

SERVICES & FACILITIES ANNUAL REPORT - FY April 2017 to March 2018

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

The British Isles continuous GNSS Facility (BIGF) is a unique and secure repository of archived GNSS data, dating back as far as 1997. All data are in RINEX** files, which are quality-assured and accompanied by metadata, and also form the basis of derived products. BIGF serves all of these data, metadata and derived products to the complete user-spectrum - nationally and internationally across academia, government, and business - with impact on research and development, policy and the wider societal good. BIGF provides data for reference stations to satisfy positioning improvement needs but also acts as a regional natural environmental laboratory, as demonstrated through facilitated studies - of horizontal and vertical land motion, the ionosphere, and the troposphere - carried out at regional, continental and global scales over the multi-decadal extent of the archive.* The data are sourced from a network of around 150 continuously recording GNSS stations, sited throughout the British Isles. The data are provided to BIGF free-of-charge by a number of collaborators, including the three national Ordnance Surveys and the Met Office. The archive currently comprises 2,135 station-years of 30 second (GPS, GPS+GLO*) data, and 947 station-years of 1Hz (GPS+GLO*) data. Users can request data and products using an online form. The service provided can be summarised in a four-part Facility remit: 1. To provide an assured repository of data and derived products, so that the costs of users setting up an ad-hoc observation network and/or deriving their own products for research are reduced or eliminated; 2. To facilitate improvements in positioning quality for historic or current research, by providing reference station data, protecting researchers from the costs and delays of having to repeat data collection exercises; 3. To facilitate the least time delay in the examination of environmental and other variables, by providing extensive backward tracts of data and/or derived products for research; 4. To inform and stimulate the research community across the spectrum of science using various media.



BIGF station network

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

1. To increase the quantity of data in the archive: hourly and daily RINEX files from around 150 CGNSS stations continue to be uploaded, at a nominal rate of 55k station-days a year.
2. To improve metadata: to support users we provide an interactive network map, station log files and data listing by year and station. The veracity of log files is also monitored, assuring accurate station history.
3. To increase archive usage: 1,165k, 5k, and 896k station-days of respectively, 30 second data, 1Hz data, and derived products were supplied in 2017/18, with a continuing steady uptake of 1Hz data and derived products. There were 73 scientific-user projects this year (and ~75 a year over the previous 5 years). There were 48 publications this year, including 8 completed PhD theses.
4. To meet the 'future developments/strategic forward look' from the 2016/17 annual report (and considering that this is the last Annual Report from BIGF as part of NERC's S&F portfolio):

- a) The 4 CGNSS stations at tide gauges, funded by NERC S&F capital in 2011/12 and installed in late 2013, have always tracked GPS+GLO+GAL+BDS, and OSGB now have firm plans to upgrade their 115 stations to have a similar capability.
- b) The final 'releasable' set of 'long term trend (LTT) derived products' at Levels 1, 2 and 3, related to station coordinates, tropospheric parameters and station velocities, created whilst BIGF was part of NERC's S&F portfolio, was the fifth 'releasable' set based on Bernese GNSS software version 5.2 (BSW5.2) and time series from 1997 to 2015:273; 'LTT derived products' at Level 1, related to ionospheric parameters, were never created.
- c) The final set of 'near real-time (NRT) derived products' at Levels 1 and 3, related to tropospheric parameters, and at Levels 1 and 2, related to ionospheric parameters, created whilst BIGF was part of NERC's S&F portfolio, were continued for the period up to the end of March 2018, based on BSW5.0 from April/July 2011 and then BSW5.2 from March 2017.
- d) The creation of enhanced 'LTT derived products' at Level 3, through collaboration with BGS on maps of vertical motions will be part of the future developments/strategic forward look following the decision made in July 2017 that "from April 2018 BIGF will be outside of NERC's S&F portfolio but its budget and capability will be incorporated into BGS Core activities."

* Global Navigation Satellite Systems: GPS, Glonass (GLO), Galileo (GAL), Beidou (BDS). ** Receiver INdependent EXchange format.

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

CAPACITY of HOST ENTITY FUNDED by S&F 100%	Staff & Status Dr Richard Bingley, Head of Facility, 40% NERC Dr David Baker, Manager, 40% NERC	Next Review (March) N/A	Contract Ends (31 March)
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FINANCIAL DETAILS: CURRENT FY						
Total Resource Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full Cash Cost £k
	Unit 1 (Products)	Unit 2 (30s data)	Unit 3 (1Hz data)			
111.44	0.000060	0.000060	0.000060			124.13

FINANCIAL COMMITMENT (by year until end of current agreement) £k					
2017-18	111.44	2018-19	N/A		

STEERING COMMITTEE NGGFSC	Independent Members 10	Meetings per annum 2	Other S&F Overseen GEF and NSGF
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APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2017/18)													
	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*			3										
Other academic			19										
Students			5										
TOTAL			27										

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2014/2015, 2015/2016 & 2016/2017)													
	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*			2.67										
Other academic			23.33										
Students		0.33	5.33	1.33									
TOTAL		0.33	31.33	1.33									

PROJECTS COMPLETED (current FY – 2017/18)													
	10 (α5)	9	8 (α4)	7	6 (α3)	5 (α2)	4	3 (α1)	2	1 (β)	0 (Reject)		Pilot
NERC Grant projects*			1										
Other Academic			2										
Students			3	2									

Project Funding Type (current FY – 2017/18) (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			NERC	Other	NERC	Other	
85	0		0	5	4	76					

Project Funding Type (per annum average previous 3 financial years - 2014/2015, 2015/2016 & 2016/2017)											
Grand Total	Infrastructure						PAYG				
	Supplement to NERC Grant *		PhD Students		NERC Centre	Other	NERC Grant*	PhD Student		NERC Centre	Other
	NERC	Other	NERC	Other			NERC	Other	NERC	Other	
95.666	1.333		0.667	8.333	4.667	80.667					

User type (current FY – 2017/18) (include each person named on application form)				
Academic	NERC Centre	NERC Fellows	PhD Students	Other
26	4	0	5	Non-PhD students 11 Collaborators 5 Central and local 22 OS user 12

User type (per annum average previous 3 financial years - 2014/2015, 2015/2016 & 2016/2017)				
Academic	NERC Centre	NERC Fellows	PhD Students	Other
31	4.667	0	9	Non-PhD students 9 Collaborators 8.333 Central/local Govt 16.333 OS user 17.333

