaign, which was already mentioned briefly in last year's report. In this case the lower stratospheric air was transported down into the middle troposphere along a tropopause fold. Simultaneously, a tongue of moist air moved under the dry stratospheric air resulting in a potential instability and hence convective activity. This observation is significant because turbulence within a tropopause fold is more often a result of shear instability. Moreover, the tropospheric air being transported into the tropopause fold was of boundary layer origin and so the mixing involves two air masses which are normally separated by 10 km in the vertical direction.

Two more investigations are concerned with convective activity, although they focus on the signature observed by the radar. The radar return signal strength has a dependence on the vertical humidity structure and is often dominated by this contribution in the lower-troposphere. Convective activity can transport humid air from the moist lower atmosphere to the drier regions of the higher troposphere leading to an increase in the radar return signal strength associated with these altitudes. Coincident increases in the radar return spectral widths confirm the fact that these regions are turbulently active. Moreover, under such conditions the assumption of a locally homogeneous wind field, which is necessary for the derivation of the three dimensional wind vector from radar observations made in a variety of beam directions, appears to be violated. This has implications for data reliability flagging. The second investigation concerns a statistical study of the temporal variations in tropospheric radar return signal strength. It is already known that precipitation can lead to a reduction in signal strength, i.e. to the opposite effect of (non-precipitating) convection. An analysis of the perturbations of signal strength, at various tropospheric altitudes, and a comparison with rainfall rates measured at the same site, appears to give a good indication of whether convection or precipitation has a dominating influence.

The raw (sub-spectral) radar data collected as part of the Egrett campaign, during summer 2000, continue to be of value. One investigation is using a novel approach to identifying regions of turbulence based on the distribution of signal amplitudes. A second investigation is experimenting with novel techniques for signal processing. Instead of using the traditional Fourier transform method of analysis it employs wavelet transforms, multi-tapering and harmonic decomposition. The technique is thought to out-perform the traditional method under conditions of low signal-to-noise ratio and hence should lead to an increase in the altitude coverage for wind-profiling purposes.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

A major undertaking for the forthcoming financial year will be the reprocessing of the entire archive of MST radar observations. Initially the old and new signal processing routines will be applied in parallel to the in-coming data. Data users will also be invited to request individual days, or groups of days, from the archives, for reprocessing. It is hoped that user feedback will help in identifying any weaknesses in the sample files. Thereafter all data, including those from the other instruments associated with the Facility, will be made available in the new file formats.

An application has been received to operate the MST radar in an experimental mode in connection with the investigation of a novel technique for identifying turbulence. The usefulness of the traditional technique decreases with increasing wind speed. Observations have therefore been requested to coincide with mountain wave breaking at a critical layer; this results in turbulent activity in a region of low wind speed. The novel technique is based on an analysis of the sub-spectral data which must be specially recorded. Other notable studies for the forthcoming year include those investigating humidity, precipitation and inertia-gravity waves.

During the last year, the number of applications for access to MST radar data for teaching and educational purposes has increased. Although these represent non-core uses of data, further promotion can be achieved with relatively little effort. It is felt that exposure of students to the data at undergraduate level might encourage them to continue their studies at postgraduate level.

The MST Radar Facility and its performance are due for review towards the end of the next financial year since this year is the fourth of the 5-year SLA contract funded by NERC; significant effort will therefore be applied to the production of the required documentation for submission to the NERC Services Review Group by the end of the calendar year.