Environment template (REF5)

Institution: Edinburgh Napier University

Unit of Assessment: 11 Computer Science and Informatics

a. Overview
Research in Computer Science and Informatics at Edinburgh Napier University is structured and managed through the Institute for Informatics and Digital Innovation (IIDI). In 2010 Edinburgh Napier University embarked on an ambitious strategy to focus all research, knowledge transfer and commercialisation activities through institutes aligned with key sectors of the Scottish economy. IIDI was established in 2010 under the directorship of Professor Jessie Kennedy. It provides a central infrastructure and unified vision for research, knowledge exchange, commercial activities and public engagement in computer science and informatics across five research centres: the Centre for Distributed Computing and Security; the Centre for interaction Design; the Centre for Emergent Computing; the Centre for Information and Software Systems; the Centre for Social Informatics. These centres work very closely together and do not constitute separate research groups as defined in the REF. Accordingly this environment statement concerns the work of IIDI with the exception of work in the Centre for Social Informatics which is returned under Unit of Assessment 36.

Members of IIDI teach in the School of Computing ensuring that the results of research inform the taught portfolio. They are also active within the Scottish Informatics and Computer Science Alliance (SICSA). SICSA is a collaboration between all fourteen Scottish universities involved in informatics and computer science research and education, partly funded by the Scottish Funding Council (SFC). It exists to encourage collaboration across universities and to work with government and industry to achieve research excellence. SICSA provides funds to encourage collaboration across its members, to support visiting fellows, seminars and meetings and to support PhD students.

b. Research strategy
In RAE2008 Napier University's return in Unit of Assessment (UoA) 23 (Computer Science and Informatics) stated that the aims for the assessment period 2008 – 2013 would be to build on the strengths of well-established research groups in the unit and to invest in more staff time for research. The submission expected that both the engineering side and the design side of computing would develop.

The vision of IIDI is to be a recognised institute of excellence, a preferred partner for industrial collaborations and knowledge exchange and to deliver internationally excellent and world-leading research to underpin teaching in the School of Computing. IIDI has 7 key objectives: to improve the quality rating of our research; to increase commercial income; to increase research income; to improve the research environment; to improve our external presence; to increase PhD numbers; to improve research-teaching linkages. We recognise that increasing commercial income is a critical part of the strategy since the unrestricted income derived from this work can be invested in research. Since 2008 average annual income has risen from £533,000 pa to £941,400 pa. Commercial income has nearly tripled since IIDI was founded in 2010 and research income (spend) has risen from under £800,000 in 2010 to nearly £1.3m in 2012. The strategy of increasing commercial income is vital for IIDI to achieve its vision.

IIDI aims to provide a highly supportive environment for PhD students and for research assistants and fellows (see section c). Another part of the IIDI strategy is to nurture and exploit the intellectual property generated by PhD students and we have been highly successful in producing spinout companies as described in REF3a. These are now delivering income to feed back into new studentships and PhD fee waivers. IIDI typically spends 35% of its disposable budget of £330,000 on PhD student support. IIDI also funds an intern programme (7% of budget) for final year undergraduates to work on specific research projects.

In the Institute there are twenty-one academics, twenty-two research staff (including four senior research fellows and four KTP associates). Forty-eight students are currently studying for research degrees. Thus the institute has a vitality and critical mass that is able to support individuals working

in specialist areas and cross-centre interdisciplinary work. Our strategic objective of improving the quality rating of our research has resulted in the submission of over 50% of IIDI's academics to the REF.

IIDI has developed a highly innovative database-driven management system of all research, knowledge transfer, commercialisation and public engagement activities that have occurred since IIDI was established in 2010. It records details of research projects classified by type and source of funding. This includes the award of over 50 "innovation vouchers" that provide up to £5000 to the university for knowledge exchange activities with SMEs, 9 European Commission (EC) funded projects and 10 research council awards. IIDI provides peer review of research proposals and coordination of European Union funding opportunities and takes full advantage of its emeritus professors to support younger researchers.

