a. Overview

The University's Digital Innovation Research Beacon has four strands: Big Data (focusing on forensics/ criminology); Informatics for Business and Manufacturing (systems in organisations); Technology-Enhanced Living (individual user-experience of digital technologies); and Energy Efficient and Safe Vehicles. The unit's research is conducted in the first three.

This is a significant restructuring of the research reported in RAE2008 and highlights our view that applied research in technological environments is multidisciplinary. Staff contribute across a number of strands as appropriate (hence individuals are not allocated to groups for REF2014). The restructuring is a response to the reduction in the department's size with its concomitant changes in teaching focus. However, we retain clear links with our previous RAE2008 groups:

- Systems Engineering, Internet Technologies and Decision Support Systems (to a lesser extent) underpin Informatics for Business and Manufacturing (IB&M);
- HCI and E-learning underpin Technology-Enhanced Living;
- Information Retrieval, Intelligent Systems and Internet Technologies underpin Big Data.

The strands' activities are managed within a governance group where KPIs and their associated data are monitored and evaluated. Dedicated centralised services also provide support for income generation, conference organisation, research student management, etc. The support systems are used at central, unit, and individual project levels to ensure effective and transparent interfaces.

b. Research Strategy

EVIDENCE OF THE ACHIEVEMENT OF RESEARCH STRATEGIC AIMS

In RAE2008 our strategic aims were to conduct basic and applied research that:

(a) fosters integration of research with teaching and learning

Computing UG, PG and doctoral provision has been evaluated and redeveloped in the period. UG and PG computing courses are accredited with the BCS (whose requirements include evidence of research informed teaching). Research findings are used by students in modules e.g.: field study design in user experience design; social network analysis and crime nets techniques in computer forensics. Students analyse case studies emerging from our research e.g.: in project quality and risk management and computer forensics. Research expertise is used to support project modules, with students engaging directly in research, e.g.: as software evaluators in the eCUTE project and via final year projects for fraud detection. In technical areas such as network security staff bring expertise in a range of areas (e.g. systems integration in the STASIS project).

(b) addresses the needs of business and the local community (through five objectives).

Objective b1: engage in regional initiatives and Objective b2: ensure knowledge transfer of research into organisations and society. These have been achieved within the key regional initiative, Sunderland Software City (SSC), see REF3. The University secured £566k of SSC's ERDF funding and £1.5M Single programming funding in 2009 (See REF3 SSC case study). SSC focuses on innovation, employment, training/education, knowledge transfer and research. The unit has contributed to SSC through pro bono consultancy (e.g. eye tracker studies), Collaborative Innovation Partnerships (CIPs) and Knowledge Transfer Partnerships (KTPs) - see section d.

For each of Objectives b3: collaborate in international networks; b4: increase interdisciplinary work; and b5: target funding to reflect different research foci, there has been success (see sections d, e).

CURRENT POSITION AND FUTURE STRATEGIC AIMS AND GOALS FOR RESEARCH

Our vision reflects the strategic aims adopted in our RAE2008 strategy. Our objectives and their implementation were re-evaluated in 2010/11 in view of three significant contextual factors:

- the reduction in the computing staff base (from 65 at RAE2008 submission to 28.7 now);
- the recognition that there are many established academics with significant technical and professional expertise who are aspirant, but not early career, researchers;
- the launch of SSC providing a focus on the development of the software industry in the region – supported by leading research.

The refreshed strategic aims (new aims **in bold**) are to:

1. **provide structure for multidisciplinary research in computing through the three strands: Big Data; Informatics for Business and Manufacturing; Technology-Enhanced Living; and to support this structure with effective management and monitoring systems (see section a), ensuring impact and dissemination of results (see REF3a);**
2. feed research into teaching and the student experience such through their use of research facilities (e.g. usability lab, the high performance computing cluster) and involvement in research and innovation (e.g. SSC);
3. target SMEs, the public and voluntary sectors, engaging them in research to benefit the regional economy;
4. **develop academic staff whether early career, established or aspirant researchers (i.e. academic staff who are starting research activity - see section c.i);**
5. **grow the research student community (see section c.ii);**
6. **adopt a hybrid revenue approach; building on partnerships to develop UK & EU funding streams (see section e**).

