

SERVICES & FACILITIES ANNUAL REPORT - FY April 2010 to March 2011

SERVICE BIGF	FUNDING BLOCK	AGREEMENT R8/H10/59	ESTABLISHED as S&F 2002 (operating since 1998)	TERM 5 years
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TYPE OF SERVICE PROVIDED:

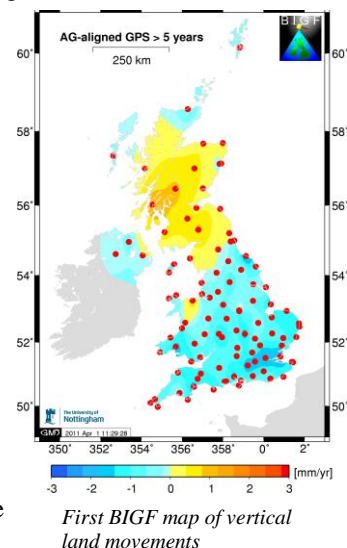
BIGF provides a unique and secure repository for quality assured data (raw data and derived products), from a network of continuous GNSS (CGNSS) stations throughout the British Isles, and the interface with the scientific community, in serving demand for these data to carry out research. Raw data are supplied free-of-charge to the archive by 9 collaborators, giving BIGF unequalled access to £3.5 m of infield data collection hardware. Users can request quality assured data using an online form at the Facility website. The product line is undergoing advanced testing, with first availability in mid-2011. The fundamental value of BIGF is in the secure archive of 30 second and 1Hz GNSS RINEX data, currently supplied from about 155 CGNSS stations. The archive comprises 1,150 station-years of 30 second, primarily GPS data, with some stations operating since 1996/7; and since 2009, 30 second GPS+GLONASS and 1Hz GPS+GLONASS data from about 100 CGNSS stations.

The service provided can be summarised in a 4-part Facility remit:

1. To reduce the costs of specific research and wider research costs, so enabling a larger volume of research to be done with the same funding budget, by providing an assured repository of raw data and derived products when users bid for funding for new research, in which the costs of setting up and manning an ad-hoc observation network are reduced or eliminated.
2. To facilitate the least time delay in the examination of environmental and other minable variables, by providing extensive backward tracts of raw data and derived products, improving the rate of return on invested funds and the rate of project completion.
3. To provide a failsafe resource to protect researchers from the costs and delays of having to repeat failed data collection exercises, and its impact on research and to improve the positioning quality obtained in historic or current research.
4. To stimulate research across the spectrum of science using various media.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

1. To increase the quantity of data in the archive: Daily data files from up to 155 CGNSS stations continued to be uploaded, at a nominal annual rate of 58k station-days. Negotiations with OS Ireland (OSi) for access to 16 stations, whose data have been archived daily since March 2007, have advanced and an agreement in principle has been reached, with a MoU imminent.
2. To improve metadata: To support user decision making when requesting data we provide a map, station log files and data listing by year and station. The veracity of all updated log files is monitored, assuring an accurate record of any change at each station. Over the last year we have also developed further metadata including cycle slips and multipath.
3. To increase archive uptake: Demand in 2010/11 was 268k station-days, cumulatively 2.75m station-days since archival commenced. Unique projects enabled increased from 8 in 2002/3 to 98 by 2010/11, with an average of about 70 scientific type projects a year, indicating an increasing awareness of the Facility, influenced by our varied activities to promote the archive's existence and to demonstrate its utility by example.
4. To meet the 'future developments/strategic forward look' from the 2009/10 annual report:
 - a. The new hardware installation was completed, with data storage now in two separate locations, and access via a dedicated server.
 - b. Extended MoUs (to 2014, 1Hz data) await signature by OSGB before distribution to other collaborators, including OSi.
 - c. Procedures to handle requests for 1Hz data are in place at the new website.
 - d. The first 'releasable' derived products (long term trends in station coordinates and troposphere, and near real-time tropospheric parameters) have been developed, and examples are available at the new website, along with procedures to handle requests.
 - e. The majority (105) of the 109 OSGB stations are now capable of tracking of Galileo, when satellites and signals become available.

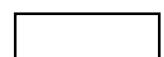


SCORES AT LAST REVIEW (each out of 5)				Date of Last Review:	2008
Need	Uniqueness	Quality of Service	Quality of Science & Training	Average	
4.5	5.0	4.0	4.5	4.5	

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
100%	Professor A Dodson, Director, 3% NERC; Dr R Bingley, Deputy Director, 22% NERC; Dr D Baker, Manager, 60% NERC; Ms D Hansen, Developer, 60% NERC	2013	2014

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			
115.64	0.000487			0	0	130.42
FINANCIAL COMMITMENT (by year until end of current agreement) £k						
2011-12	117.20	2012-13	117.80	2013-14	118.36	2014-2015
						2015-2016

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NSGSC	6	1	NSGF



APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2010/11)

	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	β	R*/Pilot	Reject
NERC Grant projects*		1						
Other academic		26						
Students		4						
Pilot								
TOTAL		31						

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2007/2008, 2008/2009 & 2009/2010)

	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	β	R*/Pilot	Reject
NERC Grant projects*		1.00						
Other Academic		9.33						
Students		4.67	0.33					
Pilot								
TOTAL		15.00	0.33					

PROJECTS COMPLETED (current FY – 2010/11)

	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	β	R*/Pilot
NERC Grant projects*							
Other Academic		4 [+1 PR]					
Students		8	1				
Pilot							

Project Funding Type (current FY – 2010/11) (select one category for each project)

Grand Total	Infrastructure				PAYG					
	Supplement to NERC Grant *	PhD Students NERC	Other	NERC C/S	Other	NERC Grant*	PhD Students NERC	Other	NERC C/S	Other
98	1	2	3	4	88					

Project Funding Type (per annum average previous 3 financial years - 2007/2008, 2008/2009 & 2009/2010)

Grand Total	Infrastructure				PAYG					
	Supplement to NERC Grant *	PhD Students NERC	Other	NERC C/S	Other	NERC Grant*	PhD Student NERC	Other	NERC C/S	Other
100	1.33	0.33	6.33	2.67	89.33					

User type (current FY – 2010/11) (include each person named on application form)

Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Other
31	4	0	5	Non-PhD students 9 Central and local Govt 13 Collaborators 11 OS user 25

