

Institution: University College London
Unit of Assessment: C16 Architecture, Built Environment and Town Planning
a. Overview

The Bartlett Faculty of the Built Environment is one of 10 faculties of University College London. Its coverage mirrors that of the C16 sub-panel and the whole faculty is therefore being submitted as a single UoA. The Bartlett has 9 research groups across its 8 administrative sections:

- **Architecture Research Group (ARG)** in The Bartlett School of Architecture (BSA)
- **Centre for Advanced Spatial Analysis (CASA)**
- **Construction and Project Management Research Group (C&PMRG)** in The Bartlett School of Construction and Project Management (BSC&PM)
- **Development Planning Research Group (DPURG)** in Development Planning Unit (DPU)
- **Space Group (SG)** in The Bartlett School of Graduate Studies (BSGS)
- **Complex Built Environment Systems (CBES)**, also in BSGS
- **Planning Research Group (PRG)** in The Bartlett School of Planning (BSP)
- **UCL Energy Institute (UCL-E)**
- **UCL Institute for Sustainable Resources (UCL-ISR)**

In RAE 2008, The Bartlett submitted 72.12 FTE staff altogether (i.e. ARG, C&PMG, SG and CBES put in 49.62 FTE to UoA30; while DPURG and PRG put in 22.5 FTE to UoA31). Now for REF 2014, The Bartlett has a single submission of 136.26 FTE staff, with 32.23 FTE from ARG, 6.5 FTE from CASA, 13 FTE from C&PMRG, 16.2 FTE from DPURG, 9.35 FTE from SG, 16 FTE from CBES, 27.5 FTE from PRG, 16.03 FTE from UCL-E/UCL-ISR. In terms of the number of research staff, there are 151 people being returned (42 Professors, 8 Readers, 31 Senior Lecturers, 56 Lecturers and 14 Researchers). This comprises 94% of our eligible staff headcount.

Since 2008, research staff in The Bartlett have produced 4 artefacts, 183 building designs, 205 books, 665 book chapters, 958 conference papers, 229 exhibition works, 63 internet publications, 1,646 journal essays, 17 journal special issues, 57 other research outputs, 1 patent, 265 reports, 3 pieces of software and 87 working papers.

b. Research Strategy

In our RAE 2008 submission we said that our goal over the next 6 years would be to create a milieu in which a creative design culture and a science culture could 'interact in imaginative and scientific innovation, while preserving the excellence and integrity of each'. To deliver that vision, we set out 6 main aims:

- (1) To develop cross-disciplinary research grounded in expertise;
- (2) To address major real-world issues;
- (3) To strengthen links to practice and the built environment professions and industry actors;
- (4) To develop research leadership through excellence in individual curiosity driven research;
- (5) To provide education imbued with world-leading research;
- (6) To increase the impact and influence of 'London's Global University' through our research.

In 2008, the scale and diversity of The Bartlett was already comprehensive in terms of the scope of its research methodologies, subjects and areas of expertise, with its scholars being drawn from disciplinary backgrounds that spanned Science, Engineering, Social Sciences, Arts and Humanities, Economics, Finance and Design. However, we also faced a number of challenges. The faculty structure within UCL had previously been largely devolved to departmental units, and investment and growth was driven by individual disciplinary considerations. There were severe staffing imbalances, a student/staff ratio of over 20:1, insufficient administrative support, drastic space shortages, and general turbulence in the sector - following the 2008 financial crisis - which led to removal of the HEFCE T grant and major changes to the student fee regime.

A change of Dean in 2009 (Penn, SG) coincided with UCL moving from a resource allocation model, appropriate to block-grant funding, to an income-and-expenditure model better suited to the new competitive fee regime. This new model enables planned investment justified by investment returns set out in business cases. In response, The Bartlett has simplified its strategy to just two

Environment template (REF5)

headline objectives: 1) '*To invest in the excellence of our parts*', and 2) '*To make the whole greater than the sum of the parts*'. Investment plans, mainly funded through a strategic increase in postgraduate student numbers, were put in place to redress historic staffing imbalances, allow significant capital spending on buildings/facilities/equipment, and provide our required contribution to UCL's central strategic fund. This is governed by a planning process that integrates research, teaching and enterprise within a rolling three-year financial plan, approved at College level.

The result has been a notable shift in culture in The Bartlett, with a dramatic rise in confidence amongst staff who have the aspiration - and the time and resources required - to set a strategic agenda as much as to respond opportunistically. Coinciding with UCL's rise in the international university rankings, and London's increasing attractiveness as a global hub for the built environment sector, it makes The Bartlett an attractive location for scholars from around the world - as is reflected in recent appointments at all levels, as well as by growth in PGR numbers.

Developing our critical mass: Since 2008, The Bartlett's expansion has been shaped by our academic aims to increase diversity within our existing disciplines and to deliver real-world impacts via cross-disciplinary research. Size enables diversity to happen, which fosters critical debate, hence our strategy of controlled growth. The Bartlett has taken full advantage to address a number of long-standing challenges and to open up new research directions. Important examples include:

- 1) Focusing expertise in *energy and sustainability* by establishing both the UCL Energy Institute (UCL-E) and the Institute of Sustainable Resources (UCL-ISR), and by new appointees in DPU who are addressing the ethical issues of urban sustainability in developing countries;
- 2) Expanding the potential of *digital technologies for architectural design and urban analysis*, firstly by bringing CASA, with its leading expertise in digital visualisation techniques and spatial understanding, fully into the faculty, and by developing skills and capacities in digital fabrication and performance design through new staff in BSA and BSGS;
- 3) Intensifying expertise in contemporary issues around *governance, regeneration and property* by developing our research capacity in real estate, project management and infrastructure through key appointments in BSC&PM and BSP;
- 4) Enhancing our expertise in *architectural history and cultural heritage* by bringing the renowned Survey of London to the BSA, thereby taking responsibility for a valuable national research asset threatened with closure by the UK Treasury's comprehensive spending review.

Developing our Capacity for Cross-Disciplinarity: The Bartlett aims to tackle the most challenging research issues within the built environment - yet we are also aware that much of this work sits on the boundaries between conventional disciplines, and thus requires methodological and conceptual innovation. We regard cross-disciplinarity as having three modes: multi-disciplinarity (where disciplines come together to approach problems but each maintains its distinct research methods); inter-disciplinarity (where gaps in knowledge between traditional research methods are analysed and new hybrid methodologies evolve); and trans-disciplinarity (which develops whole new participatory methods of discovery and exchange). These goals are also closely linked to UCL's Research Strategy which seeks to 'deliver a culture of wisdom', in which wisdom is defined as 'the judicious application of knowledge for the good of humanity'. UCL has thus set out four Grand Challenges (*Sustainable Cities, Intercultural Interaction, Wellbeing, Global Health*) in the belief that 'solutions to complex and systemic problems emerge only when different kinds of expertise and methodologies are brought together'. The Bartlett is directly involved in many of these UCL-wide initiatives to promote cross-disciplinarity, as shown by these examples:

- 1) *UCL/Lancet Commission on Healthy Cities* - led by Rydin (PRG), with a multi-disciplinary team drawn from medical and non-medical disciplines across UCL that also included other Bartlett researchers such as Lim (ARG), Davila (DPURG) and M. Davies (CBES);
- 2) *UCL Urban Laboratory* - under the directorship of Campkin (ARG) since 2011, and involving, alongside several Bartlett staff, many scholars from Geography, Anthropology, English, and Civil and Environmental Engineering who are engaged together on inter-disciplinary approaches to themes like social housing, public engagement and urban regeneration.
- 3) *Urban Buzz* (2007-09) - led by Penn (SG), which adopted a trans-disciplinary approach to ensuring the impact of sustainable communities research in 28 projects valued at around £7.75m and involving over 168 academic and 191 non-academic investigators from UCL, UEL, the UK and overseas. Although it began during the RAE period, its projects continue.

Environment template (REF5)

To achieve our goals, The Bartlett seeks to nurture its diversity of perspectives by operating a 'federal' approach in its Research Advisory Group (RAG), which has in turn helped to overcome the disciplinary divisions noted in the RAE 2008 submission. The framing, implementation and monitoring of the Faculty Research Strategy is overseen by monthly RAG meetings chaired by the Vice-Dean of Research (Fraser, ARG), and which involve the Dean, Directors of Research (DoR), Faculty Business Development Manager, and representatives from UCL's support team in the Office of the Vice-Provost (Research). The latter group of UCL Research Facilitators helps our staff to identify and prepare funding applications, acting as a conduit to funding agencies. The resulting culture enables each research group to develop its own research priorities and initiatives along with other Bartlett groups - as well as with UCL, HEFCE and wider bodies - in response to societal, governmental and enterprise agendas. Public awareness of our research is promoted through our Bartlett Communications Strategy, led by the Vice-Dean of Communications (Borden, ARG), with support also from specific staff with a focus on media and publicity in each research group.