Key to this strategy is a strong, vibrant, sustainable research community including staff and students, both on- and off- campus. We offer: a seminar series in computing, complemented by those in other units; subject-specific workshops (e.g. on repertory grids); knowledge exchange events with SMEs (e.g. commodification of digital assets); and informal social gatherings. These are to be enhanced through greater use of our virtual learning environment targeted at colleagues and students off-campus (e.g. by recording seminars and making these available); webinars (e.g. on fraud detection); and an industrial seminar series targeted at SMEs in the software sector.

c.i People – including Staffing strategy and staff development

CURRENT STAFFING SUMMARY

Of our 28.7FTE computing academics nine are returned in this unit, with *Irons* and *Nelson* in unit C25 (36% of headcount, 39% of FTE). Our submission also includes *Davies* and *McGarry* from Pharmacy, Health and Wellbeing; and early career researcher *Davinson* from Psychology. Other staff include one permanent technical project manager (*Ginty*), two research assistants (*Hume, Cranner*) and two part time Senior Research Fellows (Emeritus Professor *Smith* and *Tazzyman*). There are two faculty research administrators and one dedicated computing research technician. In addition two Visiting Professors provide specialist insights: *John Mellis* (BT) in planning for high performance computing and *Russell May* in digital forensic investigations.

STAFFING STRATEGY, RESEARCH STRATEGY AND PHYSICAL INFRASTRUCTURE.

The focus of the unit's research strategy in the REF period has been to develop and support existing staff, given a 56% academic computing staff reduction with limited opportunity for recruitment (4.5FTEs) over the period. During the period, *McDonald, Hall* and *Bowerman* were promoted to Reader. *Warrender* and *Hagan* enrolled in Professional Doctorates.

Research assistants are recruited to support funded activity (e.g. EU eCUTE project 2.6 researchers; STASIS project 3 researchers). They are developed, for example, through enrolment on Postgraduate Certificate in HE Teaching & Learning to enable progression into academic or professional roles (this is discussed further in the "concordat" section below).

Dedicated spaces and technical support exist to support activities (both teaching and research) such as the high performance computing cluster and the usability lab. With the emergence of new areas such as forensic computing investment has been made in both staff and infrastructure. Since 2011 flexible work spaces have been created (e.g. the Learning Labs that are used for user studies and experiments). The physical infrastructure is supported by a technical team including *Wilson* (HEA Technician of the Year, 2012).

CAREER DEVELOPMENT SUPPORT

The University's Academic Development team provides excellent career and personal development training for all career stages with a comprehensive research skills and personal development programme. Moreover, researchers, at all levels, are supported to engage in external

training funded from departmental staff development or the unit's QR funds. This enables involvement in research networks (e.g. EPSRC RIDERS network), developmental opportunities (e.g. Vitae) and conferences (e.g. ACM CHI Conference on Human Factors in Computing Systems). Mentoring and support for personal development is provided underpinned by HR policies. Industrial mentors also offer support through SSC to provide useful insights from an applied research context. Support is tailored to different career stages.

Research Leaders: Sunderland developed and piloted a Leadership Foundation funded programme "Leading on Research Excellence" in collaboration with the Northumbria and Teesside universities. This tailor-made strategic leadership programme is for Readers and Professors across the region. *Hall* is currently benefiting from this and all Professors/Readers will attend.

Established Researchers: Staff are developed within discipline: e.g. *Panchev* received a University Research Development Fellowship to extend his work on neural networks; and across discipline e.g. the unit invested in *Humphries's* MSc in Psychology to advance her research into technological support of social development of foundation stage children. Senior staff mentor those seeking promotion (e.g. *McDonald* was mentored by *Edwards* to a readership role).

