SERVICES & FACILITIES ANNUAL REPORT - FY April 2014 to March 2015

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
EISCAT-UK	Block	SLA	2010	2014-2019

TYPE OF SERVICE PROVIDED:

EISCAT is an international research organisation operating three radars (UHF, VHF and EISCAT Svalbard Radar), an ionospheric heater and two Dynasondes. The radars use incoherent scatter, the most powerful ground-based technique for this type of research. EISCAT measures profiles of electron density, electron and ion temperature and ion velocity. EISCAT can also be used to study plasma instabilities, for investigations of the middle atmosphere and as diagnostic instrument for heating experiments. A wide selection of radar pulse schemes is available, to adapt the experiments to the appropriate measurement regime, between about 50km and more than 1000 km altitude. A best time resolution of less than one second and altitude resolutions of a few hundred metres can be achieved. Operations of around 3000 hours each year are distributed between Common (CP) Programmes and Special Programmes (SP). Six Common Programmes run regularly, to provide a database for long-term studies. A large number of Special Programmes, defined by scientific users, are run to support national and international studies of both specific and global geophysical phenomena.

Aerial view of the EISCAT Kiruna site, with the E3D test array (bottom left)

The UK EISCAT Support Group provides advice and technical support with experiment design and implementation, software to access, analyse and display the radar data, a multi-user computing service and documentation describing the available software. The group liaises with EISCAT HQ, providing the national data and scheduling representatives (who handle the booking and accounting of UK Special Programme time, and monitor the UK time allocation). The UK Support Group also ensures that new users are trained to use the radars, by instruction at RAL, or participation in multi-national courses, produces observing schedules and provides direct staff support for campaigns, as required by the user community. The group operates, and ensures the integrity of, the data archive at RAL, ensuring that data are available in the form that users require, and maintains records of UK EISCAT publications, campaigns and meetings. We are also currently actively involved in the planning of the proposed new EISCAT facility, EISCAT_3D, which will replace the dishes of the mainland systems with multistatic phased array antennas.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

The targets for the support group are to ensure that the UK EISCAT observing time is fully utilised; to support the peer-review system which allocates time to UK researchers; to maintain an archive of all the EISCAT data accessible to UK researchers and to provide computing support, help and advice for UK EISCAT users in making and analysing their measurements. We also provide training and campaign support for UK users as required. The EISCAT data archive at RAL continues to be a full copy of the EISCAT archive at Kiruna, against which it is regularly synchronised.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review:		March 2011
Need	Uniqueness	Quality of Service	Quality of Science & Training	Average
5.0	5.0	4.5	5.0	4.875

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
13% (of total EISCAT SP) 100% (of UK allocation)	I.W. McCrea (Manager/Scientist, Band F) 50% S.R. Crothers (Data and Software, Band E) 20% A.J. Kavanagh (Science and Campaign Support, BAS) 45%	?	2019

FINANCIAL DETAILS: CURRENT FY (Figures for Calemdar Year 2014)

Total Resource Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full Cash Cost £k
	Unit 1	Unit 2	Unit 3			
	40 Special Programme hours with enhanced support @£3.7k	120 hours of Special Programme with basic support @ £1.9k	1342 Common Progamme hours (no cost)			
160 Support Group 214 Subscription						160 Sup. 214 Sub.

FINANCIAL COMMITMENT (by year until end of current agreement) £k

2014-15 160k	2015-16 157k	2016-17 157k	2017-2018 157k	2018-2019 157k

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NCAS RAG	5	1	CFARR, MSTRF

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2014/15)													
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**R***	**Pilot**
NERC Grant projects*			1										1
Other academic				1	2								
Students													
TOTAL			1	1	2								1

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years — 2011/12, 2012/13, 2013/14)													
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**R***	**Pilot**
NERC Grant projects*			1.33	0.66									
Other academic		0.66	2.66	1.33									0.33
Students													
TOTAL		2	12	6									1