User type (per annum average previous 3 financial years - 2007/2008, 2008/2009 & 2009/2010)

Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Other
27.33	2.67	0.00	6.67	Non-PhD students 4.67 Central / local Gov 20.33 Collaborators 17.33 OS user 21.00

OUTPUT & PERFORMANCE MEASURES (current year)

Publications (by science area & type) (calendar year 2010)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
0	11	1	8	8	1	0	29	6	13	10

Distribution of Projects (by science areas) (FY 2010/11)

Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
98	3.50	13.83	13.50	14.00	50.83	2.33	0.00

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

Publications (by science area & type) (Calendar years 2007, 2008 & 2009)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
0.17	12.67	1.33	2.83	7.33	1.50	0.17	26.00	6.33	13.33	6.33

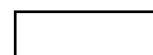
Distribution of Projects (by science areas) (FY 2007/2008, 2008/2009 & 2009/2010)

Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
100	1.33	12.58	16.86	10.68	54.68	3.70	0.17

Distribution of Projects by NERC strategic priority (current FY 2010/11)

Grand Total	Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies	Not classified
98	5.33	3.50	15.17	1.83	16.00	3.67	10.50	42.00

*Combined Responsive Mode and Directed Programme grants



OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2010/11):

Data archival: Daily data archival continued from about 155 CGNSS stations, with a current volume of about 1,150 station-years of 30 second, primarily GPS data, with some stations operating since 1996/7; and since August 2009, 30 second GPS+GLONASS and 1Hz GPS+GLONASS data from about 100 CGNSS stations.

Network development: Minor changes have taken place at many sites, but the Facility station log file monitoring system continues to enable 'clean' metadata to be stored; this is crucial to users interested in the extraction of long-term environmental signatures.

Product development : The development of derived products is well advanced, focussing initially on long term trends (LTT) in station coordinates and velocities, and LTT and near real-time (NRT) trends in tropospheric parameters. The first 'releasable' LTT products are based on time series computed from 1997-2010 data with an in-house modified version of Bernese Software version 5.0, using a global network, ITRF2008, 1st order ionosphere and GPT/GMF for troposphere. These have been QA'd through comparison with parallel in-house processing using GIPSY/OASIS II.

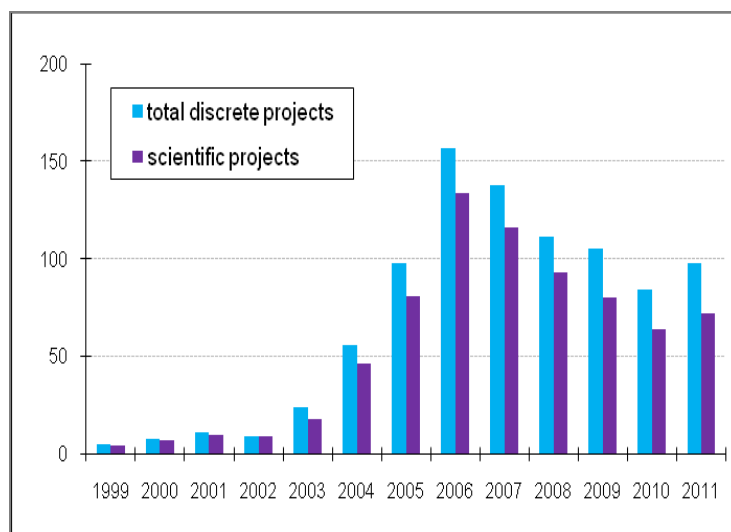
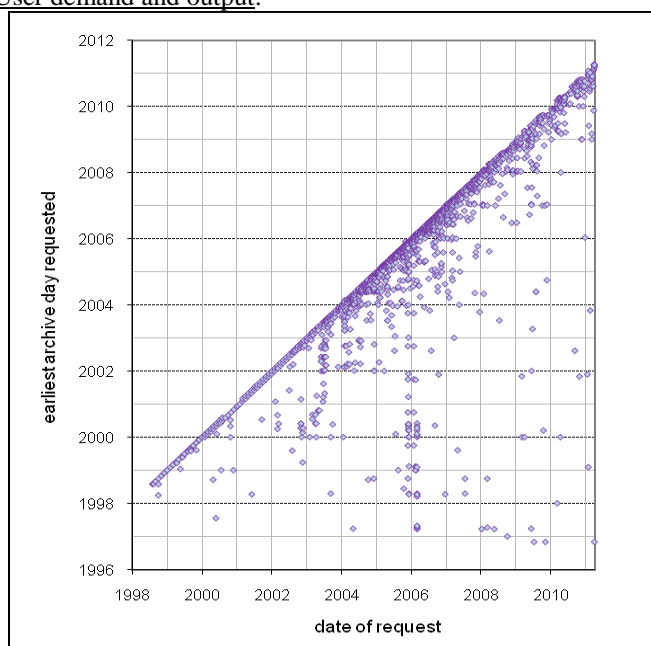
Website development: The website, which will go live in mid-2011, has been completely restructured and rewritten, both to improve the user interface and to include information on and access methods to high rate GPS+GLONASS data and derivative products.

Archive access: Access to the archive is via online request forms. The request and delivery process is intentionally maintained as a personalised transaction, with capacity for verbal and e-mail dialogue on aspects of supply, data processing and field operations, and to enable the easy gathering of user information to support NERC's reporting needs. During 2010/11 a number of major research projects led by national and international scientists, were automatically served daily data. These included: Densification of the European permanent GNSS network (EPN) for ionospheric studies [139 stations]; the European GNSS water vapour programme (E-GVAP) [up to 16 stations]; the European permanent GNSS network (EPN) [1 station]; the European Sea Level Service (ESEAS) [4 stations]; the International GNSS Service (IGS) tide gauge project (TIGA) [6 stations]; Ionospheric research using total electron content over Europe [139 stations]; Impacts of climate change on navigation and waterways [10 stations]; Near real-time atmospheric water vapour for numeric weather prediction in the UK [133 stations]; Towards a global ambiguity resolved precise point solution and time series [52 stations]. Additionally, a major NERC-funded research project at Newcastle University was supplied with 50,000 station-days of historic data for *global loading and deformation at tidal time scale*.

Advice to Government: The Facility has provided advice to the Environment Agency on the establishment of a new CGNSS station at the Thames Barrier, and to OSGB on the development of revised active station coordinates, and of the associated height corrector-surface employed by many BIGF users.