Twice a year the IIDI board meets to review progress and to monitor planning. The board is attended by senior members of the University and by an advisory board of seven leading industrialists from the Scottish computing industry. Dissemination is another key objective of our research strategy and we regularly host conferences and symposia. IIDI has its own seminar series, 'Tech Talks', where lectures are presented by external and internal speakers.

The Research Centres

IIDI consists of five research centres, four of which are returned under this unit of assessment. A Professor or Reader leads each research centre. He or she is responsible for managing the budget and providing leadership and vision. Academic staff, researchers and PhD students belong to centres. Centres have regular meetings and develop their own work to contribute to the IIDI strategy.

The Centre for Emergent Computing has played a significant role in achieving the IIDI objectives of improving external presence, improving quality and increasing research income. The Centre has led three EC-funded coordination actions (PIs Prof Hart and Prof Paechter) during the assessment period, on Pervasive Adaptation, Self-Awareness in Autonomic Systems and Fundamentals of Collective Adaptive Systems. These actions tasked with building new communities and defining future research agendas have placed the Centre at the heart of research in Europe in self-adaptive systems. Paechter was invited by the European Commission to lead a consultation that led to the defining of the 23M€ Proactive Initiative in Collective Adaptive Systems and the Centre continues to run the EvoStar conference series consisting of 5 co-located conferences and 13 workshops. Hart's influential work in Artificial Immune Systems (AIS) has led to world-wide recognition for the Centre leading to an invitation for her to attend a Royal Society Frontiers of Science meeting in Russia as one of only three computer scientists from the UK. A paper she authored in 2008 setting out a research agenda for the AIS field (10.1016/j.asoc.2006.12.004) has over 250 citations in Google Scholar and is one of the top three most cited articles from the journal. She also leads work across Scotland in bio-inspired computing, as leader of the SICSA sub-theme in this area, with members from all Scottish Universities. The Centre maintains an international membership, regularly hosting visiting PhD students and researchers from across Europe, through the HPC-Europa Programme and in light of its reputation.

The Centre for Information and Software Systems has continued to consolidate its international leading position in developing novel and effective solutions for emerging software and information systems contributing to the IIDI strategic objectives of improving research quality and knowledge transfer. Prof Kennedy leads the work on information visualisation (IV) and data-intensive systems with applications primarily in biology and was appointed an IEEE Visualisation Pioneer in 2013. Her work in collaboration with taxonomists in the Royal Botanic Garden Edinburgh and a NSF-funded e-Science project, Science Environment for Ecological Knowledge (SEEK) is the subject of one of the impact case studies described in REF3b. Kennedy plays a pivotal role in biological visualisations (BioVis) being programme chair for the IEEE BioVis symposium in 2011 and general chair in 2012 and 2013. She was invited speaker at a BBSRC challenges
in Biological Visualisation workshop and has recently been invited to lead a BBSRC network on BioVis. Dr Liu works on context-aware pervasive services, agile services and cloud service

evolution. His approach has been highly recognised by the international research community and contributed to the award of a joint international project grant from Royal Society and NSFC of China. Liu has edited two important research handbooks. The recent arrival of Prof Mitchell from Disney Corporation as a 0.2 appointment will greatly strengthen the work in games design (with Dr Chalmers), computer graphics and software engineering.