Each of the 9 research groups in The Bartlett therefore possesses its own distinctive profile and culture within our common strategy. The **ARG**, for example, clusters its activities around six broad themes: (1) *History and Theory of Architecture*; (2) *Building Projects*; (3) *Sustainable Urbanism*; (4) *Craft, Technology and Computation*; (5) *Histories and Practices of Ecology*; and (6) *Speculative and Performative Design*. Each incorporates research that is conducted through design-led, historical and theoretical methodologies, and many ARG researchers are active in several areas. Since RAE 2008, the group's research has informed the development of postgraduate programmes in the BSA, with staff numbers growing from 21 to 39 researchers, including now the employment of Research Associates from architectural practices. To stimulate and disseminate projects, the ARG has since 2008 provided funding of £620k from its *Architectural Research Fund*. These increased resources have enabled ARG to expand its research areas and above all to support early-career staff. The ARG's expansion has paralleled the UK's growth in innovation-led smaller architectural practices and of research departments within larger firms, which has thus helped dramatically to increase PGR enrolment, notably at PhD level. In terms of the quality of ARG research work, Rendell's book on *Site-Writing* was a runner-up in the 2011 RIBA Research Awards, Hill's *Weather Architecture* was shortlisted for the 2012 RIBA Research Awards, and Forty's *Concrete and Culture* won the 2013 RIBA Research Award for Outstanding University-Located Research (with Borden's *Drive* also shortlisted). Furthermore, staff members have exhibited their design projects internationally in leading venues like the Venice Biennale, Storefront for Art and Architecture, Nevada Museum of Art, Danish Architecture Centre, Centre Pompidou, Royal Academy and V&A Museum. ARG members have received many awards and honours such as: McLaughlin's shortlisting for the 2013 RIBA Stirling Prize for Bishop Edward King Chapel (which won RIBA South Building of the Year and a RIBA National Award); Manolopoulou's 2013 Stephen Lawrence Award for the Montpelier Community Nursery (also given a RIBA National Award); Sheil's 2011 RIBA Design Award for the 55/02 pavilion in The Bartlett/Kielder Park collaboration; Fraser's role in the 2013 Aga Khan Award-winning regeneration project for Birzeit in Palestine; Chinchilla's Special Mention in the 2013 arcVision Prize for Women and Architecture for her Garcimuñoz Castle refurbishment; Lim's commissions for urban designs and environmental policies for the Chinese government planning bureaus in Shenzhen, Tangshan and Guangzhou; and Miàs's 2008 European Prize for Public Space for his refurbishment of the old town of Banyoles, and his 2011 Building of the Year ArchDaily Award for the iGuzzini Office in Barcelona.

Following **CASA's** initial focus on GIS, spatial analysis, simulation and visualisation, shown in the Virtual London 3-D model for the GLA, more recently three related themes have driven its research agenda: (1) *Complexity Science for Cities*, especially in terms of developing a science of cities from social physics, urban economics and transport systems; (2) *New Methods for Handling and Visualising Big, Real-Time and Open Spatial Data*, such as via 'smart cities' in which ICT are embedded into the urban fabric; and (3) *Network Science and Local Movement Models in Urban Design*, with an emphasis on global systems dynamics. The quality of CASA's research is demonstrated by its repeated successes in grant funding, high-profile journal publication, media impact and policy outreach. Major milestones for CASA have been published by Wilson in *The Science of Cities and Regions* (2012) and Batty in *The New Science of Cities* (2013). These two senior CASA members have extremely strong impact factors, as represented in their Google H-indexes of 56 (37 since 2008) and 36 respectively. Batty was recently awarded the Lauréat Prix International de Géographie Vautrin Lud, generally known as 'the Nobel Prize of Geography'.

Environment template (REF5)

C&PMRG focuses on management and economics research within project-based environments through four strategic themes: (1) *Rethinking the Management of Projects*, so as to define the discipline and identify innovative conceptual and practice perspectives, with highlights including *The Oxford Handbook of Project Management* and *Reconstructing Project Management* (Morris), grants from IPA and APM (Morris, Gerald), and EPSRC-funded research on innovation in mega-projects (A. Davies); (2) *Management of Project Businesses*, dealing with corporate renewal and relationship management, e.g. *Managing the Professional Practice* (Smyth), *Handbook of Mergers and Acquisitions* (Teerikangas), with funding from Mercuri Urval and the Finnish National Technology Agency; (3) *Project-Based Networks*, including Pryke having established CONA as a research centre for network analysis across project organisations following two Wiley books (2008, 2012); and (4) *Economics and Financing of the Built Environment*, covering construction firms and broadening during the REF period to include performance assessments of social infrastructure and infrastructural issues of finance and investment. Led by Ive, the reputation for high-quality research since the 1990s will be acknowledged in a forthcoming festschrift in his honour. Other highlights include empirical studies of construction and engineering procurement, driven by Chang; a commission from the Department for Business, Innovation and Skills (DBIS) to analyse Trade Credits for financing UK construction contractors; and publications from research with KPMG that look into the operational cost/performance of PFI-funded schools and hospitals (Ive, Edkins).

DPURG seeks to deepen understanding of development processes and practices and of collective action in the public/private sectors of civil society, especially in the Global South. It has four research clusters: (1) *Environmental Justice, Urbanisation and Resilience*, with a focus on rural-urban linkages and metabolisms such as agriculture, infrastructure, risk and resilience, and insurgent practices for socio-environmental transformations; (2) *Urban Transformations*, with an emphasis on local governance and democracy, social mobilisation, resistance and collective action, and design and planning for the 'just' city; (3) *Diversity, Social Complexity and Planned Intervention*, with a focus on social complexity in policy, planning and methodology, and in divided cities and post-conflict resolution; and (4) *State and Market*, with an emphasis on urban and rural livelihoods, intersections between formal/informal economies, private sector roles in development, state reconstruction in post-conflict situations, and national development policies. It runs *Dialogues in Development* as an ongoing series of talks by world-leaders in DPU's research fields, and the *DPU Working Papers* and other in-house publications provide discussion points for research. DPURG maintains a very strong record of publishing in journals and books in many countries across Europe, Latin America, Africa and Asia. Its researchers participate in conferences as keynote speakers in all continents, with examples that include: high-level participation in UN advisory groups on forced evictions; invited participation in climate-change consultancy groups; leadership of the international observation of successive Somali elections; and requests for advisory and consultation roles to the Department for International Development (DFID), Foreign & Commonwealth Office, UK parliamentary groups, non-UK governments, and numerous NGOs.

SG aims to (1) Develop and test theories by studying the effects of spatial design on aspects of the social/organisational/economic performance of buildings and urban areas; (2) Integrate computational approaches at the heart of the design process, including structural/societal/environmental analysis along with generating design solutions that combine machine learning, optimisation and technological innovation; and (3) Use virtual-reality techniques to develop and disseminate ways of designing, producing and operating buildings and urban areas. The SG is thus composed of 3 research strands: *Space Syntax Laboratory* (SSL), led by Hillier and Penn; *Urban Form and Society* (UFS), led by Vaughan; and *Virtual Reality Centre for the Built Environment* (VRCBE), led by Hanna and Fatah. SG's research income includes a third tranche of EPSRC Platform Grant funding - only delivered to world-leading research groups - in order to expand the group, enhance its global links, and tackle fundamental theoretical and methodological issues relating to the morphology of the built environment. Hillier has a Google H-Index of 35, and there have been around 8,000 licensed user installations worldwide of space syntax software.

Building on the primary interest of **CBES** in interdisciplinary solutions to designing, constructing and managing environments within and around buildings, it has devised - supported by its renewed tranche of EPSRC Platform Grant funds received in 2011 - a strategic programme of activity called *Unintended Consequences of Decarbonising the Built Environment* (£1.43 to UCL, M. Davies-PI). CBES is driving forward the understanding of this urgent issue which will have enormous impact internationally. To predict the future states of complex socio-technical systems,

Environment template (REF5)

conventional scientific approaches are no longer sufficient, and hence CBES now includes building scientists, heritage scientists, economists, facility management researchers, complex systems modellers, uncertainty analysts, public health researchers and social scientists. Its research is organised into four sub-groups each with its own research theme, yet enabling vital cross-fertilisation between teams: (1) *Environmental Performance* (EP), led by M. Davies; (2) *Facility and Environment Management* (FEM), led by Marmot; (3) *Light and Lighting* (LL), led by Raynham; and (4) *The Centre for Sustainable Heritage* (CSH), led by Cassar, whose own leadership in her field was shown by a special mention in a *Nature* editorial in November 2013. There are also very close links to the UCL Energy Institute, led by Oreszczyn, which originated from CBES research.