Archive accounting: This is underpinned by a database designed to fulfil NERC's reporting needs in respect of user, project and data request information, NSGSC peer review, publications, and so on.

User demand and output:



Project support (Financial year ending)

The left hand figure clearly demonstrates a continuous need for the archive through the significant number of users requiring data of several years vintage, and in a number of cases to its full temporal extent. The right hand figure shows project usage since the archive was created in 1999. Since becoming a Facility in 2002, there have been on average about 70 scientific type projects a year, and this level has been maintained for the last 3 years.

SCIENCE HIGHLIGHTS:

There were 72 scientific user-projects supported in 2010/11, and an output of 10 PhD theses, 12 refereed and 5 non-refereed publications, of which the 3 most significant (with their ISI 2009 JCR impact factors shown in []) were:

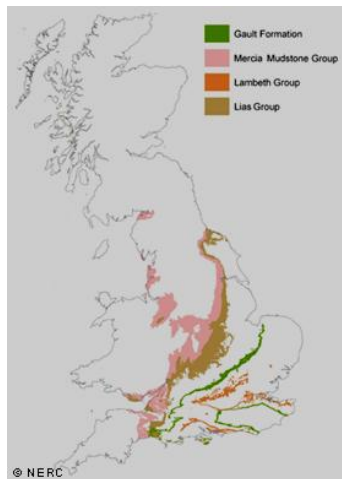
- Bouin, M-N., Wöppelmann, G. Land motion estimates from GPS at tide gauges: a geophysical evaluation? *Geophysical Journal International*, 180, 193-209, doi:10.1111/j.1365-246X.2009.04411.x., 2010. [2.435].
- Collilieux, X., Wöppelmann, G. Global sea level rise and its relation to the terrestrial reference frame definition. *Journal of Geodesy*, doi:10.1007/s00190-010-0412-4., 2010. [2.429].
- Quinn, J.D., Rosser, N.J., Murphy, W., Lawrence, J.A. Identifying the behavioural characteristics of clay cliffs using intensive monitoring and geotechnical numerical monitoring. *Geomorphology*, 2010, doi 10.1016/j.geomorph.2010.03.004, 2010. [2.119].

The remainder of this section provides brief summaries of 5 significant research projects supported by BIGF in 2010/11:



Physical properties and behaviour of UK rocks and soils (NERC BGS)

BGS, as part of the UK Geo-engineering Properties and Processes Team, is characterising geological formations in terms

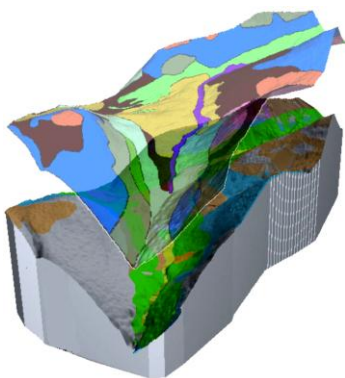


of their lithological and engineering properties. These can provide information on potential engineering behaviour, such as problem ground conditions and geological hazards; and may be used to assist ground engineers and planners in undertaking feasibility studies, site investigation design for engineering projects, and land-use planning for regional development. All geotechnical data from these studies are stored in the National

Geotechnical Properties Database. BIGF data were used to improve the accuracy of bedrock outcrop orientation, to be used in turn to assess bedrock discontinuities and mass properties.

Talla Earth Observatory (NERC BGS)

This project is investigating the relationship between soils and underlying geology in a typical area of British upland, to better understand processes involved in climate change and flooding.



A highly detailed physical model of the soil-geoscape has been produced of this small part of the Southern Uplands of Scotland. It is the second such UK site to be investigated, following a study of a riverine terrain developed on sedimentary rocks at Shelford in the Trent Valley. Talla represents a typical glaciated upland soil-geoscape developed on resistant meta-

sedimentary rocks. BIGF data facilitated landscape evolution monitoring via geo-referencing of terrestrial laser scanning.

THESEUS [www.theseusproject.eu]

(University of Wales, Bangor, funded by EU FP-7)

This project concerns coastal flooding risk and options for mitigation in Europe and research on the process of coastal erosion and the role of natural ecosystems and engineering in coastal protection. Ultimately, the aim is to inform on a systematic approach to deliver a low-risk environment for coastal people and nature. As part of the project, wave energy, sediment, erosion, ripple formation and vegetation parameters are being sampled in 7 marshlands with a maximal range of wave exposure, across Wales and NW England. Samples are taken at regular points along vertical transects, between spring



tide low and high water levels, each point being fitted with a wave sensor, sediment erosion station and transplant of salt marsh vegetation. In this way the relationship between marsh establishment and wave energy along the intertidal profile can be examined.

BIGF data were used

to improve the positioning accuracy of the samples.

Predicting salmonid population ecology from individual fish responses to environmental change

(Bournemouth University, Conservation Ecology)

This research aims to develop and test a salmonid-specific individual-based model in predicting population ecology response to the two common management regimes of in-stream weed removal and predator control. In the individual-based model, fish



will show fitness-maximising adaptive behaviour derived from a function of food intake and bio-energetic cost. Both factors are dependent

on river hydrology, for which model inputs of water height and flow measurement location were improved using BIGF data, by way of coordinating a local reference station for a real-time kinematic bed survey.

Woodland bird habitat modelling with integrated remotely sensed data

(Bournemouth University, Ecology)

This research aims to quantify the effects of habitat structure and composition on bird reproductive success in deciduous woodland,



and how this is influenced by patch and landscape metrics, and larger-scale climate effects. Studies utilising remotely sensed data in woodland depend on establishing accurate spatial relationships

between habitat variables and the ecological parameters of interest, for example tree, nest site or census plot locations. This cannot be achieved with direct use of GPS because of signal blockage by tree canopy, even in winter. So a multi-technology approach is used: by establishing a series of real-time kinematic benchmarks at woodland margins, using BIGF data, from which total-station surveys of nest-box locations are made. This approach has been successfully used to locate a large number of nest-boxes with sub metre error.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

1. To finalise extended MoUs (to 2014, 1Hz data) with existing collaborators and OSi by 30/09/2011.
2. To complete and launch the new website with procedures to handle requests for 1Hz data and derived products by 30/09/2011.
3. To put in place procedures to self-create RINEX data directly from the OSGB real-time data streams, by 31/12/11.
4. To develop the second 'releasable' derived products, focussing on long term trends (LTT) in station coordinates and velocities, and LTT and near real-time trends in tropospheric parameters, by 31/12/2011.
5. For the long term future, to expand data collection to include Galileo in addition to GPS and GLONASS.