Early career and aspirant researchers: Formal training for this group is provided centrally (e.g. via "How to be an effective researcher" and the "Principal Investigator development programme"): the associated networking at these events establishes collaborations across the University. Researchers develop their individual research plans and resource requirements in discussion with both their line managers and research leaders (e.g. *Gandy* mentored by *McDonald* now works with staff and resources from Sports Science on dynamically modelling horse and rider movement). Staff have won central funding to support research e.g. *Warrender* in 2012/13 (for 200 hours of teaching relief to pursue high performance computing research). The success of this scheme has led to a Faculty commitment in 2013/14 of £50k for relief from current duties to build research capacity. Research development routes include: Professional Doctorates (e.g. *Warrender* and *Hagan*); PhD by Existing and Published works (e.g. *Mitsche* and *Gandy*). Other staff research competencies are developed with a blend of formal and "on the job" training: for instance, as PGR supervisors working in teams with experienced colleagues (e.g. *Baglee* (unit B12) with *Hall* and *Edwards*).

Implementation of the concordat to support the career development of researchers:

The University fully subscribes to the Concordat to Support the Career Development of Researchers, and is an HR Excellence in Research Award holder. We have reviewed our support for researchers, and are implementing further improvements: e.g. a new development programme specifically for contract researchers; and a review of careers provision to ensure researcher needs are fully met. Within the unit our contract researchers are encouraged to engage in all aspects of university life, and take advantage of the training/development courses and careers advice on offer. PIs act as line managers and have responsibility for their appraisal and development needs.

Equalities and diversity. The University holds an Athena Swan Bronze award. It also holds Investor in People status, is a Stonewall Diversity Champion, and subscribes to the "two ticks" "Positive about Disability" scheme. Pre-retirement *Smith* led equality and diversity developments and was seconded as University Chair of Equality and Diversity (2008-2010).

33% of our computing academics are female: for the academics returned in this unit the ratio is 53% female. This positive gender profile also includes three women research leaders as role models and mentors (*Edwards, Hall, McDonald). Edwards* represent computing research on the Departmental Management Team. *Edwards*, *McDonald* and *Hall* are members of the university Athena Swan group and are involved in developing the departmental silver award submission.

c.ii People - Research students

Quality of training and supervision: In the 2013 HEA's Postgraduate Research Experience Survey, the University was in the top quartile for supervision, progress and assessment, rights and responsibilities, and research skills development; above sector average in responsibilities; and around sector average in skills development.

PGR recruitment: we actively target traditional PhD applicants from our on- and off- campus student base, using taster sessions, electronic notices and short term research internships. The embedded nature of our research in teaching alerts the majority of students to our research activities. Through regional engagements with local SMEs, public sector and voluntary organisations we have recruited 14 Professional Doctorate students, 37% of the 2012/13 cohort. To reach the wider applicant pool we use our PGR web portal which attracts a significant and growing number of experienced, mid-career applicants.

Recruitment management: Annual recruitment targets are set and monitored for the unit and the process is managed by the research student manager (*Bowerman*). Research proposals are assessed by subject experts and applicants are interviewed by the research student manager and potential supervisory team. Central support (Graduate Research Service, GRS) ensures applicant compliance, e.g. with UKBA requirements.

Training and support mechanisms: The University's 2012 cross-faculty external review of all PGRS activity highlighted the strength of our comprehensive skills training programme. Additional training in the unit complements this, including workshops (e.g. on specific research techniques, critical literature analysis) and seminars (providing opportunities to formally present and also to discuss specific publications). Further support is offered through the Staff-Student liaison committee. The research student manager provides supervisory-independent pastoral and critical friend support, and from January 2014, two PGRS tutors will assist in this.

Information on progress monitoring: We operate within the University's annual review process with student progress assessed by two independent staff with relevant research expertise. The formative nature of the reviews has had a significant impact on completion rates (increasing from 60% to 88%) and retention rates (2008/9: **60%,** 2009/10: **83%**, 2010/11: **88%**, 2011/12: **95%,** 2012/13: **98%).** During the REF period the total numbers of students have remained stable and the numbers entering write-up has dropped significantly (as a result of effective supervision and annual monitoring).