PRG is distinguished by its breadth of research and capacity to bring together multiple disciplinary perspectives on urban challenges. It is driven, firstly, by a belief in the power of planning, public policy and urban design to positively shape the urban built environment for social benefit; and secondly, by the conviction that only robust and innovative scholarship can deliver fundamental understanding of urban problems. PRG aims, therefore, to analyse urbanism at all scales (from neighbourhood to transnational contexts, frequently with an international focus), and using different disciplinary approaches (social science, real estate, transport and urban design) so that this can support policy design and delivery, and also advance theories and methods for urban governance, urban design and urban development. PRG members have received prestigious awards such as the Sir Patrick Abercrombie Prize from the Union Internationale des Architectes and the LEAF Award (Hall), and the AESOP Best Paper Prize (Hebbert). The environment and culture in PRG encourages bottom-up innovation in its research directions, and while not being organised into formal groupings, it does coalesce around several foci: (1) *Governance of Urban Design*; (2) *Transport Systems and Infrastructure*, including notably the efforts of two research groups, SINTROPHER (Hall) and OMEGA (Dimitriou); (3) *Urban and Regional Development and Governance*, encompassing spatial planning and urban politics, city-marketing; multiple aspects of post-suburbia, and housing delivery; and (4) *Urban Regeneration*, addressing its cultural, social, political and real estate aspects. PRG research staff have together attracted c.£4.9m of research funding sources from 2008-13, including from ESRC, EPSRC, AHRC, British Academy, European Union, and charitable trusts including the Volvo Foundation and RICS Research Trust. Much of this funding coming from national and local government is to directly support policy development.

UCL-E was launched in June 2009. Its overarching vision is for 'a globally sustainable energy system', and it uses a systems approach to analysing the energy system at a range of different scales, from global, national to sub-sector (e.g. dwellings). It has a particular strength in looking at systems from a demand-side perspective particularly for buildings and transport. UCL-E now plays a leading role in advising government, industry and research council funders to inform policy and decision-making, and to contribute to the development of research strategies and the transformation of energy systems. In order to facilitate the pathways to impact, it runs a very active knowledge transfer programme, including regular meetings with the Department of Energy and Climate Change, various seminar programmes, and employing a writer-in-residence. Research work focuses on: (1) *Whole Systems Energy Analysis and Modelling*, including the development of national and international energy systems models, least-cost optimisation and integrated assessment modelling, development of future scenarios, and collection of technology data to populate models, with specialist modelling undertaken in the areas of hydrogen, biofuels and how to inform policy. Major grants include *Whole Systems Energy Modelling* (EPSRC, £1.7m to UCL, Strachan-PI), and *UKERC 2* (£1m to UCL, Ekins-PI); (2) *End Use Energy Demand (EUED)*, with research covering the sectors of Buildings (domestic and non-domestic, from design to demolition, along with CBES) and Transport (with particular strength in international shipping and aviation). The study of people is a crucial theme running through all these projects, leading to a new focus on 'energy epidemiology' - i.e. energy use in the population - which involves the collection, organisation and analysis of data from energy monitoring and existing data-sets. Grants include *EUED Centre: RCUK Centre for Energy Epidemiology* (EPSRC, £5.75m to UCL, Oreszczyn-PI); (3) *Smart Systems*, with a particular expertise in smart heat and cooling. Grants here include *ETI Smart Systems and Heat* (£1.5m, Oreszczyn-PI) and *Cisco – Future Cities* (£5m joint UCL/Imperial with UCL Computer Science, Shipworth-CI); (4) *Process and Performance*, looking at the performance of buildings and components in the field, whether new-build or retrofit, and their relationship to context, systems and communities of practice engaged in design, production, commissioning, and operation. A number of TSB-funded projects contribute to this theme; and (5)

Environment template (REF5)

Investigating the Low-Carbon Economy, again with CBES, which includes health, comfort (e.g. summertime overheating) and productivity along with issues such as rebound. Funds include the EPSRC Platform Grant for *Unintended Consequences of Decarbonising the Built Environment* (Oreszczyn-CI). UCL-E has attracted altogether a portfolio of around £30m of project funding from government, industry and charities, making UCL now among the best funded energy research universities in the UK, and probably number one in the analysis of energy demand reduction.

UCL-ISR was created in 2011 through an initial US\$5m donation from *Sustainable Communities* (BHP Billiton's charitable foundation) to engage in cross-disciplinary, problem-oriented research into a more sustainable use of the Earth's resources. UCL-ISR draws upon the full range of UCL expertise in the areas of energy, economics, political science, waste, climate change, environmental engineering, corporate responsibility, international law, anthropology and development in the Global South. Its foci are on Abiotic resources, Biotic and renewable resources, and resource efficiency. Hence the main research themes are (1) *Definitions and Indicators of Sustainable Resource Use*; and (2) *Green Economy*, which integrates the resource programme areas with different economic models and perspectives at global/national/local levels. Research activities involve modelling the use of Abiotic resources, building on energy systems analysis by UCL-E; modelling the use of natural capital, which includes ongoing work on bioenergy by incorporating and extending knowledge from studies like *The Economics of Ecosystems and Biodiversity* (TEEB) and *Millennium Ecosystem Assessment* (MEA); as well as projects on Sustainability Indicators and Resource Efficiency policy funded by the European Commission.

Each grouping possesses a distinct research culture appropriate to its own worldview, each active and confident. Yet having set up these 9 research groups across The Bartlett, we also realise that a shifting context is requiring us once more to rethink our strategy. For example:

(1) Working in collaboration and partnership: The Bartlett is increasingly engaged in collaborations and partnerships with other UCL faculties and also with other universities and industry partners; indeed, we regard this as the best way to progress the diverse subject areas we cover. A total of 24 of our current research projects are now run in collaboration, c.15% of our research income comes from jointly-funded projects and a growing proportion of our research outputs are being co-authored with colleagues in UCL and other academic institutions. Many university and industry partners are now approaching The Bartlett to develop research partnerships in the expectation that such collaborations - whether in the UK or abroad in countries like China - will then help to leverage funding from research councils, private companies and charitable bodies. It is now our openly stated aim to be a research partner of choice for others.

(2) Innovation in cross-disciplinary approaches: We also realise the need to become more innovative in terms of our cross-disciplinary initiatives, and hence in 2011 we instigated a new Cross-Disciplinary Research Programme to offer staff greater opportunities to work together across our 9 research groups. The new initiatives include: (1) *Bartlett Research Exchanges*, a series of themed seminars with speakers from across the faculty, focusing recently on topics like urban regeneration and performance/performativity; (2) *Bartlett Research Challenges*, a small annual fund to seed cross-disciplinary research; (3) *Bartlett Visiting Research Fellows*, which supports five visiting post-doctoral researchers each year to study for three months at The Bartlett on cross-disciplinary subjects; and (4) *Research Materialisation Grant*, a substantial £50,000 annual fund to connect evidence-based and more speculative research by constructing a design project, installation, or exhibition. The Cross-Disciplinary Research Programme is then linked to the university's overall strategy by focusing upon a different UCL Grand Challenge each year.

Out of initiatives like these, a number of research strands are beginning to emerge. A prime example is the *UCL Cultural Heritage Research Network* established by Cassar (CBES) following an all-UCL 'Town Meeting' that she organised in October 2012. It brings together 36 UCL departments to share expertise within the domain. Ranging across the Arts and Humanities, Social and Historical Sciences, Built Environment, Engineering and Health Sciences, and including the renowned UCL Collections, it has five cross-disciplinary themes: (1) *Heritage Science, Materials and Cultural Transmission*; (2) *Digital Technologies, Heritage and Intangibility*; (3) *Values, Identity and Wellbeing*; (4) *The Cultural Work of Heritage*; and (5) *Cultural Partnerships*. UCL faculties have so far invested £707k in the equipment infrastructure for heritage research, and an e-journal, *Interdisciplinary Heritage Studies*, is planned. Similarly, Bartlett staff members are now centrally involved in establishing a pan-UCL domain based on environmental research. Other emerging

Environment template (REF5)

cross-disciplinary initiatives include that by Carmona (BSP) in the area of urban design, which is bringing together a wide range of research methodologies across the faculty to establish a new MRes degree, as well as writing essays for an Ashgate edited book. Also, the *Adaptable Suburbs* project funded by EPSRC/ERC for £728k and headed by Vaughan (BSGS) - the second of its kind to be led by her - involves five Co-Investigators from The Bartlett, Civil Engineering and Anthropology, and spans history, urban design, GIS, spatial data analysis and urban ethnography.