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

1. Mission Statement

To provide a unique and secure repository for quality assured raw data, and derived products, from a network of continuous GNSS (CGNSS) stations sited throughout the British Isles, and provide the interface between the archive and archive users, benefiting the spectrum of UK science, thereby enabling scientific research into the past, the present and the future.

2. Steering Committee membership and Terms of Reference

Steering Committee Members:

Dr Matt King (Chair)
School of Civil Engineering and Geosciences
Newcastle University
Newcastle-upon-Tyne NE1 7RU

Dr Zhenhong Li
School of Geographical and Earth Sciences
University of Glasgow
Glasgow G12 8QQ

Dr Steve Groom
Plymouth Marine Laboratory
Prospect Place
Plymouth PL1 3DH

Dr Helen Snaith
National Oceanography Centre, Southampton
Empress Dock
Southampton SO14 3ZH

Dr Mark Tamisiea
National Oceanography Centre, Liverpool
Joseph Proudman Building, 6 Brownlow Street
Liverpool L3 5DA

Dr Zuheir Altamimi
Institut Geographique National, ENSG/LAREG
6-8 Avenue Blaise Pascal
77455 Champs-sur-Marne, France

Mr Matthew Wilkinson (Secretary)
NERC Space Geodesy Facility
Herstmonceux Castle, Hailsham
East Sussex BN27 1RN

Terms of Reference:

To promote awareness in the UK scientific community of activities in space geodesy by:

- reviewing multi-technique space geodesy initiatives;
- organising, in collaboration with relevant learned societies, technical meetings and appropriate review papers.

To review work proposals of NSGF and of BIGF and establish priorities, for the Heads of the two Facilities, for the allocation of resources funded from the NERC Science & Innovation Funding Directorate science budget.

To monitor the level of user satisfaction with and the quality of output from the NSGF and BIGF services and to analyse the user bases.

To give guidance to the Heads of both NSGF and BIGF on improvements of the Facilities' equipment and service functions.

To advise Director, Science Delivery on:

- broad aspects of UK involvement in Space Geodesy.
- the level and direction of the internal R&D programmes for both NSGF and BIGF.
- anticipated changes in requirements from each of the two Facilities and the anticipated levels of future demand for each of them.
- technical developments in the precise tracking of satellites and on procurement in this area.
- technical developments in the use of networks of continuous receivers for scientific applications of GNSS satellites and on procurement in this area.

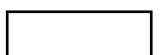
To receive annually, and comment upon, reports from both the Head of NSGF and from the Head of BIGF before they are submitted to Director, Science Delivery, and to provide advice at other times to each Facility as appropriate.

3. Equipment Inventory

a. In-kind contributions from BIGF collaborators – data from up to 155 CGNSS stations, each consisting of: dual-frequency GPS (or GPS+GLONASS, or GPS+GLONASS and Galileo ready) receiver, choke ring antenna, local data storage and communications hardware, with data transfer to BIGF enabled free of charge.

b. Resources at the University of Nottingham:

- 2 Linux Network Attached Servers of 30Tb each, serving as primary and secondary archives for 30-second and 1Hz RINEX



data and derived product storage (housed in the Nottingham Geospatial Building (NGB), on Jubilee Campus).

- 2 Linux Network Attached Servers of 30Tb each, serving as third and fourth archives for 30-second and 1Hz RINEX data and derived product storage (housed in the Data Centre, on King's Meadow Campus).
- 1 Linux workstation with 80Gb of longer-term data storage, serving as an ftp holding area for users given access to 30-second RINEX data.
- 1 Linux workstation acting as web server to the new website.
- 4 Linux servers, for product development.
- DVD writer – provides further backup (comprising 3 copies) of 30-second RINEX data on DVD, with one copy being held at NEODC, and 2 copies held offsite in Nottingham.

4. Future Developments

The success of the Facility in 2010/11 was based on the following operational tasks:

- a) Maintain the existing archive of data from the BIGF network.
- b) Maintain the on-going memorandums of understanding with collaborators to provide new data to the archive, free of charge.
- c) Develop and maintain mechanisms for the collection of new data for the archive.
- d) Develop and maintain mechanisms to provide data to international networks on European and global scales.
- e) Carry out associated R&D to improve the Facility.
- f) Develop and maintain the website.
- g) Develop and maintain mechanisms to service user requests.
- h) Stimulate increased user demand.

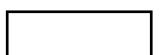
During 2011/12 proposed Facility development will be focussed on enhancements to the Facility related to the above operational tasks as follows:

- a) We will maintain the four 30Tb Linux Network Attached Servers, so that each machine holds a complete copy of the archive: two machines will remain on the Jubilee Campus, and two offsite at the separate King's Meadow Campus.
- b) The current MoUs ended in March 2009. All collaborators have indicated their willingness to continue this arrangement, and we plan to have new MoUs in place, also covering 1Hz data and including OSi, for the period to March 2014. These will be signed in 2011/12, once we have signed agreement from OSGB.
- c) We have put in place procedures to handle 1Hz data from OSGB with a 120 day delay. These data have been archived from late August 2009. This has followed the same procedure as for 30-second data, with OSGB creating the hourly RINEX files and BIGF downloading these by ftp on an hourly basis. The next phase will be for BIGF to self-create the hourly RINEX files using direct access to the RTCM data stream from the OSGB servers. This phase will be tested and monitored by OSGB IS Department to ensure that access by BIGF does not interfere with other OSGB data transmittal activities.
- d) We will continue to provide user specific access to national and international scientists requesting extensive backward and/or forward tracts of data, as part of international networks on regional or global scales. Already in 2011/12 we have provided user-specific archive access to the University of Nevada at Reno to expand from 52 to 141 stations, as part of their global network of 9,000 stations, for their research into global ambiguity resolved precise point solutions and time series; and 141 stations to the University of Arizona for studies of the present day 3D velocity field of Europe, based on a 1,300 station European network.
- e) Using the four Linux servers we have produced a range of initial and first 'releasable' derived products, as: daily coordinate time series for the period 1997 to 2010, based on a global network daily processing solution; near real-time hourly tropospheric integrated water vapour, from 1st May 2009, based on a regional network daily processing solution; and 1-hourly tropospheric zenith delay time series for the period 1997 to 2010, based on a global network daily processing solution. In 2011/12 we will develop the second 'releasable' derived products through the modification of Bernese software to enable further enhanced modelling of the troposphere i.e. using VMF1g mapping functions as opposed to GPT/GMF.
- f) We will publish the new website and continue its development, with especial regard to the presentation of sample derived products, and access to their various levels.
- g) We will continue to service user requests in line with the approved peer review procedure, offer advice and support when services are requested, provide capacity to handle very large user requests, and provide regulated high level access to some users.
- h) We will continue to disseminate comprehensive information to demonstrate BIGF's utility as widely as possible, at least cost to the Facility, capitalising on any free marketing opportunities, and targeting the widest range of relevant scientific workshops, fora and conferences. In particular we will raise awareness of the change in the Facility's role from one of providing quality assured raw data to one of providing this plus derived products, by informing all scientists who are current or past users, and identifying and targeting scientists who could potentially use our products in enabling their research.