PROJECTS COMPLETED (current FY – 2014/15)												
	10 (α5)	**9**	**8 (α4)**	**7**	**6 (α3)**	**5 (α2)**	**4**	**3 (α1)**	**2**	**1 (β)**	**0 (Reject)**	**Pilot**
NERC Grant projects*			2									1
Other Academic			3	3	2							
Students												

Project Funding Type (current FY – 2014/15) (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**		
12	3				9					

Project Funding Type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)											
Grand Total	**Infrastructure**					**PAYG**					
	Supplement to NERC Grant *	**PhD Students**		**NERC Centre**	**Other**	**NERC Grant***	**PhD Student**		**NERC Centre**	**Other**
		NERC	**Other**				**NERC**	**Other**		
9.67	2.00				7.67					

User type (current FY – 2014/15) (include each person named on application form)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
9			**3**	

User type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
18	**0.66**		**1.66**	

OUTPUT & PERFORMANCE MEASURES (current year)										
Publications (by science area & type) (calendar year 2014)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
			13				**13**	**10**	**1**	**2**

Distribution of Projects (by science areas) (FY 2014/15)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
12				**12**			

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)										
Publications (by science area & type) (Calendar years 2011, 2012 & 2013)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
			12.7				**12.66**	11.66	0.33	0.66

Distribution of Projects (by science areas) (FY 2011/2012, 2012/2013 & 2013/2014)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
9.67				**9.67**			

Distribution of Projects by NERC strategic priority (current FY 2014/15)							
Grand Total	**Climate System**	**Biodiversity**	**Earth System Science**	**Sustainable Use of Natural Resources**	**Natural Hazards**	**Environment, Pollution & Health**	**Technologies**
12	**1**		**9.2**		**1.8**		

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2014/15):

Facility Status:

Aside from some short maintenance periods, the EISCAT radar facilities remained in good technical condition during FY14/15. Some HV cabling problems affecting the Tromsø UHF radar were repaired, the glycol cooling pump was replaced and the heat exchanger wall was removed. Modifications to the UHF phase coding system allowed a first successful test of new quadrature phase coded experiments, developed in the Finnish user community. Thunderstorm damage caused some problems to the noise injection system of the Tromsø VHF radar, which were also repaired successfully. Negotiations with the new owners of the UHF bandwidth used by EISCAT in the Tromsø area established that they have no immediate plans to use any frequencies that would cause interference to EISCAT's ion line channels. The Tromsø heating array was partly damaged by lightning in summer 2014, but was successfully repaired. Two antennas burned out in Array 1 (cause unknown) and were replaced. The lack of viable transmitter tubes for the heater is becoming a concern and steps were taken to find a firm which could refurbish the existing tubes. A problem came to light when it emerged that EISCAT's shift-working arrangements were incompatible with Norwegian labour law. A solution is being negotiated with the local employer (University of Tromsø) and the relevant unions.

Modified cooling system of the EISCAT Tromsø UHF Radar

In Svalbard, the ten new klystrons acquired last year were delivered and tested successfully. Some problems have developed with the airport interlock system, needed to ensure that the radar is not operating when aeroplanes potentially approach the beam. These are being resolved in conjunction with the airport authorities. The site supervisor (Halvard Boholm) retired in 2014 and a member of Kiruna staff has moved temporarily to Svalbard to take over that position.

Publications, Campaigns and Time Applications

During calendar year 2014, the UK EISCAT community published or co-authored 10 papers in peer-reviewed journals. Two UK research students also successfully completed EISCAT-related PhDs. UK usage of EISCAT in 2014 was 115 hours on the mainland radars and 46 hours on the ESR, compared to targets of 133 hours and 49 hours respectively. The ESR usage was therefore roughly on target, though the mainland time was slightly under-used, due to difficulties in scheduling a large number of requests for operations at the end of the year. Up to the end of March 2015, the UK had already used 79 hours of mainland EISCAT time and 24 hours of ESR time, compared with allocations of 133 and 49 hours respectively. Summer 2015 will be a period of relatively low experimental activity, though more campaigns are being planned for the coming autumn and winter.