Turning now to how these changes will affect our future strategy from 2014, we foresee three main drivers in the coming period. First, to capitalize on our scale and scope to tackle the difficult challenges facing society; second, to use our London location to embed The Bartlett into the international network of firms and organisations based here, so as to deliver more impact; and third, to achieve greater integration between our research, educational and enterprise missions, and thereby develop the next generation of leaders in our many fields. We believe that for a unit of the scale and scope of The Bartlett, located in a 'world city', we have an opportunity to deliver all of this. Accordingly, for the next period we are planning three key areas for strategic development:

1. **A conceptual restructuring of our research** by moving from a cross-disciplinary to a multi-perspectival approach. Broadly, each research group already operates in a cross-disciplinary manner, comprising a range of different disciplines, with each taking a specific epistemological perspective - derived say from the physical or social sciences, or arts and humanities, or design. Addressing challenges from different vantage points can facilitate working together by valuing the different understandings that each perspective brings to a research challenge. This approach is only made possible by the size of the faculty, since it allows a range of often opposing perspectives to be deployed. Results will be monitored by tracking our level of research collaborations, co-authored outputs, and successes in winning funds for multi-perspectival projects.
2. **Setting up of 'Sector Commissions'** to look at challenges facing specific parts of the economy - e.g. health, education, manufacturing, housing, knowledge-led business services and infrastructure. The aim is also to bring together different stakeholders and external partners. Shared challenges and sectoral issues will thus be used to bring the parts of the faculty together. Our objective is to develop a set of external networks and partnerships targetted initially on four sectors (infrastructure, housing, health and education). Attainments will be monitored by research outputs and by reports written by the 'Sector Commissions'.
3. **Improving our building estate** to reduce chronic space problems. Since 2008, The Bartlett has been allocated Central House, which has helped us significantly. In 2014 we will start on a major rebuilding and extension of Wates House, home to the BSA. This will be followed by the acquisition of another building to allow co-location of the whole faculty from 7 buildings at present to just 3 buildings. The resolution of our historic space deficit and co-location will help to put recent growth onto a sustainable footing and enhance cross-faculty working. Successful delivery of building projects and a series of space KPI's will be used to measure attainment.

Looking at how this will operate in practice, it is necessary to note that the distinct perspectives within The Bartlett can be mapped onto methodological approaches as well as funding sources. The EPSRC and its peer review college is best placed to judge research from a physical science/engineering perspective, while the AHRC is better suited to an arts and humanities perspective, and the ESRC to social sciences. By bringing these underlying assumptions to the surface, our future strategy seeks to respond to the different missions of sponsors and the different languages of peer review panels, while also intending to help shape research funding policies wherever appropriate. For example, an aim is to focus increasingly on European Union funds through the Horizon 2020 programme and other streams.

Thus from 2014-20, the key priority of The Bartlett will be to increase our capacity for undertaking multi-perspectival research to deal with real-world challenges. We aim to maintain our international profile by building upon and extending our collaborations and partnerships in the UK and overseas, and to strengthen our connections to the built environment professions and industry by incorporating them into world-class research initiatives. Examples of innovative projects include:

- (1) **ARG** will set up *B-MADE* (The Bartlett's Centre for Manufacturing and Design Exchange), as led by Sheil, to expand our workshops into a cutting-edge environment for analogue and digital

Environment template (REF5)

design and fabrication that is open to research staff, students and external organisations. It will be linked closely to the UCL Engineering Faculty and industry partners in London and further afield.

(2) **UCL-E** will deliver the planned *Centre for Energy Epidemiology*, to be headed by Oreszczyn, thus building on the aforementioned recent successful bid to create one of the EPSRC's *End Use Energy Demand Centres*, with the goal of ensuring that the policy promise of UCL-E's innovative approaches to energy data analysis can be realised in practice.

(3) **UCL-ISR** aims to develop on its leading role in writing the recent 10-year policy document on *Sustainable Production and Consumption for Poverty Eradication* for the UN Environment Programme. It will help to assemble proposals for an EPSRC Programme Grant (with the Universities of Exeter and East Anglia) and an ESRC Centre (with the Universities of East Anglia and Leeds) so as to model the conditions for, and the implications of, a 'perfect storm' scenario of simultaneous crises relating to food, energy and water - all exacerbated by climate change. It is also being included in ambitious Phase 3 proposals for the UK Energy Research Centre.

c. People, including:**I. Staffing strategy and staff development**

Staffing strategy: The Bartlett's staffing policy has been devised both in response to our Faculty Research Strategy and to UCL's Human Resources policies, guidelines and procedures. The monthly RAG meetings form a vital link in the chain, with the Dean being able to report directly from the UCL Senior Management Team on key initiatives and with HR, Finance and Estates representatives also contributing specific information and advice. As noted, The Bartlett has grown very considerably since 2008, employing 86 new members of staff and experiencing relatively few retirements or other leavers during the period. The net effect has been to reduce the student/staff ratio from 20:1 to only around 12:1 today, thus giving staff more time for research. The fact that almost all of our eligible staff members are being submitted to REF 2014 demonstrates the care with which we have been proactively nurturing staff in regard to their research potential.

The Bartlett also works closely with the HR Division to provide support and advice governed by policies such as UCL's Equal Opportunities Policy on recruitment and promotion, and UCL's Work Life Balance Policy, which also incorporates UCL's statutory responsibility to consider requests for flexible working to enable staff to care for young children or dependent adults. We have taken on more early-career staff, with c.50% of new appointments during the REF period at Lecturer grade and with an increased level of female recruits. Of our 151 returned staff, 35% are female and 65% are male, with the gender balance more equal at a junior level. UCL HR runs a dedicated professional programme for ECR staff through its Organisational Development section. Of the current count of 44 ECRs in The Bartlett, 20 are women and all are being REF-returned.

Staff development: Equally essential is to ensure that our staff have sufficient time to carry out their research. In 2011 the Bartlett introduced a comprehensive Sabbatical Scheme, in line with UCL policy, whereby each of the 9 research groups offers a 'basic' provision such that all research-active staff members can apply for a 1-term sabbatical every three years so as to initiate, develop and/or complete significant outputs, or else to write up new funding bids. There is also an optional 'upgrade' facility, depending on each group's strategy, to support the production of major outputs - especially for staff who have had onerous teaching or management duties over a prolonged period - by increasing the 'basic' allowance up to a 1-year sabbatical. Furthermore, a post-maternity fund is available to female research staff for a 1-term sabbatical on their return to work. A total of 26 staff have duly been supported by sabbaticals from 2008-13, along with 2 staff helped by UCL's post-maternity sabbatical fund, and another 2 staff by the AHRC's Research Leave Scheme.

Given that the kinds of research vary across the 9 research groups in The Bartlett - ranging from teams which have funded studentships and post-doctoral positions, to sole-authored research - we have tailored the modes of support to suit specific research contexts. As noted, **ARG** runs the *Architecture Research Fund*, which provided £85k of support in 2008-09 rising to £180k in 2012-13, as the main mechanism within the BSA to support funding and sabbaticals. It is managed by the DoR and is open to staff and PhD students. **C&PMRG** started a seminar series on *Developing Research Capabilities* in 2013 to help its ECRs, and is also instigating a PhD scholarship scheme to develop new talent. **CASA** supports the careers of its Research Assistants by ensuring they get skills to equip them for lecturing posts, and it works with the Concordat to offer preferential treatment whenever a funding stream ends and if new funds are available. **SG's** stated policy is to build capacity amongst junior staff; since 2008, 1 member of the group has been promoted to

Environment template (REF5)

Professor, 4 RAs were awarded Lectureships, a Reader and Senior Lecturer were appointed from outside, and its PhD students are now taking on Teaching Assistant role. In **CBES** since 2008, 2 ECR staff members were promoted to Senior Lectureships and 4 PhD students progressed to permanent Lectureships. **PRG** offers annual internal funds to attend conferences and also a seed-corn programme for supporting research by ECRs, together amounting to c.£120k in 2012-13.

Quality mechanisms: The Bartlett operates a research mentoring system for all eligible members of staff that is then complemented by UCL's wider staff appraisal system. An annual research mentoring process is conducted by the DoR for each research group, along with a specialist advisor, and involves a review of each staff member's research plan in regard to activities, deliverables and support needs. Information from this session is fed back to the Head of School (HoS) to inform the staff member's general appraisal, and in turn the HoS feeds back to the DoR and staff member after the appraisal is completed. Within UCL, a profile in IRIS (Institutional Research Information System) compiles data about research publications, income generation and PhD student supervision for every member of research staff, also bringing a useful dimension of self-management into the monitoring and mentoring processes. As part of staff development, everyone is encouraged to attend at least three learning events per year - including specific research-related courses - as part of modules offered by UCL Human Resources.