5. Summary of Performance Information

Academic (31, 23 peer-reviewed)

1. Global loading and deformation at tidal timescales; Clarke, Prof, P; Newcastle University, Civil Engineering and Geosciences; Funded by NERC. [α 4, AS].
2. Archaeological excavation at Peacehaven; Cole, Mr, R; University College London, Geomatic Engineering; Funded by JKC



Management. [TFS/SBA].

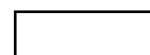
3. Atmospheric water vapour (NMA), formerly TOUGH (Targeting Optimal Use of GPS Humidity Measurements in Meteorology; Kristiansen, Dr, O; Danish Meteorological Institute; Funded by Research DG of the European Commission within the RTD activities of the Environment and Sustainable Development sub-programme (5th Framework Programme). [α 4, AS].
4. Boulby Geoscience Project; Petley, Prof, D; University of Durham, Geography; Funded by One North East. [α 4, ES/TFS].
5. Core positioning for archaeological survey; Desalle, Mr, T; UHI Millennium Institute, Orkney College. [TFS/EO/SBA].
6. Densification of European Permanent GNSS Network for ionospheric studies; Bergeot, Dr, N; Royal Observatory of Belgium. [α 4, AS].
7. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); Bruyninx, Dr, C; Royal Observatory of Belgium; COST Action 716/CSIP). [α 4, AS].
8. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); Dick, Dr, G; GFZ Potsdam (German Research Centre for Geosciences). [α 4, AS].
9. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); Dousa, Dr, J; Geodetic Observatory Pecny. [α 4, AS].
10. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); Pacione, Dr, R; Agenzia Spaziale Italiana. [α 4, AS].
11. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); de Haan (KNM1), Dr, S; Royal Meteorological Institute of the Netherlands. [α 4, AS].
12. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); de Haan (KNM2), Dr, S; Royal Meteorological Institute of the Netherlands. [α 4, AS].
13. GPS data processing demonstration; Dwarka, Mr, R; University of Mauritius. [TFS].
14. Imaging coastal archaeological sites in Uist; Roberts, Mr, K; University of Glasgow, Geographical and Earth Science [EO/SBA].
15. Impacts of climate change on navigation and waterways; Weiss, Mr, R; German Federal Institute of Hydrology. [α 4, ES/TFS].
16. International GNSS Service GPS tide gauge benchmark monitoring - pilot project; Wöppelmann, Dr, G; University of La Rochelle; Funded by IGS [α 4, ES].
17. International GNSS Service GPS tide gauge benchmark monitoring - pilot project; Schoene, Dr, T; GFZ Potsdam (German Research Centre for Geosciences); Funded by IGS. [α 4, ES].
18. Ionospheric research using total electron content over Europe; Tsugawa, Prof, T; National Institute of Information and Communications Technology. [α 4, AS].
19. Mitigation of ionospheric scintillation effects on GPS; Aquino, Dr, M; University of Nottingham, IESSG; Funded by Royal Society IJP [α 4, AS].
20. Rectifying aerial photography related to field trials for monitoring agriculture by remote sensing; Simms, Mr, D; Cranfield University, Centre for Geographical Information Management. [TFS/EO].
21. Supply of Newlyn to the EUREF Permanent Network; Bruyninx, Dr, C; Royal Observatory of Belgium; Funded by EC. [α 4, ES].
22. Supply of Newlyn to the EUREF Permanent Network; Habrich, Dr, H; Bundesamt für Kartographie und Geodäsie; funded by EC. [α 4, ES].
23. Supply of Newlyn to the EUREF Permanent Network; Villaverde, Dr, M; Instituto Geografico Nacional de Espana; Funded by EC. [α 4, ES].
24. Supply of Newlyn to the EUREF Permanent Network; Duquesnoy, Dr, T; Institut Geographique National; Funded by EC. [α 4, ES].
25. Sustainable drainage system for flooding events; Sordes, Ms, A; Scottish Agricultural College. [TFS].
26. Teaching sample data set; Lavender, Dr, S; University of Plymouth, Earth, Ocean and Environmental Sciences. [TFS].
27. The determination of vertical station velocities - implementation of the ESEAS (European Sea Level Service) CGPS processing strategy; Kristiansen, Dr, O; Norwegian Mapping Authority. Funded by EC. [α 4, ES].
28. The THESEUS project - coastal flooding risk and options for mitigation in Europe; Skov, Dr, M; University of Wales, Bangor; Ocean Sciences; Funded by EU FP-7. [α 4, ES/MS].
29. Topographical survey of A2 Activity Park Gravesend; Cole, Mr, R; University College London, Geomatic Engineering; Funded by Kent CC. [TFS].
30. Towards a global ambiguity resolved precise point solution and time series; Kreemer, Dr, C; University of Nevada, Reno; Nevada Bureau of Mines and Geology; Funded by JPL and NASA. [α 4, ES].
31. Woodland bird habitat modelling with integrated remotely sensed data; Hill, Dr, R; Bournemouth University, Conservation Ecology. [α 4, TFS].

NERC centres, surveys and facilities (4, 4 peer reviewed)

1. Coastal Observation Project, previously CEEP; Morgan, Mr, D; NERC British Geological Survey. [α 4, TFS].
2. Physical properties and behaviour of UK rocks and soils; Jones, Dr, L; NERC British Geological Survey. [α 4, ES].
3. South baseline comparison at the NERC Space Geodesy Facility, and of other baselines; Wilkinson, Mr, M; NERC Space Geodesy Facility. [α 4, ES].
4. Talla Earth Observatory; Jones, Mr, L; NERC British Geological Survey [α 4, ES/TFS/EO].