OUTPUT & PERFORMANCE MEASURES (current year)											
Publications (by science area & type) (calendar year 2017)*											
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses	
0	17.25	4.75	19	6.5	0.5	0	48	29	11	8	

Distribution of Projects (by science areas) (FY 2017/18)											
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar				
85	1.5	16.5	17	11.5	35	3.5	0				

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)*											
Publications (by science area & type) (Calendar years 2014, 2015 & 2016)											
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses	
0.167	20.75	3.917	20.5	5.5	0.5	0	51.333	24.667	21.667	5	

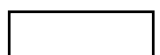
Distribution of Projects (by science areas) (FY 2014/2015, 2015/2016 & 2016/2017)											
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar				
95.666	1.611	18.278	20.666	12.833	36.778	5.5	0				

Distribution of Projects by NERC strategic priority (current FY 2017/18)								
Grand Total	Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies	Unclassified
85	7.167	3.5	4	13.667	26.167	0.5	0	30

*Either Discovery Science (Responsive Mode) or Strategic Science (Directed Programme) grants

NOTE: All metrics should be presented as whole or part of whole number NOT as a %

Note: From 1998 to 2017 there were 229 publications in Web of Science, generating 3,969 citations; and a total output of 757 publications, including 77 PhD theses. From 2015 to 2017 there were 73 publications added to Web of Science, generating 495 citations.



OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2017/18):

BIGF supported not only frontline UK academic research (29% of projects) and EU/International academic research (25%), but also projects serving UK government and policy (32%) and UK industry (14%). This support impacts on and benefits society as a whole, in terms of e.g. conservation – archaeology, mapping of grassland, salt meadow, fish ecology, and invertebrate mapping; environmental monitoring – weather forecasting, remote sensing, sea level change; natural hazards - storm driven coastal erosion, landslides, ground deformation, flood risk alert and river management; guidance – vehicle-based mapping systems, networked aircraft; and regional and global threats – glaciers and climate change, cyclical solar activity, tectonics and seismology, and tsunamis.

Data archival: Hourly and daily data archival continued from around 150 CGNSS stations, comprising two data sets: 30 second (GPS, GPS+GLO) with a current volume of about 2,135 station-years, and some stations operating since 1996/7; and 1Hz (GPS+GLO) from 119 CGNSS stations, with a current volume of about 947 station-years and some stations operating since August 2009.

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

Product development: The creation of derived products continued over 2017/18 such that, in relation to BIGF as part of NERC's S&F portfolio: the final 'releasable' set of 'long term trend (LTT) derived products' at Levels 1, 2 and 3, related to station coordinates, tropospheric parameters and station velocities was the fifth 'releasable' set based on BSW5.2 and time series from 1997 to 2015:273; the final set of 'near real-time (NRT) derived products' at Levels 1 and 3, related to tropospheric parameters, and at Levels 1 and 2, related to ionospheric parameters, were continued for the period up to the end of March 2018, based on BSW5.0 from April/July 2011 and then BSW5.2 from March 2017.

Website development: This continued to adapt to accommodate derived products as they were developed and launched; text and graphic content and FAQs were similarly enhanced to improve the user experience.

Archive access: Access to the archive was via an online request form. The request and delivery process was intentionally maintained as a personalised transaction, with capacity for verbal and e-mail dialogue on all aspects of supply, data processing and field operations, and to enable the easy gathering of user information to support NERC's reporting needs. A number of approved nationally and internationally led major research projects were served an automated continuous data stream.

Archive accounting: This was underpinned by a database designed to fulfil NERC's reporting, with user demand summarised as:

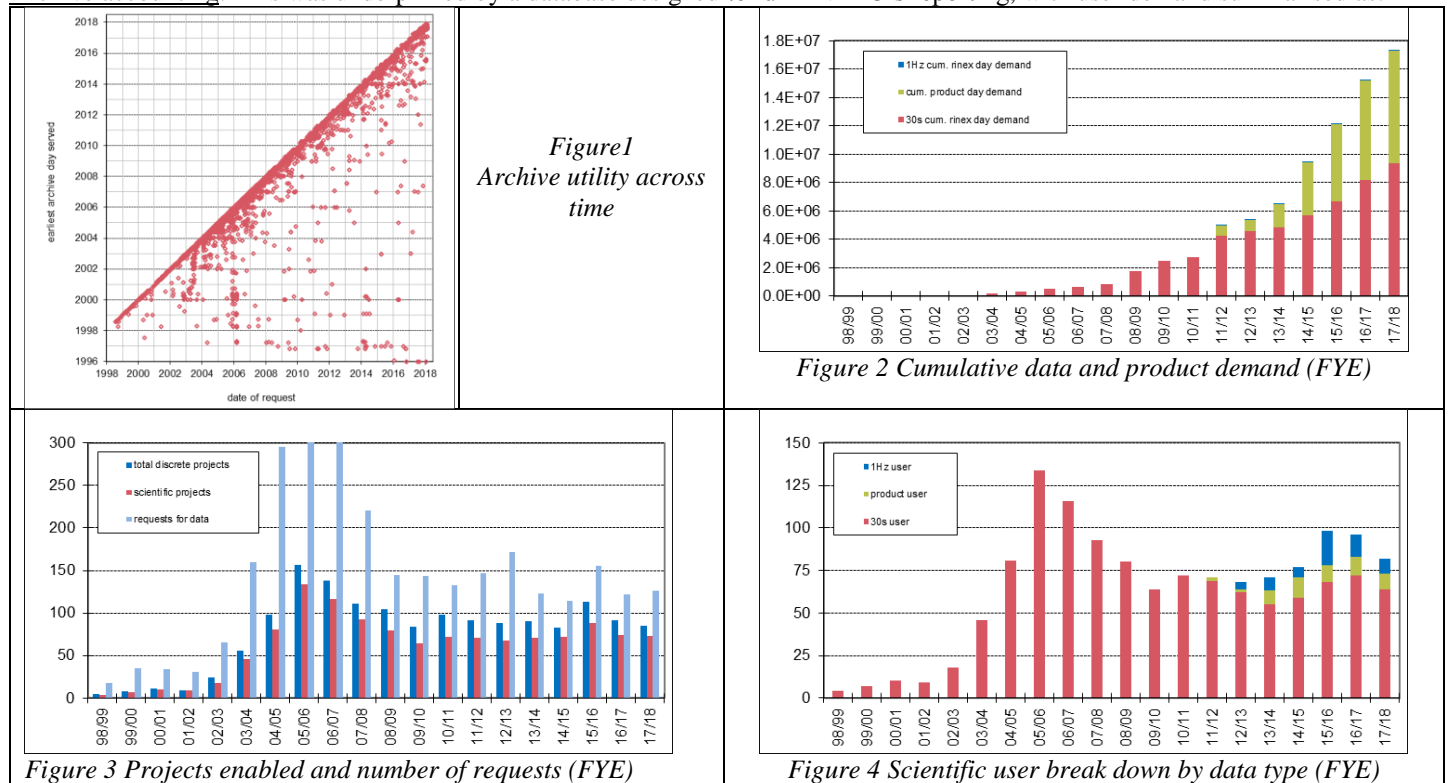


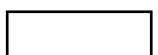
Fig. 1 clearly demonstrates a continuous need for the archive through the significant number of users requiring data of several years' vintage, and in a number of cases to its full temporal extent. Fig. 2 shows a continued, year-on-year demand for 30 second data and 1Hz data and a steady demand for derived products since their first availability six years ago. Fig. 3 shows that there has been a consistent level of about 75 scientific-user projects a year over the previous five full years, and Fig. 4 illustrates the arrival and sustained uptake of both 1Hz data and derived products.

SCIENCE HIGHLIGHTS. To focus on economic and societal impacts and benefits where possible:

There were 73 scientific-user projects supported in 2017/18, an output of 7 PhD theses (plus 16 in progress), 29 refereed and 11 non-refereed publications; the 3 most significant refereed, based on their ISI 2016 JCR impact factors, shown in [], were:

1. Dangendorf, S., Marcos, M., Woppelmann, G., et al. Reassessment of 20th century global mean sea level rise. Proceedings of the National Academy of Sciences of the USA. Vol.114, No.23, pp.5946:5951, doi:10.1073/pnas.1616007114, 2017 [9.661].
2. Robl, J., Hergarten, S., Prasicek, G. The topographic state of fluvially conditioned mountain ranges. Earth-Science Reviews, Vol.168, pp.190-217, doi:10.1016/j.earscirev.2017.03.007, May 2017 [7.051].
3. Yu, C., Li, Z., Penna, N. Interferometric synthetic aperture radar atmospheric correction using a GPS-based iterative tropospheric decomposition model. Remote Sensing of Environment, online, doi:10.1016/j.rse.2017.10.038, October 2017 [6.625].

The remainder of this section provides brief summaries of four notable research projects supported by BIGF in 2017/18:



Ardnamurchan Transitions Project. University of Leicester.

Community Archaeology

Field Schools and Projects

The School of Archaeology and Ancient History students and Outreach team are involved in a number of projects and field schools around the country including:

Ardnamurchan Transitions Project



The **Ardnamurchan Transitions Project** is a long-running research and community project exploring the archaeology of the Ardnamurchan Peninsula, Western Scotland. The project is a collaborative effort between archaeologists from the universities of Manchester and Leicester, CFA-Archaeology and Archaeology Scotland.

(Image credit University of Leicester)

A long-running research and community project exploring the archaeology of the Ardnamurchan Peninsula, Western Scotland. The project is a collaborative effort between archaeologists from the universities of Manchester and Leicester, CFA-Archaeology and Archaeology Scotland. BIGF 30s data were supplied to improve the accuracy of field observations recorded in July and August 2016, and January 2017.

PROtection of European Cultural Heritage from Geo-hazards (PROTHEGO) - Derwent Valley site. BGS, EC funded.

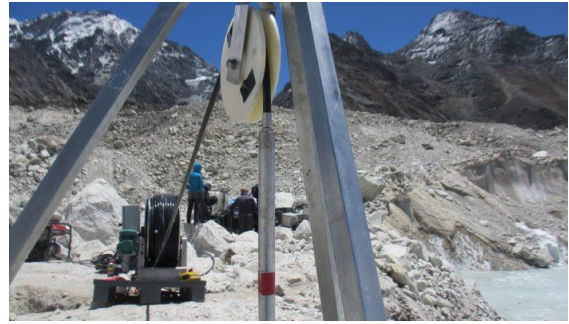


PROTHEGO aims to make an innovative contribution towards the analysis of geohazards in areas of cultural heritage in Europe. A comprehensive picture of sites affected by geohazards is not available as yet, and only some of the endangered sites are on the 1972 World Heritage in Danger list. This project makes an effort to fill this gap, and applies novel space technology based on radar interferometry (InSAR) to monitor monuments and sites in Europe which are inscribed on UNESCO's World Heritage List (WHL) and are potentially unstable due to geohazards. BIGF provided long-term station coordinate trend data to validate remotely acquired InSAR data covering a 7,500km² area.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

This is the last Annual Report from BIGF as part of NERC's S&F portfolio, since the decision made in July 2017 that "from April 2018 the NERC British Isles continuous GNSS Facility (BIGF) will be outside of NERC's S&F portfolio but its budget and capability will be incorporated into British Geological Survey (BGS) Core activities." As a consequence of this, any future developments/strategic forward look will be considered in this context and are not reported on here.

Everdrill. Universities of Aberystwyth and Leeds, NERC funded.



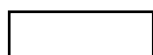
(Image credit Katie Miles)

This project aims to collect real measurements of sub-surface properties of Himalayan glaciers and so make more robust predictions of how glaciers may change with climate. Bore holes will be drilled into the Khumbu Glacier, Nepal, which descends from Mount Everest. Visual footage of each borehole interior will be gathered, and a multi-sensor array installed at the bed at each of the four locations. These will log water pressure, temperature, electrical conductivity and turbidity, and show how each of these parameters changes through the seasons. Additionally, surface position will be logged with L1 GPS sensors. BIGF data will be used to test the post-processed sensor accuracy with different baselines.

Will climate change in the Arctic increase the landslide-tsunami risk to the UK? University of Dundee, and others, NERC funded.



This project is examining new coastal sites in Shetland to determine the regional extent of potential tsunami deposits (such as those at ~1.5 and 5.5 Ka) that are younger than the Storegga Slide, to analyse sediments and check their tsunami origin and reported age. BIGF data were used to improve the accuracy of field observations recorded in the Lerwick catchment.



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

1. Mission Statement

To provide a unique and secure repository for archived, quality-assured GNSS (Global Navigation Satellite System) data, metadata and derived products dating back to 1997, from a network of continuous GNSS (CGNSS) stations sited throughout the British Isles, and to provide the interface between the archive and archive users, thereby facilitating research into the past, the present and the future, serving the complete user-spectrum - nationally and internationally across academia, government, and business, with impact on research and development, policy and the wider societal good.