The Centre for Distributed Computing and Security focuses on the key issues in the area including forensic computing systems, ad-hoc routing, mobile internet and mobile agents and has been particularly effective in achieving IIDI's objectives of improving research, increasing commercial income and enhancing research into teaching. Prof Buchanan's work has attracted central Scottish government funding through the proof of concept scheme (PoC). This scheme provides significant funding (£100k - £300k) to develop promising ideas to near market readiness and has resulted in two spinout companies (see REF3a). Buchanan leads Edinburgh Napier's involvement with the Scottish Institute for Policing Research and organises regular symposia on cyber crime and the future of e-Health that attract 150 – 250 external delegates from industry and academia. Dr Al-Dubai, who has recently been appointed to Reader, has developed a significant international reputation for his work on advanced networks, particularly wireless mesh networks and has been recognised for his leadership of the IEEE International Conference on Ubiquitous Computing and Communications. Dr Romdhani's work is also in this area and has resulted in a patent for a novel network architecture. He also has important cross-centre collaborations around parallel architectures with Chalmers.

Research in the Centre for interaction Design focuses on new methods, paradigms and modalities of interaction and on user experience, within a wide range of computationally enhanced environments. CiD has contributed significantly to increasing IIDI's research income through consultancy and contract research work on multi-touch interaction and interactive room environments including work for the Norwegian National Museum. The Centre has attracted significant funding from the EC. Prof Benyon led Edinburgh Napier's involvement in the Companions EC-funded Integrated Project (2006 – 2010; value to Napier, £1m), looking at concepts of artificial companions and is CI on the FI-Star project (2013 – 2015; value to Edinburgh Napier £500k) project in digital health. Both Dr S Turner and Dr P Turner are active in the area of presence research and hosted the annual conference of the International Society for Presence Research in 2012. P Turner also contributes to HCI theory, recently completing an invited monograph for the prestigious Morgan and Claypool Lecture series edited by Prof John Carroll.

Conclusion: The Future for Computer Science and Informatics Research at Edinburgh Napier University

Looking forward, the work of the Institute will continue to form the basis of Edinburgh Napier's academic excellence in computer science and the provision of specialist educational provision. The highly successful strategy of working with SMEs, obtaining commercial income and using the profit on this to supplement research funding, will be maintained. The Institute's five centres will continue, broadly, with their current focus. We will seek to grow the number of PhD students in line with the University's ambitious target substantially to increase PhD students by 2020. It is intended to grow the Digital Health theme with funding from Horizon 2020 where digital health is specifically identified. The Institute will also continue to play a leading role in the Future and Emerging Technologies programme of Horizon 2020 through the areas of urban interaction design and of autonomous and adaptive computing. Work in visualisation is expected to grow, particularly in BioVis and data analytics. Institute research is also well aligned with the current TSB strategy where Data Exploration, User Experience, Confidence in Distributed ICT and Software Engineering are the key themes. A SICSA-led Scottish innovation centre, Data Lab, will also support work in this area.

c. People, including:
  i.   Staffing strategy and staff development
     Resources

Each member of staff actively undertaking research is allocated a research time allowance from a central, Faculty level resource managed through IIDI. This typically amounts to 20% of time. Additional time for research can be provided where staff are paid from externally funded projects or through the profit from commercial contracts, a proportion of which comes back to IIDI.

Funding from the EC and UK research councils has been vital in delivering resources for research. IIDI's policy of developing ties with European collaborators in industry and in academia has been highly successful, with nearly £2m of EC funds received during the assessment period. The cumulative effect of these collaborations has been felt across IIDI. EC funding under Horizon 2020 will continue to be an important component of its income along with the UK Research Councils, particularly in BioVis and the digital economy.

IIDI's management board allocates resources. Some funds are kept centrally to cover administrative costs, research degree fees, bursaries and interns. The policy throughout the assessment period has been to use this to target early career researchers. Additional resources are also provided for directors of the centres and others who provide a mentoring role. The remaining funds are allocated to centres broadly in proportion to their membership, biased towards those bringing in external income. The centres provide a home for academics and research students and manage their income to fund travel to conferences, to employ research assistants and to buy specialist equipment.

Staffing

University policy is moving towards appointing PhD qualified academic staff with the aim of ensuring that an increasing proportion of academics are research active. The University has a promotion process to encourage staff development with merit-based promotions to reader and professor. The Strategic Approach to Effective Researcher Development, endorsed in September 2011, takes an inclusive approach to the development of early career researchers, to include research students, their supervisors, as well as early career and established researchers. A dedicated full-time Researcher Developer role was established in Dec 2011.