Ethics procedures, in relation to appropriate research methodologies, are conducted in line with the policies and guidelines set by the UCL Research Ethics Committee. As we are increasingly seeking funds from private sources, such as charities and corporations, the need for transparency in accepting such funds is becoming imperative to safeguard academic freedom and reputation. In May 2012, UCL's Development and Alumni Relations Office published its *Guidelines for the Acceptance of Gifts and Donations*, which outlines the ethical conduct expected for accepting research donations. UCL has also restructured its committees dealing with research ethics such that they now feed into the Research Governance Committee, chaired by the Vice-Provost (Research), and the Council Ethics Committee, chaired by a lay member of UCL Council.

Personal research fellowships: A number of prestigious research fellowships were won by Bartlett staff during the period from 2008 to 2013. In **PRG**, 3 staff members have been recipients of Humboldt and Marie Curie Fellowships (Colomb, Arbaci and Sonn), and a research fellowship was awarded by the Japan Society for the Promotion of Science (Carmona). Within **ARG**, 2 staff members were recipients of AHRC Research Fellowships (Forty and Rendell), while another won an AHRC Fellowship in the Creative and Performing Arts (Powell).

c. II. Research students

In the REF census period, The Bartlett made 178.5 research student awards (33 MRes, 7 MPhil and 138.5 PhD). In line with our strategic growth, the annual recruitment of PhD students across the faculty rose from 41.5 FTE in 2008-09 to 72 FTE in 2012-13. Because the FTE count of our research-active staff has also grown so rapidly during the REF period, it makes it harder to capture the average rate of completion per doctoral supervisor. However, as a benchmark, if one takes the number of doctoral tutors in June 2009, which is the last plausible date to ensure a student could complete before the REF census date, there were 78 Bartlett staff serving as primary supervisors, giving them each an average completion rate of 1.8 PhD students within the period. At the present time, we have a total of 221.5 FTE PhD students enrolled across the faculty.

Training and supervision: The Bartlett Research Degrees Committee (BRDC), which meets once a term, is responsible for the overall monitoring and direction of our doctoral programmes in light of UCL and national policies for higher degrees. Day-to-day management, including admissions, upgrades, and the appointment of examiners, is carried out by the Committee's Admissions Sub-Committee (CASC), which meets every 3 weeks. The Faculty Graduate Tutor is Chair of CASC, and also sits on BRDC and the UCL Research Degrees Committee. All research-active staff on eligible contracts are expected to offer PhD supervision in their specialist areas, initially as secondary supervisors until the upgrade stage for students from MPhil to PhD, and then to assume primary supervisory responsibility. Each member of supervisory staff has to undertake the required course on supervision. The UCL Graduate School provides mandatory training courses for students, with each of the 9 research groups also providing specific disciplinary training and a chance to take relevant Masters modules. Every student records his/her progress every three months in an online logbook that is checked as part of the formal upgrade from MPhil to PhD, and as part of the final thesis submission. The Bartlett's commitment to Equal

Environment template (REF5)

Opportunities is reflected in equitable policies on travel funds, skills training and study leave. All PGR students, including those studying part-time, are entitled to apply for project and conference funding to their appropriate research group and to the UCL Graduate School, which both jointly contribute. The Bartlett allows all PGR students to take unpaid study leave, and those in receipt of a UCL or Faculty Scholarship are also entitled to full maternity leave provision.

A clear indicator of the quality of training and supervision of PGR students is the degree of innovation in The Bartlett in this respect. We have been part of three EPSRC Centres for Doctoral Training (CDT) at UCL during the REF period - *Virtual Environments, Imaging and Visualisation (VEIV)*; *Urban Sustainability and Resilience (USR)*; and the *London-Loughborough Centre for Doctoral Research in Energy Demand (LoLo)*. The Bartlett was also very successful in the latest EPSRC CDT round in late-2013, winning one continuation bid (*LoLo*) and one new bid (*Scientific Cultural Heritage*; two other bids were shortlisted). These CDTs are highly competitive and evidence of quality is shown by being successfully shortlisted for new and continuation funds. With our two new successful bids, we will have 100 additional doctoral students in the years ahead. A further example of doctoral innovation comes from **ARG**, which in 1996 became the first in the world to establish a PhD in Architectural Design, thus responding to clear demand by architectural practices for doctoral training in the industry. The programme is now the same size as the ARG's longstanding PhD in Architectural History and Theory, with the two having c.55 students between them. Since 2008, ARG has had 3 winners and 8 shortlisted entrants in the annual RIBA President's Award for Outstanding PhD Thesis. The Bartlett is also innovative in providing a growing number of MRes PGR courses, not just for students in EPSRC CDTs, but as our deliberate strategy to develop research across a wide range of built environment subjects. Already we have expanded to 44.5 FTE students on MRes courses, now offered in *Adaptive Architecture and Computation*, *Spatial Design: Architecture and Cities*, *Heritage Science*, *Urban Design*, *Economics and Policy of Energy* and *Smart Cities*. Each MRes course is intended as a first port-of-call for prospective research students, and so relates to a specific doctoral or EngD stream.

Competitive studentships: Our PhD students are funded from a range of sources. From 2008-13 this included 9 scholarships from AHRC, 63 from EPSRC, 3 from ESRC, plus a few from the ERC or other EU grants. Overseas government sponsors included many full state-funded scholarships from Canada, Chile, Colombia, Greece, Mexico, Portugal, Syria, Thailand and Turkey, as well as from the Onassis Public Benefit Foundation, Portuguese National Institute for Housing and Urban Conservation, China Scholarship Council, Niger Delta Development Commission, and British Commonwealth sources. In the case of **SG** and **CBES** in BSGS, together in 2009 they secured EPSRC funding for 50 EngD Scholarships, i.e. 10 per year. These EngD students are also being sponsored by, for example, AEDAS, Natural Building Technologies, CIBSE, BRE, National Archief, MODUS, Laing O'Rourke and PLP Architecture. In **C&PMRG**, the Major Projects Association has provided 2 doctoral awards. **UCL-ISR** has set up a training centre in the *Sustainable Use of Resources* which will appoint 20 PhD students funded by BHP Billiton's *Sustainable Communities* from 2011-16, again based on a 4-year MRes/PhD programme. The 13 students selected by UCL-SR in 2013 were drawn from an outstanding field of over 90 applicants.

Integrated research culture: Doctoral student research is regarded across The Bartlett as a vital link between research and teaching, helping us to build strength in established research areas and develop emerging themes, and to connect to taught or research-based Masters courses. Each of our 9 research groups offers a strong basis for integrating doctoral students into research culture by providing plentiful contact with tutorial staff, plus there is a dedicated Director of PhD Studies for each group. **ARG** provides specific training in architectural research through several avenues: its bi-weekly *PhD Research Conversation* seminars, its annual *PhD Research Projects* Conference as a major event/exhibition/publication, and professional development seminars to assist completing students and recent graduates. Doctoral students in **C&PMRG** have to attend monthly *Building Research Capabilities* workshops. **DPURG's** PhD students are required to become actively involved in research activities and in jointly authoring papers. For **SG** and **CBES**, there is an annual programme of specialised training workshops to support PhD student learning, a PhD student conference, plus informal social events organised by BSGS, or by specific research groups, and by students themselves. In **PRG**, PhD students form an integral part of the research community and engage fully in planning debates and research seminars. **UCL-E** is now launching a CPD course for knowledge transfer to industry, titled *Practical Environment and Energy Efficiency Management for Shipping*, along with Lloyds Register, Fathom and GL Reynolds. Their

Environment template (REF5)

PhD students have begun to drive their own training programmes by running special skills seminars and setting up a UCL-Energy Social Sciences Group.

As well as a supportive culture in each research group, in 2012 we set up a termly series of Bartlett Research Exchange seminars for PhD students across the faculty, again to encourage cross-disciplinary discussions. Each of these sessions focuses on a specific theme and has invited external respondents. The Bartlett also actively encourages cross-disciplinary supervisions across its research groups, as well as within UCL, such as with the Slade School of Fine Art, Anthropology or Computer Science. As a clear example, the EngD *VEIV* CDT is jointly run by UCL Computer Science and **CBES** (Mumovic). Externally, **ARG** has strong links with the Royal Academy of Music and it runs an annual award to fund archival study by PhD students at the Canadian Centre for Architecture in Montreal. **DPU** is participating in the Marie Curie Actions International Research Staff Exchange Scheme, part of the EU FP7 Programme from 2012-16, in order to bring in additional supervisory knowledge. Much emphasis is also placed across The Bartlett on trying to help graduating PhD students find jobs, whether through teaching or research positions here or elsewhere. Despite the lengthy recession, we have found that Bartlett PhD students are continuing to find employment whether in universities or in the professions and culture industries.

d. Income, infrastructure and facilities

Research funding: In RAE 2008, The Bartlett reported research income of £10.03m for UoA30 (ARG, C&PMRG, SG and CBES) and £4.53m for UoA31 (DPURG and PRG). For REF 2014, we are reporting a total research income of £23.96m and an annual research income level that has increased from £2.79m pa in 2008-09 to £6.76m pa in 2012-13. Furthermore, our combined current portfolio of competitively won research bids stands at £50.53m across the faculty.