2. Steering Committee membership and Terms of Reference

Steering Committee Members:

Dr N Linford (Chair), English Heritage.
Dr B Kulesa, Swansea University.
Dr J Hammond, Birkbeck University of London.
Professor J Brasington, Queen Mary University of London.
Professor C Hughes (deputy chair), University of Liverpool.
Dr N Penna, Newcastle University.
Professor T van Dam, University of Luxembourg.
Dr A Ferreira, University College London.
Dr J Biggs, University of Bristol.
Prof O Ritter, GeoForschungsZentrum GFZ, Potsdam.

Remit

The NERC Geophysics and Geodesy Facilities Steering Committee oversees the Geophysical Equipment Facility (GEF), British Isles continuous GNSS Facility (BIGF) and Space Geodesy Facility (SGF) and exists to:

- review applications for usage of the Geophysical Equipment Facility (GEF) and monitor the British Isles continuous GNSS Facility (BIGF) peer review process.
- monitor outputs from the three Facilities.
- provide advice to BGS Director and NERC Director of Science on aspects of the operations and development of the Facilities.

BGS Director and NERC Director of Science, in turn, provide advice to the NERC executive and NERC boards on Services and Facilities relevant to their remit.

Terms of Reference

- To review applications and establish priorities for the Heads of the Facilities, for the allocation of the facilities' resources funded from the Services and Facilities Science Budget, taking into account recommendations made through the NERC peer-review mechanisms.
- To review the scientific quality of work undertaken by users of the Facilities, based on reports and publications.
- To monitor the level of user satisfaction with the service and to analyse the user-base.
- To provide guidance to the Heads of the Facilities on improvement of the Facility's equipment and on its service function.
- To receive and comment upon the annual report from the Heads of Facilities, before it is submitted to NERC Swindon Office.
- To advise BGS Director and NERC Director of Science on:
 - a. the level and direction of the internal R&D programme for the Facilities;
 - b. emerging technical developments within the community;
 - c. anticipated changes in requirements from the Facilities and the anticipated levels of future demand.
- To provide advice at other times as appropriate.

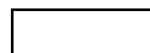
Membership constraints

Membership of the Committee, including the chair, will be decided by the Earth Science (ES) Services and Facilities management team at BGS with advice and suggestions from the Committee itself. It will include the Heads of the Facilities/nodes and a representative from the ES Facilities Management Team at BGS.

Members, other than ex-officio members will be invited to serve for a term of up to four years with a maximum extension of a further two years. The Chairperson will serve a maximum of four years.

3. Equipment Inventory

a. In-kind contributions from BIGF collaborators – data from around 150 CGNSS stations, each consisting of: dual-frequency GPS (or GPS+GLO, or GPS+GLO+GAL+BDS) 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:

- a) 2 Linux Network Attached Servers of 23Tb each, serving as primary and secondary archives for 30-second and 1Hz RINEX files of data and derived products (housed in the Nottingham Geospatial Building (NGB), on Jubilee Campus).
- b) 2 Linux Network Attached Servers of 23Tb each, serving as tertiary and quaternary archives for 30-second and 1Hz RINEX files of data and derived products (housed in the Data Centre, on King's Meadow Campus).
- c) 1 Linux workstation, serving to collect 30-second and 1Hz RINEX files of data from collaborators.
- d) 1 Linux workstation with 80Gb of data storage, serving to enable external users to take delivery of data and derived products.
- e) 1 Linux workstation acting as web server.
- f) 1 Linux server, for product development.

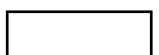
4. Future Developments

This is the last Annual Report from BIGF as part of NERC's S&F portfolio, since the decision made in July 2017 that "from April 2018 the NERC British Isles continuous GNSS Facility (BIGF) will be outside of NERC's S&F portfolio but its budget and capability will be incorporated into British Geological Survey (BGS) Core activities." As a consequence of this, any future developments will be considered in this context and are not reported on here.

5. Summary of Performance Information

Academic (26, 22 peer-reviewed)

1. EverDrill: Accessing the interior and bed of a Himalayan debris-covered glacier to forecast future mass loss; Quincey, Dr, D; University of Leeds; Funded by NERC. [8, ES].
2. South West Partnership for Environment and Economic Prosperity (SWEEP), locating a tide pressure sensor; Masselink, Prof, G; University of Plymouth; Funded by NERC [8, MS].
3. Will climate change in the Arctic increase the landslide-tsunami risk to the UK? Dawson, Dr, S; University of Dundee; Funded by NERC [8, ES/MS].
4. Aerosol and Clouds Consortium - cirrus climatology from ground-based remote sensing; University of Hertfordshire. [AS].
5. Ardnamurchan Transitions Project; University of Leicester; Harris, Dr, O; University of Leicester. [SBA].
6. Caernarfon and Milford Haven hi-res multi-beam echo sounder survey; Rowlands, Mr, S; University of Wales, Bangor; Funded by ERDF. [8, MS].
7. Densification of European Permanent GNSS Network for ionospheric studies; Pottiaux, Dr, E; Royal Observatory of Belgium. [8, AS].
8. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); Pacione, Dr, R; Agenzia Spaziale Italiana. [8, AS].
9. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); Dousa, Dr, J; Geodetic Observatory Pecny. [8, AS].
10. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); Dick, Dr, G; GFZ Potsdam (German Research Centre for Geosciences). [8, AS].
11. E-GVAP near real-time atmospheric water vapour (formerly COST Action 716/CSIP); de Haan, Dr, S; Royal Meteorological Institute of the Netherlands. [8, AS].
12. GPS/GLONASS precise point positioning and undifferenced ambiguity resolution; Geng, Prof, J; Wuhan University; Funded by National Science Foundation of China. [8, TFS].
13. International GNSS Service GPS tide gauge benchmark monitoring - pilot project; Woppelmann, Dr, G; University of La Rochelle; Funded by IGS. [8, ES].
14. International GNSS Service GPS tide gauge benchmark monitoring - pilot project; Teferle, Dr, N; University of Luxembourg; Funded by IGS. [8, ES].
15. International GNSS Service GPS tide gauge benchmark monitoring - pilot project; Schoene, Dr, T; GFZ Potsdam (German Research Centre for Geosciences); Funded by IGS. [8, ES].
16. Intraplate deformation in western Europe; Calais, Dr, E; École Normale Supérieure, Paris; Funded by CNRS/INSU National Funding Agency. [8, ES].
17. Ionospheric research using total electron content over Europe; Tsugawa, Prof, T; National Institute of Information and Communications Technology. [8, AS].
18. Quantifying the effects of slump blocks on bank erosion rates across a range of flow stages; Parsons, Prof, D; University of Hull; Funded by British Society for Geomorphology. [TFS].
19. Shipwreck monitoring - studying the long-term impact that man-made objects have on the sea floor; Roberts, Dr, R; University of Wales, Bangor; Funded by Welsh European Funding Office. [8, MS].
20. Supply of Newlyn to the EUREF Permanent Network; Habrich, Dr, H; Bundesamt für Kartographie und Geodäsie; Funded by EC. [8, ES].
21. Supply of Newlyn to the EUREF Permanent Network; Duquesnoy, Dr, T; Institut Geographique National; Funded by EC. [8, ES].
22. Supply of Newlyn to the EUREF Permanent Network; Villaverde, Dr, M; Instituto Geografico Nacional de Espana; Funded by EC. [8, ES].
23. Supply of Newlyn to the EUREF Permanent Network; Bruyninx, Dr, C; Royal Observatory of Belgium; Funded by EC. [8, ES].
24. The potential of precipitable water vapour measurements from GNSS in Luxembourg; Teferle, Prof, N; University of