Equality and diversity are priorities for a University with a female Vice-Chancellor, a Faculty with a female Dean, a School with we have a female head and an Institute with a female Director. The Connect scheme at the University is aimed at women studying computing and we host the Scottish Resource Centre for Women in STEM. The University has a detailed equality and diversity plan. Prof Hazel Hall leads work on the Athena Swan Charter for women in STEM.

EC HR Excellence in Research Award

The EU HR Excellence in Research Award recognises a commitment to the principles of the Concordat to support the career development of researchers. Edinburgh Napier University received the award in December 2010. We gained the award through a detailed gap analysis of our existing policies followed by the development and implementation of a robust action plan. This had taken into account the views of researchers at all stages. In December 2012 we successfully retained our award for a further two years due to our continued progress against our Concordat Action Plan. As part of our commitment to the Concordat we have created a Concordat Working Group that comprises researchers at a variety of career stages. This provides a further route for communication between researchers and the University, with the working group reporting directly to the University's Research and Knowledge Exchange Committee.

Recruitment, Selection and Promotion

Capacity building for research sustainability is central to all aspects of work in the unit of assessment. We adhere to HR good practice in staff recruitment and promotion in line with university policies and use a Personal Development Review (PDR) process to identify specific staff development needs. Our approach has three key elements: the recruitment of experienced researchers to enhance existing areas of excellence and provide research leadership; the

recruitment and development of junior staff with a demonstrable research potential; and the development of existing staff through active participation in events, mentoring and development programmes tailored to staff in the unit, as well as in those offered at University level

Staff development strategy
In 2011 a gap analysis on our training and development provision for researchers was conducted using the Researcher Development Framework (RDF) created by Vitae. All events in the Researcher Development Programme are mapped against the RDF so that researchers can obtain comprehensive development to support their own career development and planning. An extensive programme of approximately 20 events per trimester has been developed. These are all tailored to our researchers and comprise relevant sessions for all stages of a research career. The programme has helped foster the research culture across the University by bringing researchers together to share best practice. All sessions are evaluated by the researchers, which allows us to maintain the relevance of the session to the development needs of the researchers. As part of the creation of the Researcher Development Programme we have further increased our online provision of resources. We now have tailored online provision covering induction to the University and research ethics and integrity. Using the Researcher Development Framework graphic we have created a dynamic portal for researchers to identify their own development needs and help with their career planning.

In December 2012 the University held a researcher development conference on *'Supporting Researchers at Edinburgh Napier'* which was attended by over 45 researchers and was well received by researchers from all career stages. Through such events as these conferences we continue to build the research culture of the University. Our achievements have already been recognised nationally through a THE award in 2010 for Outstanding Support for Early Career Researchers (Edinburgh Napier chaired the award-winning team, the Universities Scotland Research Training Sub-committee).

Visitors

IIDI has hosted a visiting PhD student from Universita di Modena e Reggio Emilia and at least 5 students via the HPC-EUROPA Transnational Access programme - who requested to receive expert supervision at Edinburgh Napier while making use of high-performance computing facilities at the European Parallel Computing Centre. We have also hosted visiting professors from Constantina University, Algeria and Tsinhua and North China universities in China. John Howie recently based at Microsoft and Blaise Cronin from Indiana University are currently visiting professors.

ii.   **Research students**
Against the background of increasing stipends and changes to EPSRC policy, IIDI has pursued a policy of supporting PhD students from its central funds and developing joint programmes with Yunnan Economics University, China and King Abdul Aziz University in Saudi Arabia. IIDI studentships are advertised once or twice a year and through a competitive interview process, the best students are selected and allocated to supervisors in one or two of the centres.