Funding comes essentially from a mixture of UK research councils, European Union agencies, and industrial sources. Income from EPSRC makes up around 50% of The Bartlett's competitively won funding, notably the two EPSRC Platform Grants (**SG** and **CBES/UCL-E**) which provide core/bridging funding and, as noted, are awarded only to 'world-leading' research groups. Since 2008, **SG** has attracted £2.1m in research funding, including an active EPSRC portfolio, notably the award of its third consecutive Platform Grant (£1.17m, Penn-PI) and three further grants totalling £800k. **CBES's** current funding portfolio exceeds £10m and includes - along with the £1.43m Platform Grant that it holds jointly with UCL-E - two EPSRC grants for *People, Energy and Buildings* (£850k, Oreszczyń-PI) and *New Empirically-Based Models of Energy Use in the Building Stock* (£460k, Lowe-PI). CBES's other funding streams include the European Commission (PURGE, £430k), the National Institute for Health Research (£235k) and NERC (AWESOME, £290k). Cassar (CBES, Director of CSH) leads the AHRC and EPSRC joint-funded *Science & Heritage Programme*, obtaining £1.35m in funds for The Bartlett, creating the encompassing intellectual framework, and overseeing a total award of nearly £7.37m to the research community.

In 2011-12, **UCL-E** submitted 35 proposals, some 17 of which were funded with a value to UCL of £2.3m. Most recently, UCL-E has won major awards including £5.75m from EPSRC for an *End Use Energy Demand* centre, intended for 'collaborations of leading academics', and to lead a university consortium focusing on whole system energy modelling - plus there is another £3m from the Energy Technologies Institute to study consumer behaviour relating to UK heat and energy consumption. The quality of UCL-E's research has been acknowledged in its joint EPSRC Platform Grant and through its recognition by the Royal Academy of Engineering as a Centre of Excellence in Sustainable Building Design. **UCL-ISR** has won three EU FP7 projects including *Policies for a Resource-Efficient Economy* (£3m, Ekins-PI), for which it is also the coordinator. It is also involved in the projects on *Choosing Efficient Combinations of Policy Instruments for Low-Carbon Development and Innovation to Achieve Europe's 2050 Climate Targets* (CECILIA2050), and *Environmental Macro-Indicators of Eco-Innovation* (2011-15).

Research into the application of complexity theory to cities through ideas about social physics and scaling, and into new techniques for visualising spatial data and simulations using various multimedia, have been pioneered during the last five years by **CASA**, which has secured funding for this work from EPSRC, ESCR and ERC around these themes. Batty's ERC Advanced Grant for *Mechanicity* (worth £1.8m) is enriching CASA's work in land-use transportation modelling - as funded by the NERC *Tyndall Cities* programme, EPSRC's ARCC programme under *ARCADIA*, and the *SCALE* project under EPSRC's Complexity Science and Energy Efficiency programme (£1.3m). The theme of complexity and global dynamics, led by Wilson, has been funded under

Environment template (REF5)

IPSec's *Complexity for the Real World* programme (£2.5m). The other main theme, involving the development of visualisation methods for urban data and simulation, initially funded by ESRC under the National Centre for e-Social Science's *Genesis* (£1.3m) project, has now been extended in the *Talisman* project, this being a node in ESRC's National Centre for Research Methods (£0.7m). The tools developed here involve online mapping, crowd-sourcing of spatial data, 'city dashboards' involving sensor data and its display, mining social media for spatial visualisation, and a variety of big data projects for public transport, with the latter funded as COSMIC (€0.5m) under the EPSRC/ERA *Net Complexity* call.

EPSRC funding has also been secured by **C&PMRG**, including *Hacric Research* (£118k); EPSRC/UCL *Pathways to Impact* (£20k); and *Procurement for Innovation* (£78k). In the study of megaprojects, the EPSRC Innovation Studies Centre and Crossrail Ltd funded Davies in 2012-13 to analyse *Innovation in Crossrail* (£250,000), building upon his previous research at Imperial College. In the area of behavioural finance, Baddeley has had successes as: (1) Joint-PI for the Google Research Award, 2013 (\$70k); (2) EPSRC Institutional Sponsorship Grant to investigate household energy consumption, 2012-13 (£30k), which develops initiatives from her previous post at Cambridge University; and (3) securing a Leverhulme Trust grant (£79k).

ESRC funding for urban research is mostly concentrated in **PRG**, such as for global space and new London squares (£166k), and governing suburban growth (£162k). PRG has also obtained AHRC funds for design governance in the built environment (£252k) and EPSRC funds for challenging 'lock-in' problems through urban energy systems (£791k). Funding for urban regeneration research also comes from the EU, including a FP7 project on governance of diversity in European cities (€4.6m, Raco, Colomb, Arbaci-PIs). PRG also regularly wins funding for housing standards, housing planning and economic governance from the RICS Research Trust. Substantial funding for research transport systems and infrastructure has been concentrated in two main centres: SINTROPHER (£20m) and OMEGA (£2.3m). In addition, consultancy-led research includes that for the Guangzhou CBD project (£122,000) and Asian Development Bank (£25k).

DPU often wins research funding via partnerships with international collaborators in the Global South, being funded by the MRC with NERC/ESRC/BBRC in two cases: (1) Medellín Metrocable project, *Local governance, urban mobility and poverty reduction: Lessons from Medellín, Colombia* (£242k, Davila-PI); and (2) *Epidemiology, Ecology and Socio-Economics of Disease Emergence in Nairobi* (£2.56m, Davila/Allen-CIs). Humanities-related research in **ARG** includes, along with the AHRC Research Leaves and AHRC Fellowship (Powell, £259k), an AHRC Research Grant for *Equalities of Wellbeing in Philosophy and Architecture* (£73k, Rawes-PI).

In terms of knowledge exchange, The Bartlett - with its close relations to the built environment professions in Architecture, Planning and Construction - leads UCL in terms of the number of KTPs it holds. **C&PMRG** is particularly strong in this area, having KTPs with KPMG (£147k), VINCI (£147k), Laing O'Rourke (£40k) and now Transport for London (£130k), plus consultancy-led research such as IPA (\$100k), Brookfield (£40k), Mercuri Urval International (£30k), and HM Treasury (£19k). **ARG** has KTPs totalling around £150k with Bompas & Parr, Loanguard Ltd and SE Controls Ltd. Also, Manolopoulou coordinated five designer teams (Andrasek, Colletti/Cruz, Lim, Smout/Allen/Borden, and her own) in creating installations for the 2012 London Olympics, with £544k funding from the GLA. **SG** has extremely close links to a UCL spin-out company, Space Syntax Limited (SSLtd), which is currently working on a range of live projects with end-user organisations in industry and local government. It has also started a new KTP with the architectural consultancy, SpaceLab. **CBES** likewise works closely with industry and has an active consultancy portfolio, with its clients including Arup, Barratt Development, Bere Associates, CIBSE, Good Homes Alliance, and the Metropolitan Housing Partnership.

Research infrastructure and facilities: Commencing in 2014, the UCL Estates Strategy will address the historical deficit in The Bartlett's building stock, consolidating the faculty from 7 to 3 sites, and allowing for spatial expansion of approaching 10,000 sq m. In the REF period, however, we were still able to develop research facilities in specific growth areas. For example, in terms of digital design and fabrication, **ARG** has built up a substantial CAD/CAM Lab run by an experienced team of craftsmen and architects, with clusters of advanced computing facilities and The Bartlett Media Hub. The Digital Manufacturing Centre, established in 2008, services the digital manufacturing requirements of the BSA and other UCL departments, as well as many London-based architectural SMEs. The Scan LAB, founded in 2011, develops the use of 3D-scanned data in the built environment across academia and industry. As also noted, our current facility plans

Environment template (REF5)

include the creation of B-MADE with over £2m of investment in equipment. **CASA** is modelled as a well-established laboratory, and given its focus on ICT most of its researchers have relevant equipment funded by research grants. It also has 10 off-site servers. CASA was a hub in ESRC's National Centre for e-Social Science and is now a hub in the National Centre for Research Methods. The group is also involved in ESRC's 5-year Longitudinal Study. In **CBES**, CSH has developed its own state-of-the-art heritage science laboratory, equipped with instrumentation for environmental and material studies, with £680k funding from UCL, SRIF 3 and CIF. The UCL Heritage Science Network has pioneered an equipment inventory and sharing scheme to pool resources across UCL. In general, the UCL Library facilities are exemplary, with The Bartlett having a comprehensive subject library in Wates House with 35,000 books and 250 current journal titles.

e. Collaboration and contribution to the discipline or research base

The Bartlett is fully engaged with the built environment professions, industry bodies and academic societies. It conducts peer review and external examining processes, generates discourse by organising and participating in conferences, and pursues many other modes of dissemination inside and outside academia. From 2008-13, our staff held 67 leading roles in Professional Bodies, 72 roles as Visiting Academics, 138 roles as Conference Organisers, 179 Journal Editorships, 242 External Examiner roles, 82 Fellowships, and 39 Research Coordination positions. They gave 185 Invited Contributions, 2,067 Invited Speeches, 289 Media Appearances, 42 Named Lectures, 52 Public Engagement roles, and were involved as Peer Reviewers for 272 journals/publishers. In addition, they were awarded 3 Lifetime Achievement Awards, 76 Conference Awards, 8 Honorary Degrees, 2 Honorary Doctorates, 4 Honorary Professorships, 13 Honours, 45 Industrial Honours, 101 Prizes, and 15 were elected to Learned Societies.