PhD (5, 4 peer-reviewed)

1. Channel-Scale Discrete Particle Modelling of River Channel Junctions; Tancock, Mr, M; University of Durham, Geography.



Funded by NERC. PhD to be completed in 2012. [α 4, TFS].

2. Cold air pooling over complex terrain; Jennett-Smith, Mr, B; University of Leeds, Earth and Environment. Funded by NERC/Met Office CASE award. PhD to be completed in 2012. [α 4, AS].
3. Ionospheric scintillation effects on GNSS: monitoring and data treatment development; Romano, Mr, V; University of Nottingham, IESSG. PhD to be completed in 2012. [α 4, AS].
4. Predicting salmonid population ecology from individual fish responses to environmental change; bridging behaviour, conservation and fishery management; Sui Chian Phang, Mr; Bournemouth University, Conservation & Ecology. PhD to be completed in 2012. [α 4, TFS].
5. Testing the accuracy of internet-based PPP services, related to integrated flood management strategy in an un-gauged river basin; Sanyal, Ms, J; University of Durham, Geography PhD to be completed in 2012. [TFS].

Ongoing PhDs with no data taken in 2010/11 (4, 4 peer reviewed)

1. Up-scaling of peatland methane emission estimates from small to large scales; Mohammed, Mr, A; University of Edinburgh, Geosciences; Funded by NERC/Royal Society/Dorothy Hodgkin. PhD to be completed in 2011. [α 4, AS].
2. Application of the ionospheric tomographic inversion method MIDAS to radio astronomy; Katamzi, Ms, Z; University of Bath, Electronic and Electrical Engineering. PhD to be completed in 2011. [α 4, AS].
3. Post-project monitoring and evaluation of river rehabilitation projects in the UK and Japan; Aberg, Ms, U; University of Leeds, Earth and Environment; PhD to be completed in 2011. [α 4, TFS].
4. Towards centimetre level real-time kinematic GNSS single point precise positioning; Martin, Mr, I; Newcastle University. Funded by EPSRC/Subsea 7. PhD to be completed in 2011. [α 4, ES/MS].

Non-PhD students (9)

1. A multidimensional geophysical approach to the study of buried ecclesiastical remains; Grogan, Mr, C; UHI Millennium Institute, Orkney College. [TFS/SBA].
2. An assessment of ocean tide loading in the south-west; Kauluma, Ms, J; University of Plymouth, Marine Science and Engineering Sciences. [ES].
3. An investigation into the Carrier Phase Multipath signal for the determination of change in sea level at North Shields; Wilson, Ms, A; Newcastle University, Civil Engineering and Geosciences. [MS].
4. Can GNSS *see* the weather? Duncan, Mr, E; Newcastle University, Civil Engineering and Geosciences. [AS].
5. Evaluating accuracy improvement when combining GPS and GLONASS; Deeming, Mr, N; Newcastle University, Civil Engineering and Geosciences. [TFS].
6. Evaluation and comparison of online precise point positioning services; Ajewole, Mr, L; University College London, Geomatic Engineering. [TFS].
7. Laser scanning an old limestone quarry to determine fracture spacing and orientation; Baldini, Dr, J; University of Durham, Earth Sciences. [ES/EO].
8. Monitoring coastal landslide movement using dGPS of markers; Ford, Mr, A; Bournemouth University, Conservation Ecology. [ES/MS].
9. Review and testing of free web based positioning services; Edwards, Dr, S; Newcastle University, Civil Engineering and Geosciences. [TFS].

Collaborators (11)

1. Cell 11 Regional Monitoring Strategy (CERMS); Whittle, Mr, L; Environment Agency, Flood Risk Mapping & Data Management.
2. Differential correction and analysis of North Sea data; Fane, Mr, C; Ordnance Survey of Great Britain.
3. Establishing the EA GPS network (E1 control stations); Smith, Mr, P; Environment Agency.
4. Establishing, densifying and checking the EA GPS network (E2 and E3 control stations) for water level management; Tilley, Mr, T; Environment Agency.
5. Near real-time atmospheric water vapour for numeric weather prediction in the UK; Jones, Dr, J; Met Office.
6. Outfall chamber flood risk management improvement project; Basford, Mr, A; Environment Agency Wales.
7. Re-levelling or levelling in new flood warning gauging station benchmarks; Coward, Mr, M; Environment Agency.
8. River channel survey and creation of 3D topographic model, for flood risk assessment; Groom, Mr, R; Environment Agency.
9. Thames Barrier GPS monitoring, and datum point establishment; Hall, Mr, C; Environment Agency.
10. The determination of urban flood routes; Hopkins, Mr, M; Environment Agency.
11. Watercourse flood modelling survey; Maltby, Mr, A; Environment Agency.

Government / .org (13)

1. 3-dimensional control of a hydrographic survey; Robertson, Mr, P; Maritime and Coastguard Agency.
2. Aggregate extraction monitoring report; Downton, Mr, J; Crown Estate.
3. Airborne data post processing using Applanix POSPAC MMS; Hall, Mr, T; Infoterra, for Local and central government.
4. Archaeological research and training excavation of a Neolithic site; Hopher, Mr, J; Historic Scotland.
5. Archaeological site surveys throughout England; Thomason, Mr, B; English Heritage, Research and Standards.
6. Assessing the performance of a marine motion sensor; Talbot, Mr, A; United Kingdom Hydrographic Office.
7. Establishing long-term vegetation monitoring of special sites; Mellor, Ms, S; Countryside Council for Wales.
8. Forensic consultancy related to stability of GPS data at specific time and location; Last, Prof, D; UK Police Forces.



9. Geo-video capture and street furniture/highway assets database creation and maintenance; Martindale, Mr, J; Various Local Councils.
10. Highway asset capture, Traill, Mr, C; Leeds City Council.
11. Highway asset, asset condition and management survey; Traill, Mr, C; Conwy County Council.
12. Maritime and Coastguard Agency routine re-survey contract, and feeder to a pilot study for VORF (Vertical Offshore Reference Frame) ; Mallace, Mr, D; Maritime and Coastguard Agency.
13. Processing geodetic control established by the Royal Navy for hydrographic survey control; Worth, Mr, G; United Kingdom Hydrographic Office.