	Mode			Origin		**Total**	Write-up	Doctoral Awards					MPhil
								On campus		Off campus		**Total**	
Year	FT	PT	DL	EU	OS			PhD	ProfDoc	PhD	PhDEx		
2007/8	16	18	12	30	33	**46**	17						
2008/9	14	22	6	29	24	**42**	11	6	0	0	0	**6**	0
2009/10	7	27	6	23	17	**40**	9	3	0	2	0	**5**	0
2010/11	7	27	6	23	17	**40**	9	4	0	0	0	**4**	1
2011/12	6	22	2	28	8	**30**	6	4	1	2	0	**7**	0
2012/13	5	25*	6	28	10	**38**	0	3	4	0	1	**8**	0

*14DProf,1PhDEx

The doctoral student profile: This has changed significantly: in the unit p/t study has risen from 16% in 2007/8 to 62% in 2013/4, with many mid-career professionals being attracted to our professional doctorates. Currently 76% of research students are male. This an area we are examining as part of our Athena Swan activities to develop effective action plans to encourage women to undertake doctoral studies with us.

d. Income, infrastructure and facilities

INFRASTRUCTURE AND FACILITIES

In 2009/10 £70k was invested in servers and PCs with £20k invested in video walls & plasma screens. 2011/12 there was a £500k redesign of the computing terraces (including £300k for computing facilities). This redesign included features to support research activity (e.g. multi-use learning labs for use by user experience researchers). Investments have been as below.

User experience facilities:

- A mobile "in the wild" user experience lab (equipped with iPads, mobile display screens, Kinect, laptops, etc.) has been developed at a cost of £20k and is used in school classrooms and industrial environments by *Hall, Jones, Tazzyman* and *Humphries*.

- A traditional usability testing lab. £25k was invested in 2012/13 to relocate this lab and upgrade its equipment (e.g. TobiiT60XL eyetracker). This is use by *McDonald* and *Edwards* and there are plans for its use in in future work by *Davinson, Hall* and *Scott* (UoA12).
- A driving simulator lab is shared with engineering supporting *Hall* and *Scott's* vehicular user experience research: a £15k upgrade took place in 2011 funded by One North East (ONE).
- SSC has also invested in innovation suites in its Software Centre which are available to researchers in the unit for multi-user studies.

The high-performance computing cluster:

This was established in 2007 by (now Emeritus Professor) *Tindle* to extend the research and collaboration presented in the REF3 BT impact case study. He further developed its use for multidisciplinary research (linked to drug discovery, materials for increasing safety of automotive bodies, etc.). As Emeritus Professor (from 2012) he works with *Warrender* to continue this research. The work is outgrowing the current lab capacity and new investment will be sought to enhance this facility using a different design strategy that has emerged from *Warrender's* research.

Forensic computing:

In 2008/09 an investment was made in technology and software to support forensic computing teaching. This was enhanced in 2012/13 investing £25.5k into a new ediscovery lab which is increasingly supporting the research of *Panchev* and *Irons* (UoA 25) in addition to teaching.

Network labs:

£60k has been invested in upgrading the Cisco network labs. These are currently used for teaching but provide the necessary infrastructure for research planned by aspirant researcher *Irving*.

Research student rooms:

Two bespoke rooms have been refurbished to cater for increasing number of on-campus students. These include breakout facilities, interactive displays as well as newly refurbished work spaces.

Staffing:

The unit has access to a range of technical personnel: the technical computing team (including a dedicated research technician) and specialist programmers. Other support includes two faculty administrators, the central Research Support team in Academic Services and the university Business Services team.

RESEARCH FUNDING PORTFOLIO

The RAE2008 income was £6.3M for 33.97 research staff (around £28k per capita per annum) The £1.7M income for this REF period equates to an annual per capita value (for 13 staff) of £26k . As can be seen from the table below, the per capita income is relatively stable:

Year	00/01*	01/02	02/03	03/04	04/05	05/06	06/07	08/09	09/10	10/11	11/12	12/13
£(k)	673	1159	1810	983	686	454	570	468	188	339	413	298
Per capita	20	34	53	29	20	13	17	36	14	26	32	23

*Partial

The research strategy focuses on a hybrid revenue stream including EU projects and UK funding: EU: £878k, KTP: £493k, JISC: £251k, HEA: £22k, other sources: £70k.