Interdisciplinary research: The Bartlett's approach to collaborative and cross-disciplinary research has been noted above. Other examples where we are working with scholars from outside our UoA include: (1) *Enfolding*, a project exploring complexity and global dynamics, led by Wilson (CASA) and involving researchers from BSGS and four UCL departments (Geography, Mathematics, Political Science and Crime Science, Civil Engineering), as funded by IPSec's *Complexity for the Real World* programme for £2.5m to look at development aid, shipping, trade, migration and conflict dynamics; (2) *Sexuate Subjects*, a 3-day international conference in 2010 led by Rawes (ARG) and incorporating colleagues from UCL's Slade, History of Art and Modern Languages, and many scholars from around the world, including Luce Irigaray, leading to two publications from Routledge and IB Tauris; and (3) *Deterrence of Deception in Socio-Technical Systems*, a £1.2m EPSRC multi-university project between computer scientists, psychologists and economists, led on the UCL side by Baddeley (C&PMRG) and Sasse from Computer Sciences.

Industry collaborations: The Bartlett also has numerous external research links with industrial and third-sector partners, many of them cited in our REF 3a Impact Narrative. In **ARG**, design research is carried out by staff who also run their own architectural practices, including SmoutAllen, sixteen*(makers), AY Architects, Niall McLaughlin Architects, Izaskun Chinchilla Architects, Storp-Weber Architecture and Miàs Arquitectes. Other ARG staff sit on the steering groups of public arts organisations like This is Not a Gateway (Campkin), Situations and Platform (Rendell); or they participate in judging panels for international architectural competitions - such as for the 2013 EU Mies van der Rohe Award (Migayrou) - or else they take key positions in curation/design/criticism, as in the Centre Pompidou (Migayrou), Serpentine Gallery, Berlin Hamburger Bahnhof and FRAC (Rendell), the 2008 and 2012 Venice Biennales (Rendell, SmoutAllen), and the 2013 Hong Kong/Shenzhen Architecture and Urbanism Biennale (Fournier). Another example is Borden's role as consultant in redesigning the skateboarding park in the South Bank Centre. Also, Bishop was the Founding Director of the GLA's Design for London, Group Director of the London Development Agency, penned *The Bishop Review* (2011) on the merger of CABE and the Design Council, and is also a Director at Allies and Morrison Architects. He has now been brought part-time into the BSA to add real-world expertise in urban regeneration.

For **C&PMRG**, a pan-European study on private equity buyouts was conducted with Mercuri Urval by Teerikangas, while Pryke is Founder and Director of UCL's new Centre of Organisational Network Analysis (CONA). In **DPURG**, researchers are involved in projects with many tertiary organisations and industry bodies in the UK and abroad, such as Architecture Sans Frontières, Royal Institute for International Affairs (Chatham House), UN and others. **SG** is closely linked to industry through the Karimi, Penn and Hillier's involvement as directors of Space Syntax

Environment template (REF5)

Limited, while Psarra acted as a design consultant to Salford Museum and Art Gallery. Work by **CBES** has impacted on a range of key national and international policy formulations recently, including: DEFRA/CCRA report, GLA London Plan, GLA Adaptation Strategy, Approved Document F (Building Regulations) and WHO mould guidelines. CBES staff held central roles in the 2009 *Task Force on the Public Health Impacts of Greenhouse Gas Reduction*, whose work, published as a *Lancet* series, has contributed to a fundamental shift of thinking on the health impacts of carbon mitigation measures. M. Davies leads the UK team participating in the International Energy Agency (IEA) Annex 55 project. As noted, **PRG's** collaborations with industry are clearly exemplified by the SINTROPHER and OMEGA Centres.

In **UCL-E** and **UCL-ISR**, Ekins and Oreszczyn have worked as advisors to the Energy Efficiency Deployment Office of DECC, producing over six reports, and have established a close relationship with the UN Economic and Social Commission for Asia-Pacific (UNESCAP) and Global Green Growth Institute in Korea. Ekins is also one of only 2 Academic Members of the European Resource Efficiency Platform, which contains 5 EU Commissioners. Strachan is the invited lead author of the Intergovernmental Panel on Climate Change (IPCC) Working Group III, and the lead author of Chapter 7: Energy Systems for their fifth assessment report. UCL-ISR has coordinated research partnerships to produce reports such as for Rio Tinto on China's electricity demand.

Academic collaborations: As a faculty-level initiative, the aforementioned *Urban Buzz* project was an exemplary knowledge exchange programme that developed the impact of The Bartlett's urban research on sustainability by establishing a network of links with research users and other universities. In **ARG**, Fraser has recently set up the new ARENA network across leading research-orientated European architectural schools. **CASA's** research in complexity theory and new ways of looking at cities is informed by international academic links with MIT's SENSEable Cities Lab, CUSP in NYU, Santa Fe Institute, EU Global Systems Dynamics Programme, ASU GeoDa Center, and CNRS Géographie-cités Lab in Paris, as well as developing close links to Transport and Complexity Science at Oxford, Geography at Cambridge, Engineering at Newcastle, Business at Warwick, and Architecture at Edinburgh University.

C&PMRG conducts infrastructural research with the University of Bristol (for HM Treasury); *Hacric Research* with Loughborough and Reading Universities; RIVANS research with University of Hong Kong and National University of Technology in Singapore, and trust-in-projects research with the Project-Based Institute, Åbo Akademi University in Turku, Finland. Their collaborations also involve co-authored publications with other universities, e.g. Penn State University, Imperial College, Cranfield, and the Universities of Cambridge, Lancaster, Glasgow, St Gallen, Lausanne, Aalto and Toulouse. Visiting international academics come to C&PMRG from the Universities of Manchester, Reading, Cranfield, British University of Dubai; and BI Norwegian Business School.

DPU has extensive international networks across the northern and southern hemispheres, including Urban Knowledge Network Asia - which has over 100 researchers from 13 institutes in Europe, China, India and the United States, and is funded by a £186k grant - and the *Epidemiology, Ecology and Socio-Economics of Disease Emergence in Nairobi* project, with partners that include the Centre for Immunity, Infection and Evolution at the University of Edinburgh, International Institute for Environment and Development at the University of Nairobi, International Livestock Research Institute in Nairobi, Kenya Medical Research Institute, African Population and Health Research Centre, Royal Veterinary College, UN Food and Agriculture Organization, University of Liverpool, Roslin Institute, and Wellcome Trust Sanger Centre.

Both **UCL-E** and **UCL-ISR** have strong global links, including £1m of DFID and EPSRC funding for UCL-E to undertake research in the Mekong Delta and Africa, the appointment of a Visiting Professor with Lawrence Berkeley National Laboratory, a EU-funded research project with major European energy and climate modelling universities (€8m, Strachan, Keppo-PIs), and the plan to establish an International Energy Epidemiology Network which already has potential academic partners in France, USA, Canada, Australia, Qatar, New Zealand, China, Netherlands, Italy, Portugal, Greece and Nigeria, plus the IEA. They have hosted visiting academics from China, Japan and Australia and organised seminars for 8 academics from different East Asian countries on energy-related issues; and engage in joint research with UCL's campus in Adelaide. UCL-E is the UK host for the IEA International Energy Agency's Energy Conservation in Buildings and Community Systems (ECBCS), and sits on the EU FP7 Environment Advisory Group.

BSP maintains international links through outgoing Marie Curie Fellows to EU universities such as in Barcelona and the Centre for Metropolitan Studies, Berlin, and incoming fellows from

Environment template (REF5)

IUAV University in Venice, plus it has an EU project with 13 EU partners including the University of Utrecht. There is collaborative research on global suburbanism with York University in Toronto (funded by the Social and Humanities Research Council of Canada), and the Korean Research Institute on Human Settlement. PRG's China Planning Research Group (CPRG) has links with professional bodies like the Urban Planning Society of China, organised the China-UK Sustainable Cities workshop supported by EPSRC, and hosts the China Planning Research Symposium.