1

Ordnance Survey user (25)

1. Analysis of GPS data; Souter, Mr, J; Survey Solutions.
2. Archaeological survey around a known Romano-British site; Cordes, Mr, P; Northern Archaeological Group.
3. Base station post-processing, for monitoring agricultural machinery; Pyves, Mr, R; LH Agro.
4. Checking condition and verticality of electricity towers; Verth, Mr, S; National Grid.
5. Comparison position estimation using alternative base stations; Clark, Mr, R; Nuvia Ltd.
6. Control for railway survey; Watt, Mr, J; Network Rail.
7. Establishment of a survey control grid for Nexus-Metro rail infrastructure; Kusior, Mr, L; Newcastle Nexus-Metro.
8. Hard infringement survey of power lines; Verth, Mr, S; National Grid.
9. Improvement in the accuracy of telecomms asset records; Edwards, Mr, C; Network Rail.
10. Laser scan survey control of a telecomms mast; Thomas, Mr, S; Star Net Geomatics.
11. Navigation systems check; Ferris, Ms, K; Gardline Geosurvey.
12. Offshore tidal reduction testing; Clement, Mr, P; EGS Survey.
13. Orientating survey to OSGB control; McGarragh, Mr, M; Star Net Geomatics.
14. Processing aerial IMU data for Ortho-rectification of aerial photography; Philpot, Mr, D; Geosense.
15. Production of a topographical survey drawing; Sewell, Mr, C; Jacobs Babbie.
16. Research into SirfSTAR II GPS accuracy; Forsberg, Mr, C; Forsberg Services.
17. Sewage treatment works development survey; Matthews, Mr, P; Thames Water.
18. Site survey using GPS methods; Lindsay, Mr, H; MJCA.
19. Software testing; Joyce, Mr, A; Gardline Geosurvey.
20. Solway Firth water quality monitoring survey; Nelson, Mr, G; United Utilities.
21. Testing Topcon IP-S2 System; Givens, Mr, A; Topcon.
22. Topographic survey control; Bilicer, Mr, J; Atlantic Geomatics.
23. Verifying a DGPS system; Ashley, Mr, R; GEMS Survey.
24. Verifying RTK coverage; Sadler, Mr, J; Pelorus Surveys.
25. Underground utility and topographical surveys along overhead cable routes; Tissington, Mr, N; National Grid.

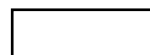
6. Publication details for the calendar year (2010)

Refereed (6, with their ISI 2009 JCR impact factors shown in [])

1. Bouin, M-N., Wöppelmann, G. Land motion estimates from GPS at tide gauges: a geophysical evaluation? *Geophysical Journal International*, 180, 193-209, doi:10.1111/j.1365-246X.2009.04411.x., 2010. [2.435].
2. Clarke P.J., Penna N.T. Ocean tide loading and relative GNSS in the British Isles. *Survey Review*, 42(317), 2010. [0.258].
3. Collilieux, X., Wöppelmann, G. Global sea level rise and its relation to the terrestrial reference frame definition. *Journal of Geodesy*, doi:10.1007/s00190-010-0412-4., 2010. . [2.429].
4. Dayoub, N., Moore, P., Penna, N.T., Edwards, S.J. Evaluation of EGM2008 within geopotential space from GPS. *Tide Gauges and Altimetry. Geodesy for Planet Earth: Proceedings of the 2009 IAG Symposium, Buenos Aires, Argentina, International Association of Geodesy Symposia, Vol. 136, Springer. [N/A].*
5. Quinn, J.D., Rosser, N.J., Murphy, W., Lawrence, J.A. Identifying the behavioural characteristics of clay cliffs using intensive monitoring and geotechnical numerical monitoring. *Geomorphology*, doi 10.1016/j.geomorph.2010.03.004., 2010. [2.119].
6. Sun, X., Shiono, K., Rameshwaran, P., Chandler, J.H. Modelling vegetation effects in irregular meandering river. *Journal of Hydraulic Research*, 48(6), doi:10.1080/00221686.2010.531101, 2010. [0.801].

Non-Refereed/Conference Proceedings (13)

1. Bos, M.S., Penna, N.T., Keshin, M., Clarke, P.J., Baker, T.F. Status of ocean tide loading displacement modelling. Oral presentation at the IGS Workshop 2010, Newcastle, UK, June 2010.
2. Burston, R., Bergeot N., Bruyninx C., Chevalier J.-M., Legrand J. A two-stage mid-latitude instability process: Gradient-drift and Kelvin-Helmholtz Waves. *Proc. Beacon Satellites Symposium, Barcelona, Spain, 2010.*
3. Chevalier, J-M., Bruyninx C., Legrand J., Bergeot N., Burston R. Impact of dense GNSS networks and multi-GNSS on trans-ionospheric ray path distribution for tomographic applications. *Proc. Beacon Satellites Symposium, Barcelona, Spain, 2010.*
4. Chevalier, J-M., Bruyninx C., Legrand J., Bergeot N., Burston R. Assessing the added value of dense GNSS networks and multi-GNSS observations for tomographic applications. *Geophysical Research Abstracts Vol.12, EGU2010-10538., 2010.*
5. Chevalier, J-M., Bruyninx C., Legrand J., Bergeot N., Burston R. Sounding the atmosphere: Improvement of ray geometry using dense European GNSS Networks and multi-GNSS signals. *Report on the Symposium of the IAG Sub-Commission for the European Reference Frame (EUREF), Gavle, Sweden, 2010.*
6. Dayoub, N., Moore, P., Penna, N.T., Edwards, S. Secular change of the geoid geopotential value, W_0 , from sea level

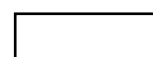


measurements and GRACE. Geophysical Research Abstracts Vol.12, EGU2010-5816, 2010.