EU funded projects have included interdisciplinary projects*: Bowerman* - FP7 Excellence in Mobility, International Cooperation; *Hall* - FP6 eCIRCUS and FP7 eCUTE; *Ginty* - FP6 STASIS; *Stokoe* - FP6 Vidipedia-2 and *Oakes* - FP7 Vitalis.

UK funding includes *Oatley* - EPSRC funded Medusa project; *Erwin* – EPSRC funded MiCRAM project; *Kerridge* and *Ginty* - JISC projects (C4D, RMAS); *Edwards* and *McDonald* - Sunderland City Council's Digital City; and 21 academic staff involved in KTPs.

Future Funding Plans: We will continue to target funders who support applied research such as the Technology Strategy Board. In addition we will target funding bodies such as EPSRC for any basic research activities and Horizon 2020 to continue established and new European

collaborations. To generate sets of research studentships to support our full time traditional PhD students we will apply to Marie Curie, Erasmus Mundi and British Council funding streams.

CONSULTANCIES AND PROFESSIONAL SERVICES

£637k income has been generated, independent of SSC. Examples include: *Bowerman* - elearning with Training in Care; *McDonald* - usability testing for Nexus and others; *Panchev* - interpreting large data sets for Performance Horizon Group Ltd.

e. Collaboration and contribution to the discipline or research base

COLLABORATIONS

International impact: examples include:

- *Bowerman's* research with the Turkish National Police, Counter Terrorism Analysis Unit in criminal networks had impact in the discovery of criminals/terrorists in Turkey.
- *Ginty's* CERIF for Datasets project has resulted in the development of a European standard for research information systems.

International collaborations (projects)

- *Bowerman's* interdisciplinary projects: International Collaboration in Computing & Engineering, and Excellence in Mobility with university partners in the EU (Algarve, Sunderland, Hagen) and the USA.
- *Ginty's* collaboration with German, French, Italian, Chinese and Spanish partners on STASIS enables semantic interoperability between businesses, particularly SMEs.
- *Ginty* and *Kerridge* collaborated with representatives from euroCRIS, EPSRC, NERC, University of Glasgow, and University of St Andrews in the JISC projects IRIOS-2, CERIF for Datasets to develop Research Management Tools.
- *Hall, Tazzyman, Humphries* and *Jones'* eCircus and eCUTE interdisciplinary research projects with partners including Interagens (an Italian SME), the Universities of Augsburg, Heriot Watt, Wageningen, Seikei and Kyoto.
- Archival approaches and data mining - the focus in Vidipedia-2 and *Oakes'* Vitalis project with BELGA (Belgium), INA (France) and ITR (Germany).

International collaborations

- *Davies's* outputs result from work with the University of Hong Kong (global top 35 universities).
- *Hall* and *Jones:* intelligent agents collaboration with the University of Baja California (Mexico) leading to staff/student exchange opportunities.
- The Sunderland-Washington DC Friendship Agreement includes formal interactions with the universities there, providing collaboration opportunities e.g. via sabbaticals/visits.

National collaborations:

- *Tindle* and (Visiting Professor) *Mellis* at BT awarded an EPSRC CASE studentship to develop efficient telecoms network layout tools (linked to REF3 BT case study).
- Resulting from professional doctorates *Smith* collaborates in health informatics with: a Royal College of Surgeons member (integrated risk systems in the NHS) and a Sunderland Royal Hospital chief pharmacist (novel electronic prescribing and robotic dispensing system). This work was recently discussed with a Chinese delegation in Dublin.
- *Oatley's* EPSRC Medusa project, focused on the use of CCTV to combat gun crime and collaborated with ACPO CCTV/ Video Working Group CCTV User Group, Forensic Alliance Ltd, Greater Manchester Police, Metropolitan Police, National Firearms Centre.
- *Hall* is a founding member of the interdisciplinary EPSRC RIDERS, Interactive Digital Storytelling network.