Each research student is allocated a thesis panel consisting of three academics — a director of studies (DoS), a second supervisor (SS) and a panel chair who comes from outside the research area. There must be a minimum of two PhD completions between the DoS and SS. Regular supervisory meetings between the DoS, SS and student are held. The panel meets formally twice a year and produces a report on progress that is considered at the School of Computing's research degrees committee that also meets twice a year. This committee monitors the progress of each student against a clear timetable of expected outputs from the thesis work, makes recommendations concerning progress and passes key information to the Faculty committee.

A Faculty-wide programme of research training has been established for all PhD students. This covers the essential issues and milestones over the three years of study and ties in with the record of postgraduate development and skills audit that is maintained by each PhD student. School and Faculty level PhD conferences are held annually. The University provides additional support for research degree students. It appoints external examiners, scrutinises the composition of

supervisory panels and ensures appropriate resources are available.

The SICSA Graduate Academy provides a range of PhD activities with an annual conference, support for meetings and travel and opportunities to supervise across the Scottish universities. Al-Dubai co-supervises a student at Glasgow University and a professor from Edinburgh University is on the supervisory panel for a PhD student in CiD. The SICSA PhD conference is a 2-day event that attracts over 150 computer science PhD students annually. IIDI staff and students organise, attend and present at the conference

d. Income, infrastructure and facilities

Edinburgh Napier University provides all the infrastructure support for research that would be expected from a research informed university including excellent library access, financial, human resources and research offices. There is a Faculty Assistant Dean (Research and Innovation) who leads research initiatives across the faculty.

During the period the Faculty invested £150,000 in a 'future meeting room' facility to support work in the area of interactive collaborative environments and established an auralisation suite (approximately £50,000) to support interdisciplinary work across computing and the built environment in this important growth area. A high performance cluster was commissioned at a cost of £20,000 to support optimisation research. IIDI also has invested in its own cloud infrastructure.

Overall income has increased from £683,900 in 2010/11 to £1,304,373 in 2012/13 thanks largely to the IIDI strategy. Just over 40% comes from the EC through their Framework Programmes and 16% from Research Councils. Consultancy and contract research has been an important part of IIDI's income with over £150,000 earned from consultancy and over £300,000 from contract research coming from both government bodies and UK industry. Many of these industry contracts are with large multi-nationals, particularly as a result of the research arising from investment in the future meeting room, such as AstraZeneca, Enquest, Blue Rubicon and Logica (now CGI).

e. Collaboration and contribution to the discipline or research base

International collaborations (excluding standard EC-funded projects)
Benyon; Contract research with National Museum, Norway.
Liu: RSE and China NSFC joint project on evolution of cloud service architecture.
Mitchell: Disney UK collaborations with Studio Gobo, BBC, Technicolor, Orange, Thales, Barco, Fraunhofer, RBB, DFKI, NVIDIA;
Paechter: Member of the Management Advisory Group for the FuturICT FET Flagship candidate;
Romdhani: Founder of the open real-time mobility European initiative, REALMv6
International Reviewing
Al-Dubai: Grant reviewer, Omani Research Council
Benyon: Reviewer. Laboratories of Excellence (LABEX) National Research Agency, France; Luxembourg National Research Fund (FNR); Ontario Research Fund.
Hart: Grant Reviewer, Superior Council of the National Fund for Scientific & Technological Development, Chile (FONDECYT)
Kennedy: Grant Reviewer Austrian Science Foundation; Science Foundation Ireland panel member; Swedish Computer Science Funding Council panel member
Liu: Grant Reviewer, Swedish Research Council
Mitchell: Vienna Science and Technology Fund Reviewer
Paechter: European Commission, FP7 Project Reviewer and Evaluator
Romdhani: Reviewer of 3 Internet standards; reviewer for Internet Engineering Task Force
S Turner: Member of the ergonomics standards panels PH/009 Applied ergonomics (BSI) and ISO/TC 159/SC 4/WG 6 (ISO)
Consultations on EC funding
Al-Dubai: invited to participate in the discussion related to the 10 year rolling agenda on Smart Cities, Budapest, 5-6 June 2013.
Benyon: Invited participant at EC Research and Development Programme Framework 7 workshop on Human-Computer Confluence, 2011
Hart: Invitation to participate in consultation meeting by EC on Fundamentals of Collective Adaptive Systems that led to defining of Proactive Initiative within FET programme, FP7
Paechter: Chair of the European Commission Consultation on Fundamentals of Collective

Adaptive systems.