Five UK EISCAT time applications were received between April 2014 and March 2015, collectively requesting 96 hours of mainland time and 44 hours of ESR time. The time allocation panel awarded 56 hours of mainland time and 36 hours of ESR time. In the same interval, six "active" UK EISCAT campaigns took place (using the transmitting as well as the receiving capabilities of EISCAT), in addition to one interval of interplanetary scintillation experiments involving passive use of the facilities in a radio astronomy mode. Experimental activity was therefore at the same level as last year.

EISCAT_3D

Progress has continued in raising capital funding for the proposed new EISCAT_3D system. The Swedish proposal for capital funding of Phase 1 (three sites and a 5 MW transmitter) was reviewed very positively and Sweden announced a funding pledge of 120M SEK (about €12M), conditional on matching funding coming from the other associates. As of March 2014, review processes were ongoing into the Norwegian and Finnish applications (together expected to amount to around €39M) with decisions expected in the summer. Unfortunately the Japanese community did not secure the expected funding in their 2014 budget and, as a result, the possibilities for Japanese funding have been delayed by at least a year. In the UK we have been working to ensure that the issue of EISCAT_3D capital funding remains visible within NERC, with the expectation that a UK contribution will be included in a capital bid to BIS later in the year. The FP7 funded EISCAT_3D Preparatory Phase was concluded successfully, with the UK element achieving a full cost recovery. An application for follow-on funding under the Horizon 2020 scheme, entitled "EISCAT_3D: Preparation for Production" was prepared and submitted. The EISCAT_3D Science Case was written up and submitted for journal publication by Dr. McCrea (working with a large international team) at the request of the Japanese community

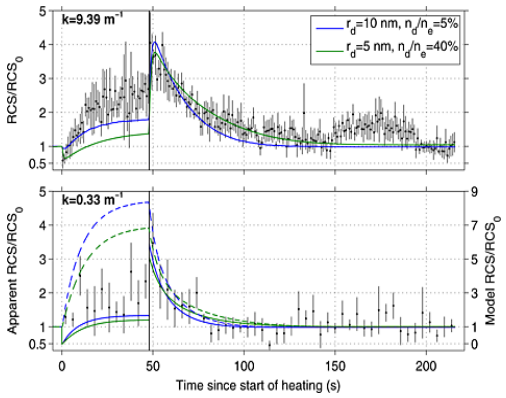
Committees. meetings etc

Dr. McCrea (NCAS) and Dr. Mervyn Freeman (BAS) continue to act as the two UK members of EISCAT Council, with Dr. Freeman being the voting member. Dr. McCrea finished his term as Council vice-chair at the end of 2014 and took over as chair of EISCAT Council, a post in which he will serve until December 2016. Dr. Kavanagh continues to serve as the UK member of the EISCAT Science Advisory Committee.

SCIENCE HIGHLIGHTS:

Mesospheric Physics

Senior et al (2014) published the first ever observations of the modulation of Polar Mesospheric Summer Echoes at HF frequencies (8 MHz), with the EISCAT Tromso Heater being used both for the modification and as a receiving array. They showed that the echo intensity was enhanced at times during heating and that the properties of the modulation were qualitatively consistent with earlier theoretical predictions, assuming certain ranges of ice particle radius and concentration.