7. Dayoub, N., Moore, P., Edwards, S., Penna, N.T. European vertical datum: Unification within geopotential space. Geophysical Research Abstracts Vol.12, EGU2010-5811, 2010.
8. Greaves, M., Fane, C., Cruddace, P., Bingley, R.M., Baker, D.F., Teferle, N., Hansen, D., Aquino, M., Appleby, G., Sherwood, R., King, M., Clarke, P.J. National Report of Great Britain, 2010. Report on the Symposium of the IAG Sub-Commission for the European Reference Frame (EUREF), Gavle, Sweden, 2010.
9. Keshin, M., Penna, N.T., Clarke, P.J., Bos, M.S., Baker, T.F. Anomalous tidal loading signals in south-west England and Brittany, Geophysical Research Abstracts Vol.12, EGU2010-5814, 2010.
10. Keshin, M., Penna, N.T., Clarke, P.J., Bos, M.S., Baker, T.F. GPS estimation of anomalous tidal loading displacements. Poster presentation at the IGS Workshop 2010, Newcastle, UK, June 2010.
11. Suzuki, Y., Otsuka, Y., Shiokawa, K., Tsugawa, T. A study of medium-scale travelling ionospheric disturbances observed with a GPS network in Europe. Japan Geoscience Meeting, Chiba, Japan, 2010.
12. Tsugawa, T., Kato, H., Kubota, M., Jin, H., Maruyama, I., Nagatsuma, T., Saito, A., Nishioka, M., Otsuka, Y., Miyake, W., Supnithi, P., Kenpankho, P. High-resolution total electron content observations of severe ionospheric disturbances using dense receiver networks. 38th COSPAR Scientific Assembly, Bremen, Germany, 18-25 July 2010.
13. Williams, S.D.P., Penna, N.T. Non-tidal loading effects on GPS. Oral presentation at the IGS Workshop 2010, Newcastle, UK, June 2010.

PhD Theses (10)

1. Design of low cost remote sensing equipment for agricultural use; Shuib, Mr; Aston University, Engineering & Applied Science; Funded by Malaysian Government. [α 3, TFS/EO].
2. Development of a system to measure ZTD and IWV in near real-time; Jones, Mr J; University of Nottingham, IESSG. Funded by the Met Office. [α 4, AS].
3. Establishing geodetic control in the monitoring of urban subsidence using InSAR; Leighton, Mr, J; University of Nottingham, IESSG. Funded by NERC BGS and the University of Nottingham. [α 4, TFS/EO].
4. Evaluating the role of grass buffer strips in arable catchments; Pillidge, Ms, S; University of Plymouth. [α 4, TFS].
5. GNSS related (restricted access); Dodson, Prof, A; University of Nottingham. [TFS].
6. Integration of geometric city models and GNSS for the simulation and modelling of availability and multipath, paving the way for new applications; Bradbury, Mr J; University College London, Geomatic Engineering. Funded by EPSRC. [α 4, TFS].
7. Post-project monitoring and evaluation of river rehabilitation projects in the UK and Japan; Aberg, Ms, U; University of Leeds, Earth and Environment. [α 4, TFS].
8. Sounding the atmosphere using the signals emitted by geodesic satellites; Pottiaux, Mr, E; Catholic University of Louvain-La-Neuve. [α 4, AS].
9. Towards unification of the vertical datum in the UK; Dayoub, Mr N; Newcastle University, Civil Engineering and Geosciences. Funded by Tishreen University. [α 4, ES].
10. Ubiquitous positioning using high precision integrated GPS and INS sensors; Kealy, Dr, A; University of Melbourne, Australia. [α 4, TFS].



Appendix 2: Optional Annexes

1. Projects completed

Academic (10)

1. Coastal Observation Project, previously CEEP; Morgan, Mr, D; NERC BGS. [α 4, TFS]
2. Physical properties and behaviour of UK rocks and soils; Jones, Dr, L; NERC BGS. [α 4, ES].
3. Use of persistent scatterer interferometry for vertical land movement; Tragheim, Dr, D; NERC BGS. [α 4, ES/EO].
4. Core positioning for archaeological survey; Desalle, Mr, T; UHI, Orkney College. [TFS/SBA/EO].
5. Detection of storm surge loading with GPS; Penna, Dr, N; Newcastle University. [α 4, ES].
6. GPS data processing demonstration; Dwarka, Mr, R; University of Mauritius. [TFS].
7. Imaging coastal archaeological sites in Uist; Roberts, Mr, K; University of Glasgow. [TFS/SBA].
8. Rectifying aerial photography related to field trials for monitoring agriculture by remote sensing; Simms, Mr, D; Cranfield University. [TFS/EO].
9. Sustainable drainage system for flooding event; Sordes, Ms, A; Scottish Agricultural College; [TFS].
10. Woodland bird habitat modelling with integrated remotely sensed data; Hill, Dr, R; Bournemouth University. [α ?, TFS].

PhD (9)

1. Establishing geodetic control in the monitoring of urban subsidence using InSAR; Leighton, Mr, J; University of Nottingham, IESSG. Funded by NERC BGS and the University of Nottingham. [α 4, TFS/EO].
2. Design of low cost remote sensing equipment for agricultural use; Shuib, Mr; Aston University, Engineering & Applied Science; Funded by Malaysian Government. [α 3, TFS/EO].
3. Development of a system to measure ZTD and IWV in near real-time; Jones, Mr J; University of Nottingham, IESSG. Funded by the Met Office. [α 4, AS].
4. Evaluating the role of grass buffer strips in arable catchments; Pillidge, Ms, S; University of Plymouth. [α 4, TFS].
5. GNSS related (restricted access); Dodson, Prof, A; University of Nottingham. [TFS].
6. Integration of geometric city models and GNSS for the simulation and modelling of availability and multipath, paving the way for new applications; Bradbury, Mr J; University College London, Geomatic Engineering. Funded by EPSRC. [α 4, TFS].
7. Sounding the atmosphere using the signals emitted by geodesic satellites; Pottiaux, Mr, E; Catholic University of Louvain-La-Neuve. [α 4, AS].
8. Towards unification of the vertical datum in the UK; Dayoub, Mr N; Newcastle University, Civil Engineering and Geosciences. Funded by Tishreen University. [α 4, ES].
9. Ubiquitous positioning using high precision integrated GPS and INS sensors; Kealy, Dr, A; University of Melbourne, Australia. [α 4, TFS].

7. Targets and Milestones

No further comments to add to the information given in the ANNUAL TARGETS AND PROGRESS TOWARDS THEM section of the main report.

8. Finance

Spend	£130, 420
Revenue	£0
Unit cost	£0.487
Planned capital spend	£0

9. Service Management

Professor Alan Dodson, Director
Dr Richard Bingley, Deputy Director
Dr David Baker, Manager
Ms Dionne Hansen, Developer