Luxembourg. [ES]

25. 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. [8, ES].
26. Diabatic processes during the North Atlantic waveguide and downstream impact experiment; Bossler, Dr, P; Ecole Nationale Supérieure de Techniques Avancées Bretagne; Funded by ANR (French Research Agency). [8, AS].

NERC centres, surveys and facilities (4)

1. Proof of concept: use of GPS reflection measurements for tide gauge levelling; NERC National Oceanography Centre, Liverpool. [MS].
2. PROTection of European Cultural HEritage from GeO-hazards (PROTHEGO) - Derwent Valley; BGS. [ES/EO].
3. Shallow geohazards and risks - characterising coastal landslides; BGS. [ES/EO].
4. South baseline comparison at the NERC Space Geodesy Facility, and of other baselines; Wilkinson, Mr, M; NSGF. [ES].

PhD (5, 5 peer-reviewed)

1. Integrity and reliability analysis of PPP ambiguity resolution; Pearson, Mr, C; Newcastle University. To be completed in 2018. [8, MS, EPSRC and Fugro Intersite]
2. Interferometric synthetic aperture radar atmospheric correction using a GPS-based iterative tropospheric decomposition model; Yu, Mr, C; Newcastle University. To be completed in 2019. [8, AS/EO, Chinese Scholarship Council].
3. Monitoring ground deformation in London, UK; Bischoff, Ms, C; Imperial College. To be completed in 2019. [8, ES, Imperial College]
4. Probing the asthenosphere beneath the Australian region with surface GPS/GNSS; Matviichuk, Mr, B; University of Tasmania. To be completed in 2020. [8, ES, University of Tasmania].
5. Tidal measurements for coastal resilience and survey; Knight, Mr, P; University of Liverpool. To be completed in 2021. [8, ES/MS, University of Liverpool].

Ongoing PhDs with no data taken in 2017/18 (12, 8 peer reviewed)

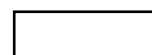
1. Application of satellite InSAR data in the assessment of ground motion in areas of historic mining to aid environmental and resource management; University of Nottingham. To be completed in 2019. [8, ES, GERC].
2. Assessment of the accuracy and the contribution of multi-GNSS in structural monitoring; Msaewe, Mr, H; University of Nottingham. To be completed in 2018. [8, TFS].
3. Development of 4D Chirp. Faggetter, Mr, M; University of Southampton/National Oceanography Centre, Southampton; To be completed in 2019. [8, ES/MS/SBA].
4. Geophysical methods for identifying streambed structural heterogeneity and implications for groundwater - surface water exchange flow; Dara, Mr, R; University of Birmingham. To be completed in 2018. [ES/TFS, Iraqi Government].
5. High accuracy GNSS processing for a road vehicle; Feng, Mr, S; Imperial College London. To be completed in 2018. [7, TFS, Imperial College London].
6. Is Glacial Isostatic Adjustment continuing in Scotland? Stockamp, Ms, J; University of Glasgow. To be completed in 2018. [9, ES/EO, University of Glasgow / Scottish National Heritage].
7. Monitoring ground deformation patterns at London and Thames Estuary area from 2002 to 2009 by using ISBAS DInSAR results; Al-Shammari, Ms, L; University of Nottingham. To be completed in 2018. [ES/EO, University of Nottingham].
8. Soil erosion control using cover crops in maize; Mancini, Ms, A, Cranfield University. To be completed in 2018. [TFS, Douglas Bomford Trust, Wye and Usk Foundation].
9. Space weather effects; Alsaleh, Ms, H; University of Bath. PhD to be completed in 2016. [7, AS, Self-funded].
10. Sub-surface feature detection using the Sub-SAR technique; Athab, Mr, A; University of Nottingham. To be completed in 2018. [ES/EO, Iraqi Government].
11. Terrestrial water storage anomalies as estimated using GPS and GRACE observations; Adusumili, Mr, S; Scripps Institution of Oceanography (USA). To be completed in 2021. [8, ES/TFS/EO, Regents Fellowship (UCSD)].
12. The effects of storminess on coastal ecosystem services and wellbeing; Holmes, Mr, T; University of York. To be completed in 2018. [8, MS/TFS, NERC].

Non-PhD students (11)

1. Reconstructing the Holocene floodplains in the Cairngorms national park; Catholic University of Leuven.
2. GNSS meteorology in support of severe weather forecasting; Technical University of Ostrava.
3. Ocean tidal loading; University of Plymouth.
4. Investigation into the requirement for annual routine resurvey in the Thames Estuary; University of Plymouth.
5. Comparing online services for processing GNSS data; University of Nottingham.
6. Process static data from the Scillies; University of Plymouth.
7. An investigation of recent beach sediment dynamics in Studland Bay, Dorset, UK; University of Brighton.
8. Natural flood management in Southwell; Nottingham Trent University.
9. Multispectral surveying; University of Plymouth.
10. Establishing the magnitude of ocean tide loading; University of Plymouth.
11. Assessing the feasibility of a National InSAR ground deformation map of Great Britain with Sentinel-1 data; NERC British Geological Survey.

Collaborators (5)

1. Heighting of river gauge stations; EA.



2. Hydrometric and telemetry (Wessex Region) flow station surveys; EA.
3. Near real-time atmospheric water vapour for numeric weather prediction in the UK; Met Office.
4. Structural monitoring of Thames Barrier; EA.
5. To determine whether there is a 35mm height error in OSGB station MANR; EA.