Regional:

- There is extensive collaboration regionally through SSC. For instance nine KTPs over the period (involving 21 academics), three were rated as outstanding: Tait Walker in money laundering and fraud (*Irons*, *Dunne*); Orchidsoft internet technology using with best practice

design & development techniques (*Nelson*, *Gandy*); and Imprint Creative Solutions to develop a virtual reality MIS system (*Nelson*, *Warrender*, *Hall*).

- *Bowerman*, *McDonald* and *Irons* work with Durham and Northumbria Police Forces investigating Computer Forensics and fraud, and are currently seeking funding with them as partners.
- *Warrender* has given invited presentations on our High Performance Cluster to the BCS and SOCITM (the association for ICT professionals in local authorities, the public and third sectors, and their suppliers). He works with a university pharmacy team to optimise their drug discovery working using Gaussian molecular modelling on the cluster.
- *Edwards* is a founding member of North East Research in Information Systems (NERIS) an academic network currently focused on developing an effective evidence-based paradigm for information systems.

Industrial collaborations:

- Funded consultancy (e.g. *Bowerman's* elearning with Training in Care; *McDonald's* usability testing with Nexus, NE Business Innovation Centre);
- Pro bono collaborations (e.g. *Jones* on user experience and cultural heritage with Local History North East).

USERS – INDUSTRY, RESEARCH AND STRATEGY

A strategic aim is to "impact on local economy and industry." This is driven through Sunderland Software City (see REF3 Impact case study). *Hall*, *Irons* and *Smith* have leading roles alongside industry and partners, including Sunderland City Council. Our three research strands have been devised through consultation, with big data a key topic for both the City Council and many SMEs, and an area we are seeking to grow in response to this need. Our focus on KTPs also reflects research users' needs and requirements for the translation of knowledge into SMEs

ACADEMIC LEADERSHIP

We are involved in:

- Editorial Boards as members, e.g.: *Panchev* – peer review editor of Journal of Neural Computing and Applications; *Smith* - International Journal of Doctoral Studies; *Bowerman* - International Journal of Web-based Communities; *Hall* - International Journal of Technology Enhanced Learning).
- Conference leadership roles include *Edwards's* steering committee membership (2007-12) Tutorials Chair (2009) of IEEE Conference on Software Engineering Education and Training.
- Peer reviewing papers, brief examples include (i) journals: *Davinson* - Computers in Human Behavior; *McGarry* - Knowledge-Based & Intelligent Engineering Systems (ii) conferences: *McDonald* - ACM CHI; *Hagan* - UKAIS;
- Accreditation of governmental research units, e.g. *Davies* - Expert Panel Chair and Member, Accreditation Council of the Agency for Science and Higher Education, Croatia.
- Peer reviewing grant proposals such as *McGarry* for UKRC - BBSRC Tools & Resources fund & MRC grants; *Davies* as project proposal evaluator, mid-term project reviewer and ERA-NET evaluator, EU Framework Programme 7 (2010-2013); *Tazzyman* for ESRC.
- Invited presentations include *Jones*'s Workshops on Computational Modelling and Complex Systems (WCMCS) in 2009 and 2012, *McDonald* invited to give tutorial at BCS SIG in IR Search Solutions 2013.
- Professional bodies, examples: Irons is Vice Chair BCS Cybercrime SIG (2008 – present), FBCS (*Edwards, Irons, Smith*), FHEA (*Hall, Irons, Nelson, Warrender*), FRSA: *Humphries*, Member of UKAIS/AIS: *Edwards,* Member of BPS *Tazzyman, McDonald (CPsychol)*.

Awards and prizes

- *Hall's* DIMPLE software was selected for the Home Office INSTINCT TD3 Augmented Reality trials and resulted in her winning the Blueprint Knowledge Transfer Award at the University level and Highly Commended (3rd) in the regional competition.