International PhD examining (as external):

Al-Dubai: University of Sydney (2)

Benyon: University of Uema, Sweden; University of Limerick, Ireland: Indian Institute of Information Technology, Allahabad; Indian Institute of Technology, Guwahati

Hart: Hong Kong Polytechnic, University of Pretoria, South Africa, Swinburne University of Technology, Australia

Kennedy: Linnaeus University, Växjö, Sweden; Univ. of Leiden, Netherlands

Turner, P. University of Tampere, Finland

Journal Editorial Board Memberships

Al-Dubai: Future Generation Communication and Networking Journal.

Benyon: International Journal of Cognitive Performance Support; International Journal of People-Oriented Programming; Expert Systems: The Journal of Knowledge Engineering; PsychNology; Knowledge-Based Systems.

Hart: International Journal of Natural Computing Research; Associate Editor of the International Journal of Metaheuristics.

Liu: International Journal of Software Architecture; International Journal of Software Reuse; Journal of Computers; International Journal of Software.

P Turner: Interacting with Computers; AI & Society; Open Journal of Ergonomics.

Paechter: Associate Editor of Evolutionary Computation.

Conference Chairs

Al-Dubai: Programme Chair of the IEEE International Conference on Ubiquitous Computing and Communications, IUCC-2013, IUCC-2012, IUCC-11.

Hart: Technical Chair, IEEE Congress on Evolutionary Computing 2009; General Chair ICARIS 2010; Technical Chair Bionetics 2011.

Kennedy: General chair BioVis 2013, BioVis 2012; Programme Chair BioVis 2011.

P. Turner: Chair International Society for Presence Research annual conference, ISPR 2011; co-chair European Conference of Cognitive Ergonomics, ECCE 2012.

S. Turner: Programme Co-Chair ISPR 2011, Co-Chair ECCE 2012.

National Funding Bodies

Benyon: Member Research Excellence Framework (REF) sub-panel 11.

Benyon, Hart, Kennedy: Member of EPSRC Peer Review College.

Kennedy: EPSRC Funding Panel Member; EPSRC Funding Panel meeting Chair (x4); BBSRC Funding Panel Meeting Member (x3).

Mitchell: EPSRC User Panel; Digital Economy Review Panel Member.

Awards, Prizes

Hart: Invited participant in Royal Society Frontiers of Science, Kazan 2013.

Liu: The FlexiCAGE project and its spinout won "Highly Commended" in IET Innovation Awards with the entry of Edinburgh Napier University, 2010.

Mitchell**:** BAFTA 2010 for Boom Blox video game: 10 Disney Inventor Awards (10 further pending at present).

Keynotes

Al-Dubai: The Low Carbon Earth Summit 2012, Guangzhou, China; The 2nd Annual International Congress of U-World, Dalian, China 2012.

Benyon: 27th Annual British HCI conference, 2013; International Conference on Intelligent Multimedia, Allahabad, India 2012; Interacting with Immersive Worlds: Third Brock University Conference on the Interactive Arts & Sciences, Canada 2012.

Kennedy: 16th International Conference on Information Visualization, IV 2012 Montpelier; VIZBI 2012, European Molecular Biology Laboratory, Heidelberg; 7th International Conference on Collaborative Data Visualisation, Mallorca, 2010.

Mitchell**:** Eurographics UK 2013.