Government / .org (22)

1. Assessment of the condition of chasmophytic vegetation within the Brecon Beacons SAC; Natural Resources Wales.
2. Fish ecology in the Firth of Forth; Scottish Environment Protection Agency.
3. Forensic consultancy related to stability of GPS data at specific time and location; UK Police Forces.
4. Fraserburgh & Macduff studies - reduce flood risk to a number of properties; Aberdeenshire Council.
5. Georeferencing mobile mapping data for areas of London to be used to improve traffic congestion; Transport for London.
6. HI1519 Bathymetric Wreck Survey, Goodwin Sands to North Foreland Survey; Maritime and Coastguard Agency.
7. Hydrographic survey of UK waters to IHO special order standard; United Kingdom Hydrographic Office.
8. Maritime and Coastguard Agency routine re-survey project; Maritime and Coastguard Agency.
9. MCA Civil Hydrography Programme; Maritime and Coastguard Agency.
10. Monitoring Calcareous grassland dry heath at Castlemartin; Natural Resources Wales.
11. Process static point against OS Active Stations and compare baselines with two CORS at Hastings and Newhaven; United Kingdom Hydrographic Office.
12. Production of survey data to assist flood risk assessments; Staffordshire CC.
13. Rae Project - to digitally document in 3D the 336 historic sites in the care of Historic Environment Scotland on behalf of the Scottish Government; Historic Environment Scotland.
14. Real time kinematic (RTK) solutions for networked aircraft; Defence Science and Technology Laboratory.
15. S&C Alliance - Topographical surveys works required for the S&C South Alliance to renew S&C units in the South East; Network Rail.
16. Severn Estuary Atlantic Salt Meadows SAC Monitoring; Natural Resources Wales.
17. Surrey geo-referenced video survey; Various Local Councils.
18. To assess the condition of the population of Narrow-mouth Whorl Snail *Vertigo angustior* at Whiteford Burrows, using permanently marked plots created in 1999; Natural Resources Wales.
19. To determine the condition of the sand dune habitat at Kenfig and SACs; Countryside Council for Wales.
20. To establish site control to Network Rail spec to work as a basis of design for a new station in Warrington; Network Rail.
21. Using vessel based laser to map land features from afloat vessels; Port of London Authority.
22. Validation of Hastings and Newhaven CORS - examine any seasonal effects; United Kingdom Hydrographic Office.

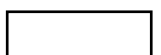
Ordnance Survey user (12)

1. Trialling Oxford Technology GPS equipment; Jaguar Landrover.
2. Verification of RTK accuracy; Forsberg Services/Novatel.
3. RINEX data for post processing of position; Teledyne.
4. Data comparability test for OSGB02 to OSGB15; AG Surveys.
5. To ascertain the relative serviceability of navigational systems (GPS) in the Hitchin area on 21/11/16 used with tagging technologies; Evidence Matters.
6. Cross check of existing post processed GPS information to provide a report on the accuracy of a control network; Babcock International.
7. Topographic and utility survey to assist Blackpool South Sewer improvements; United Utilities.
8. Mapping the distribution of power-line networks and any potential vegetation infringements across Scotland using aerially acquired LiDAR data; National Grid.
9. SEPD Fernhurst to Plaistow 33kV underground cable scheme topographical survey; National Grid.
10. Coupling between GPS and INS (post-processing); Oxford Technical Solutions.
11. Survey new culvert outfall level and position; FC Geomatics.
12. Review L2 quality of RTK solution in our product from a data set; Oxford Technical Solutions.

6. Publication details for the calendar year (2017)

Refereed (29, with, where available, their ISI 2016 JCR impact factors shown in [])

1. Altamimi, Z., Metivier, L., Rebischung, P., Rouby, P. ITRF2014 plate motion model. *Geophysical Journal International*, Vol.209, Issue 3, doi:10.1093/gji/ggx136, June 2017 [2.414]
2. Astafyeva, E., Zakharenkova, I., Huda, J.D., Doornbos, E., Ijssel, v.d.J. Global ionospheric and thermospheric effects of the June 2015 geomagnetic disturbances: multi-instrumental observations and modeling. *Journal of Geophysical Research –Space Physics*, Vol.122, Issue 11, pp.11716-11742, doi:10.1002/2017JA024174, November 2017 [2.733].
3. Bennitt, G.V., Johnson, H.R., Weston, P.P., Jones, J., Pottiaux, E. An assessment of ground-based GNSS zenith total delay observation errors and their correlations using the Met Office UKV model. *Quarterly Journal of the Royal Meteorological Society* (early online version), doi:10.1002/qj.3097, August 2017 [3.444].
4. Cherniak, I., Zakharenkova, I. New advantages of the combined GPS and GLONASS observations for high-latitude ionospheric irregularities monitoring: case study of June 2015 geomagnetic storm. *Earth, Planets and Space*, Vol. 69, No.66, doi:10.1186/s40623-017-0652-0, May 2017 [2.243].
5. Dangendorf, S., Marcos, M., Woppelmann, G., Conrad, C., Frederikse, T., Riva, R. Reassessment of 20th century global mean sea level rise. *Proceedings of the National Academy of Sciences of the USA*. Vol.114, No.23, pp.5946:5951,

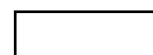


doi:10.1073/pnas.1616007114, April 2017 [9.661].