Comparison of heater-induced PMSE intensity changes at VHF (top) and HF (bottom) frequencies from Senior et al (2014). Heating is applied during the interval from 0 to 48 seconds. The blue and green lines represent model fits to a dust radius of 10nm and a dust-to-charge ratio of 5% (blue) and dust radius 5nm and dust-to-charge ratio of 40% (green)

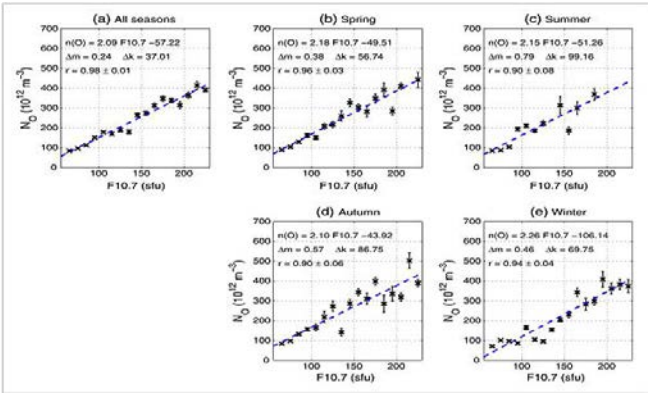
Auroral Physics

Tuttle et al (2014) presented a novel method for estimating the spatial and temporal evolution of aurora at very small scales, applying it to an event in which substantial small-scale structure was observed. Their technique produced modelled images which could be compared with actual observations, showing that they could reproduce the brightness and structure of the aurora to within the uncertainties of the technique. EISCAT data were used to estimate the energy flux, but this estimate may have been underestimated by as much as 30%, which might account for the underestimate in the brightness of the aurora.

Long-term atmospheric change

Vickers et al (2014) used a 13-year dataset from the EISCAT Svalbard Radar to infer the long-term variation in neutral oxygen density at 350km altitude, by solving a simplified version of the ion momentum equation. They found that the atomic oxygen density apparently decreased by a factor of between 5 and 6 from the solar maximum of 2002 to the solar minimum of 2008, and declined by a few percent over the whole period from 2000 to 2012, though the latter decrease was within the bounds of experimental error. The results for the variation related to solar activity were qualitatively consistent with trends inferred from satellite data at similar altitudes.

Variation of neutral oxygen density as a function of solar flux (F10.7) for all data (left) and sorted by season (right) from Vickers et al (2014)



Four high-impact publications (ranked by journal impact):

Senior, A., A. Mahmoudian, H. Pinedo, C. La Hoz, M. T. Rietveld, W. A. Scales, and M. J. Kosch, First modulation of high-frequency polar mesospheric summer echoes by radio heating of the ionosphere, Geophys. Res. Lett., 41, 15, 5347-5353, DOI: 10.1002/2014GL060703, 2014.

Kosch, M.J., H.Vickers, Y.Ogawa, A.Senior, N. Blagoveshchenskaya, First observation of the anomalous electric field in the topside ionosphere by ionospheric modification over EISCAT, Geophys. Res. Lett., 41, 21, 7427-7435, DOI: 10.1002/2014GL061679, 2014.

Vickers, H., M. J. Kosch, E. Sutton, L. Bjoland, Y. Ogawa and C. LaHoz, A solar cycle of upper thermosphere density observations from the EISCAT Svalbard Radar, J. Geophys. Res., 119, 8, 6833–6845, DOI: 10.1002/2014JA019885, 2014.

Tuttle, S., B. Gustavsson, and B. Lanchester, Temporal and spatial evolution of auroral electron energy spectra in a region surrounding the magnetic zenith, J. Geophys. Res., doi:10.1002/2013JA019627, 2014.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

The viability of the EISCAT_3D project is the most important issue for determining the long-term future of EISCAT. Major decisions are expected in the coming year on capital funding from Norway and Finland and perhaps from Japan. We will also continue to pursue the possibility of a UK capital contribution, ideally by means of a NERC capital bid to BIS. In addition, the EU decision on funding the EISCAT_3D Horizon2020 proposal will be important to continuing the momentum of the project and engaging with prospective construction partners.

Non-Mandatory Facility-specific OPMs: utilisation, allocation of capacity etc

Given the level of activity in the first three months of 2015 and the planned campaigns for the remainder of the year, we anticipate that we will have no problem in filling our allocation of observing hours.