6. Devoti, R., D'Agostino, N., Serpelloni, E., Pietrantonio, G., Riguzzi, F., et al. A combined velocity field of the Mediterranean region. *Annals of Geophysics*, Vol.60, No.2, doi:0.4401/ag-7059, 2017 [0.915].
7. Dousa, J., Vaclavovic, P., Elias, M. Tropospheric products of the second GOP European GNSS reprocessing (1996–2014). *Atmospheric Measurement Techniques*, Vol.10, pp.3589-3607, doi:10.5194/amt-10-3589-2017, 2017 [3.089].
8. Guerrero, A., Palacios, J., Rodriguez-Bouza, M., Rodriguez-Bilbao, I., et al. Storm and sub-storm causes and effects at mid-latitude location for the St. Patrick's 2013 and 2015 events. *Journal of Geophysical Research – Space Physics*, Vol.22, No.10, pp.9994-10011, doi:10.1002/2017JA024224, October 2017 [2.733].
9. Jiang, W.P., An, X., Chen, H., Zhao, W. A new method for GLONASS inter-frequency bias estimation based on long baselines. *GPS Solutions*, Vol.21, No.4, pp.1765-1779, doi:10.1007/s10291-017-0652-3, October 2017 [4.061].
10. Kagan, Y.Y. Worldwide earthquake forecasts. *Stochastic Environmental Research and Risk Assessment*, pp.1273-1290, Issue 6, Vol.31, doi:10.1007/s00477-016-1268-9, August 2017 [2.629].
11. Klos, A., Olivares, G., Teferle, F.N., Hunegnaw, A., Bogusz, J. On the combined effect of periodic signals and colored noise on velocity uncertainties. *GPS Solutions*, online, doi:10.1007/s10291-017-0674-x, November 2017 [4.061].
12. Klos, A., Bogusz, J. An evaluation of velocity estimates with a correlated noise: case study of IGS ITRF2014 European stations. *Acta Geodynamica Geomaterialia*, Vol.14, No.3, pp.255-265, doi:10.13168/AGG.2017.0009, 2017 [0.699].
13. Klos, A., Gruszczynska, M., Bos, M., Boy, J-P., Bogusz, J. Estimates of vertical velocity errors for IGS ITRF2014 stations by applying the Improved singular spectrum analysis method and environmental loading models. *Pure and Applied Geophysics*, doi: 10.1007/s00024-017-1494-1, February 2017 [1.591].
14. Kotsakis, C., Chatzinikos, M. Rank defect analysis and the realization of proper singularity in normal equations of geodetic networks. *Journal of Geodesy* (online), pp.1-26, doi:10.1007/s00190-016-0989-3, January 2017 [2.949].
15. Meyssignac, B., Slangen, A.B., Melet, A., Church, J.A., et al. Evaluating model simulations of twentieth-century sea-level rise. Part II: Regional sea-level changes. *Journal of Climate*, Vol.30, No24, doi:10.1175/JCLI-D-17-0112.1, [online] September 2017 [4.161].
16. Novellino, A., Cigna, F., Brahmī, M., Sowter, A., Bateson, L., Marsh, S. Assessing the feasibility of a national InSAR Ground deformation map of Great Britain with Sentinel-1. *Geosciences*, 7(2), 19; doi:10.3390/geosciences7020019, 2017.
17. Pacione, R., Araszkievicz, A., Brockman, E., Dousa, J. EPN-Repro2: A reference GNSS tropospheric data set over Europe. *Atmospheric Measurement Techniques*, No.10, pp.1689-1705, doi:10.5194/amt-10-1689-2017, 2017 [3.089].
18. Pfeffer, J., Spada, G., Memin, A., Boy, J., Allemand, P. Decoding the origins of vertical land motions observed today at coasts. *Geophysical Journal International*, Vol.210 (1), pp.148-165, doi:10.1093/gji/ggx142, May 2017 [2.414].
19. Robl, J., Hergarten, S., Prasicek, G. The topographic state of fluvially conditioned mountain ranges. *Earth-Science Reviews*, Vol.168, pp.190-217, doi:10.1016/j.earscirev.2017.03.007, May 2017 [7.051].
20. Rodriguez-Bouza, M., Papparini, C., Otero, X., Herraiz, M., Radicella, S., Abe, O., Rodriguez-Caderot, G. Southern European Ionospheric TEC Maps based on Kriging technique to monitor ionosphere behavior. *Advances in Space Research*, online, doi:10.1016/j.asr.2017.05.008, May 2017 [1.401].
21. Santamaria-Gomez, A., Gravelle, M., Dangendorf, S., Marcos, M., Spada, G., Woppelmann, G. Uncertainty of the 20th century sea-level rise due to vertical land motion errors. *Earth and Planetary Science Letters*, Vol.473, pp.24-32, doi:10.1016/j.epsl.2017.05.038, September 2017 [4.409].
22. Stankov, S., Bergeot, N., Berghmans, D., Bolsee, D., Bruyninx, C., Chevalier, J-M., et al. Multi-instrument observations of the solar eclipse on 20 March 2015 and its effects on the ionosphere over Belgium and Europe. *Journal of Space Weather and Space Climate*, 23 pp., Art.19, Vol.7, doi:10.1051/swsc/2017017, 2017 [2.446].
23. Thorne, P.W., Madonna, F., Schulz, J., Oakley, T., Ingleby, B., et al. Making better sense of the mosaic of environmental measurement networks: a system of systems approach and quantitative assessment. *Geoscientific Instrumentation Methods and Data Systems*, Vol.6, Issue 2, pp.453-471, doi:10.5194/gi-6-453-2017, November 2017 [1.023].
24. Weiping, J., Xiangdong, A., Hua, C., Wen, Z. A new method for GLONASS inter-frequency bias estimation based on long baselines. *GPS Solutions*, pp.1-15, doi:10.1007/s10291-017-0652-3, July 2017 [4.061].
25. Wielgosz, P., Krypiak-Gregorczyk, A. Regional atmospheric modeling based on multi-GNSS data and TPS interpolation. *Proceedings of the Baltic Geodetic Congress (BGC Geomatics)*, Gdansk, Poland, pp.287-291, doi:10.1109/BGC.Geomatics.2017.64, June 2017.
26. Williams, S.D.P., Nievinski, F.G. Tropospheric delays in ground-based GNSS multipath reflectometry - experimental evidence from coastal sites. *Journal of Geophysical Research - Solid Earth*, doi:10.1002/2016JB013612, March 2017 [3.350].
27. Yu, C., Li, Z., Penna, N. Interferometric synthetic aperture radar atmospheric correction using a GPS-based iterative tropospheric decomposition model. *Remote Sensing of Environment*, online, doi:10.1016/j.rse.2017.10.038, October 2017 [6.625].
28. Zhao, Q., Li, X., Liu, Y., Geng, J., Liu, J. Undifferenced ionospheric-free ambiguity resolution using GLONASS data from inhomogeneous stations. *GPS Solutions*, online, doi:10.1007/s10291-017-0691-9, December 2017 [4.061].
29. Zus, F., Deng, Z., Wickert, J. The impact of higher-order ionospheric effects on estimated tropospheric parameters in Precise Point Positioning. *Radio Science*, Vol.52, Issue 7, doi:10.1002/2017RS006254, August 2017 [1.581].

Non-Refereed/Conference Proceedings (11)

1. Ahmed, F., Hunegnaw, A., Teferle, F.N., Bingley, R.M. Evaluation of ERA-Interim for tropospheric delay and water vapour estimation in different climate zones using ground-based GNSS observations. *European Geoscience Union General Assembly*, Vienna, Austria, April 2017.
2. Berckmans, J., Malderen v.d., R., Pottiaux, E., Pacione, R. Evaluation of the atmospheric water vapor content in the regional climate model ALARO-0 using GNSS observations. *EUREF Symposium*, Wroclaw, Poland, May 2017.
3. Bruyninx, C., Araszkievicz, A., Brockmann, E., et al. *EUREF Network Technical Report 2016*, in *IGS Technical Report 2016*.



4. Fernandes, R., Bos, M., Bruyninx, C., Crocker, P., et al. EPOS – Improving the infrastructure for GNSS data and products in Europe. FIG Working Week 2017, Helsinki, Finland, May 2017.
5. Fleury, R. GPS et ionosphere. Twelfth Meeting of the International Committee on Global Navigation Satellite Systems, UN Office for Outer space affairs, Japan, December 2017.
6. Hoque, M., Jakowski, N., Berderman, J. Ionospheric effects over Europe during the solar eclipse on 20 March 2015. Proceedings of 19th EGU General Assembly, p.4540, Vienna, Austria, April 2017.
7. Hunegnaw, A., Teferle, F.N., Abraha, K.E., Santamaria-Gomez, A., Gravelle, M., Woppelman, G., Schone, T., Deng, Z., Bingley, R.M., et al. A new global vertical land movement data set from the TIGA combined solution. EGU, Vienna, Austria, April 2017.
8. Hunegnaw, A., Teferle, F.N., Abraha, K.E., Santamaria-Gomez, A., Gravelle, M., Woppelman, G., Schone, T., Deng, Z., Bingley, R.M., et al. On the scientific applications of IGS Products: an assessment of the reprocessed TIGA solutions and combined products. IGS Workshop 2017, Pathways to Improved Precision, Paris, France, July 2017.
9. Hunegnaw, A., Teferle, F.N., Abraha, K.E., Santamaria-Gomez, A., Gravelle, M., Woppelman, G., Schone, T., Deng, Z., Bingley, R.M., et al. A global vertical land movement data set from a combination of Global Navigation Satellite System solutions. International WCRP/IOC Conference 2017 Regional Sea Level Changes and Coastal Impacts, New York, USA, July 2017.
10. Husson, L., Bodin, T., Choblet, G., Kreemer, C. Probabilistic reconstruction of GPS vertical ground motion and comparison with GIA models. Proc. 19th EGU General Assembly, Vienna, Austria, April 2017.
11. Knight, P.J. Tidal measurements for coastal resilience and survey (using GPS-reflectometry). Sea level & coastal change group, SLACC (QRA research group) Conference, Liverpool, September 2017.

PhD Theses (8)

1. A novel GNSS-based positioning system to support railway operations. Imperial College; Damy, S. [7, TFS, Lloyd's Register Foundation,].
2. Acoustic Doppler current profiler positioning near river engineering structures. Cranfield University; Kriechbaumer, T. [8, TFS, EPSRC].
3. Advanced assistance services of high performance in harsh environments, part of Marie Curie Initial Training Network MULTI-POS. Universitat Autònoma de Barcelona; Pasnikowski, M. [8, TFS, EC].
4. Assessment of long-term deformation in Johor, Malaysia using Global Positioning System (GPS) and Interferometric Synthetic Aperture Radar (InSAR). University of Nottingham; Bin Che Amat, M. [ES/EO].
5. Multi-sensor fusion for driverless car technologies. University of Wales, Aberystwyth; Lu L. [7, TFS].
6. Precise Point Positioning (PPP0: GPS vs. GLONASS and GPS+GLONASS with an alternative strategy for tropospheric Zenith Total Delay (ZTD) estimation. University of Nottingham; Mohammed, J. [AS].
7. Study of the ionospheric disturbances through total electron content over southern Europe. University of Madrid; Bouza, M.R. [AS].
8. Sidereal filtering for multi-GNSS precise point positioning and deformation monitoring; Cowles, Ms, P; Newcastle University. [8, ES, NERC].

Appendix 2: Optional Annexes

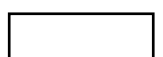
1. Projects completed

Academic (5)

1. Will climate change in the Arctic increase the landslide-tsunami risk to the UK? Dawson, Dr, S; University of Dundee; Funded by NERC [8, ES/MS].
2. PROtection of European Cultural HERitage from GeO-hazards (PROTHEGO) - Derwent Valley; BGS. [ES/EO].
3. Caernarfon and Milford Haven hi-res multi-beam echo sounder survey; Rowlands, Mr, S; University of Wales, Bangor; Funded by ERDF. [8, MS].
4. Quantifying the effects of slump blocks on bank erosion rates across a range of flow stages; Parsons, Prof, D; University of Hull; Funded by British Society for Geomorphology. [TFS].
5. Intraplate deformation in western Europe; Calais, Dr, E; École Normale Supérieure, Paris; Funded by CNRS/INSU National Funding Agency. [8, ES].

PhD (8)

1. A novel GNSS-based positioning system to support railway operations. Imperial College; Damy, S. [7, TFS, Lloyd's Register Foundation,].
2. Acoustic Doppler current profiler positioning near river engineering structures. Cranfield University; Kriechbaumer, T. [8, TFS, EPSRC].
3. Advanced assistance services of high performance in harsh environments, part of Marie Curie Initial Training Network MULTI-POS. Universitat Autònoma de Barcelona; Pasnikowski, M. [8, TFS, EC].
4. Assessment of long-term deformation in Johor, Malaysia using Global Positioning System (GPS) and Interferometric Synthetic Aperture Radar (InSAR). University of Nottingham; Bin Che Amat, M. [ES/EO].
5. Multi-sensor fusion for driverless car technologies. University of Wales, Aberystwyth; Lu L. [7, TFS].
6. Precise Point Positioning (PPP0: GPS vs. GLONASS and GPS+GLONASS with an alternative strategy for tropospheric Zenith Total Delay (ZTD) estimation. University of Nottingham; Mohammed, J. [AS].
7. Study of the ionospheric disturbances through total electron content over southern Europe. University of Madrid; Bouza, M.R.



[AS].

8. Sidereal filtering for multi-GNSS precise point positioning and deformation monitoring; Cowles, Ms, P; Newcastle University. [8, ES, NERC].

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	£124,130
Revenue	£0
Unit cost	£0.060
Planned capital spend	£0

9. Service Management

Dr Richard Bingley, Head of Facility, 40% NERC

Dr David Baker, Manager, 40% NERC