Journal editorships: Many of The Bartlett's researchers contribute to academic journals and book publishing in their specialist areas, so only a brief overview can be given here. Staff act as editors, co-editors and reviews editors for peer-reviewed titles that include: *The Journal of Architecture*, *International Journal of Project Management*, *Journal of Economic Psychology*, *Urban Design International*; *European Journal of International Management*, *Urban Design International*, *Journal of Facility Management*, *Architectural Science Review*, *Environment and Planning B + C*, *International Planning Studies*, *Journal of Urban Design*, *Built Environment*, *Journal of Space Syntax*, *European Urban and Regional Studies*; *Planning Perspectives and International Planning Studies*. Again, simply as examples, they sit on the editorial boards of: *The Journal of Architecture*, *Architectural Histories*, *Journal of Architectural Education*, *Architectural Research Quarterly*, *Architectural Theory Review*, *Construction Management and Economics*, *International Journal of Project Management*, *Journal of Management*, *Journal of Complex Networks*, *Journal of Engineering Design*, *Urban Design International*, *Journal of Architectural Conservation*, and *International Journal of Ventilation*. In terms of book publishing, they are series editors for *Design Research in Architecture* (Ashgate), *Urban Modelling* (Routledge) and *Innovation in Construction* (Wiley-Blackwell), as well as carrying out countless peer reviews.

Conferences and CPD research: Researchers from The Bartlett also contributed greatly from 2008-13 to developing their disciplines by organising many conferences and/or by being involved in peer reviewing processes, giving papers, invited talks and keynotes, and lecturing to groups outside academia. Staff members have run conferences across a wide range of topics in built environment research. In **ARG** alone, this amounts to 34 conferences/symposia/workshops, which in 2011 included *Fabricate* (Sheil, Glynn), a major international conference, exhibition and publication exploring digital fabrication in design with expert speakers across academia and practice from around the world, and in 2012 the *Smart Geometry* conference (Glynn). Examples from **CASA** are the *Virtual Geographic Environments* (2008) at the Chinese University of Hong Kong and *The Comparative Genetics of Cities* (2010) with Arizona State and Newcastle Universities. In **CBES** there was, for instance, the Science and Heritage Programme international conference on *Sustaining the Impact of UK Science and Heritage Research* (2013).

Bartlett researchers have given academic keynotes, to cite just some examples, at MIT, Cornell, Michigan, Syracuse, Bezalel Academy (Jerusalem), Tasmania, RMIT Melbourne, Aoyama Gakuin University (Tokyo), Bergen, Innsbruck, Leiden, Weimar, KTH Stockholm, Finnish Academy, Bauhaus University and Darmstadt University of Technology. They have also given many invited talks internationally, including at the following universities: Beijing, Tongji, UC Berkeley, Stanford, Carnegie Mellon, Montreal, Vienna, Oslo, Toulouse, Chalmers, Aalto, and BI Norwegian School of Management. **UCL-E** staff have been invited speakers at *Adaptation and Resilience in a Changing Climate* events, and have delivered lectures in plenary sessions at two European Facilities Management conferences. Ekins (**UCL-ISR**) has given keynotes to the Mannheim Energy Conference, the 14th Global Conference on Environmental Taxation, and the Global Environment Action conference (both in Japan, with the latter also addressed by the Japanese Prime Minister).

Outside of academia, our staff have given talks - for instance - to the GLA, Cabinet Office, Department of Business Innovation and Skills, various government ministries in Sudan and Libya and elsewhere, Finnish Technology Agency, Strata EU Conference, ACM Conference on Ubiquitous Computing, Colloque La Modélisation Des Flux Au Service De L'aménagement Urbain, TED.com, Serpentine Gallery, Storefront Gallery (New York), International Centre for Complex Project Management, as well as for associations such as the Finnish, Swedish and French Venture Capital Associations, training organisations like Marcus Evans Amsterdam, and corporations such as Mercuri Urval, Deloitte, Tieto Group Global, Ernst & Young, Kraft Foods, Nokia and Ericsson.

Contributions to professions and learned bodies: In **ARG**, staff have served in 56 key professional roles including President of the European Architectural History Network (Forty); Chair of the RIBA Research and Innovation Group and the Chair of the RIBA Research Trust Awards (Fraser); and judges for the President's Awards for Research (Rendell, Sheil). For **CASA**, Batty is

Environment template (REF5)

a past Chair of the ESRC Census Advisory Committee, while Wilson is Chair of AHRC, a past Member of the Council of the Royal Society, and oversaw the British Academy Report on *Punching Our Weight: The Humanities and Social Science in Public Policy Making* (2008). In **C&PMRG**, staff include the Vice-President of ICE and the Chair of Membership Panel of the Royal Academy of Engineering (Broyd); Fellow of ICE and CIOB, Honorary Fellow and Vice-President of APM (Morris); Member of the TSB Knowledge Transfer Network's Advisory Board, Electricity Policy Research Management Committee, Defra's Hazardous Substances Advisory Committee (Baddeley); and Member of the International Advisory Board of Process and System Innovation in Construction (A. Davies). For **SG**, Penn is Chair of the UK-China Task Force sub-group, set up by government; Raynham is President of the Society of Light and Lighting and Director of the International Association of Lighting Designers; and Mumovic is Founder and Executive Board Member of the CIBSE School Design Group. **PRG** members are Trustee and President of the Town and Country Planning Association and Fellow of the British Academy (Hall); Member of the Urban Studies Foundation and Foundation for Urban and Regional Studies (Wu); Academicians of the Academy of Social Science (Carmona, Hall and Tomaney); Design Council CABE (Carmona); West End Commission (Rydin); and International Federation for Housing and Planning (Gallent). In **UCL-E**, Oreszczyn is a Fellow and Board Member of CIBSE. In **UCL-ISR** Ekins is a Fellow of the Energy Institute and a member of UNEP's International Resource Panel, Expert Panel of the UK National Ecosystem Assessment, Government Office for Science's Foresight Project on Demographic Change, and Ofgem's Sustainable Development Advisory Group.

Developmental disciplinary initiatives: Bartlett researchers have carried out peer review activities for research councils, universities and other funding bodies, or as external examiners and visiting professors. In **ARG**, researchers have served in 57 peer review roles including: AHRC Peer Review College (Campkin, Manolopoulou); external research assessors for international universities (e.g. KTH Stockholm, TU Delft, Innsbruck, Queensland, City University of Hong Kong); overseas research councils (Australia, Hong Kong, Canada, Denmark, Greece, Portugal and The Netherlands); and REF 2014 advisors (Fraser; for the Universities of Liverpool, Dundee, Kent, Oxford Brookes, Greenwich, Plymouth, De Montfort, Northumbria, Cardiff, Queen's Belfast, and Northumbria). In **CASA**, Batty is advisor to the Chinese University of Hong Kong on their research in geographical science, and in 2012 was a member of the CHE Board reviewing Israeli geography departments; Cheshire is Secretary of the Royal Geographical Society's Special Interest Group in GIS; and Wilson was Chair of the Science Community Partnership Representing Education from 2007-10. Staff in **C&PMRG** have reviewed for the EPSRC and ESRC; Dutch Funding Council, PSI Bouw, Canadian SSHRC and NAO; they also sit on the review steering group of the EPSRC-funded *Adaptation and Resilience to a Changing Climate* and the *Sustainable Urban Environments* programmes, plus the EPSRC *Ground and Structural Engineering Research Strategy*. **CBES** staff members have reviewed proposals for AHRC, EPSRC, EU FP7 and funding bodies in Italy, Portugal, Austria, Norway, Slovenia, Estonia, Poland and the Czech Republic, or they serve on the AHRC Peer Review College (Strlic) and as EPSRC Panel Members (M. Davies). **PRG** researchers serve on the ESRC Peer Review College as well as the ESRC Future Research Leaders Sift Panel (Gallent), and the Hong Kong Research Grants Council Peer Review College (Wu).

In terms of external examination processes, **ARG** staff have held external examiner roles in the UK (e.g. Architectural Association, Bath University, Edinburgh University), in mainland Europe (e.g. ETH Zürich, Ecole Spéciale d'Architecture Paris, Oslo School of Architecture and Design), and internationally (e.g. Tunghai University, UCLA, Georgia Tech, RMIT University, Witswaterand University). **CASA's** Batty has been a PhD external examiner in 17 universities since 2008 and as external examiner for GIS Masters programmes at Kingston and Southampton. **CBES** members have acted as external examiners at a wide range of institutions including University of Barcelona, University of Ljubljana, University of Manchester, Eindhoven University, etc. **PRG** members have served as external examiners for 29 programmes at other universities since 2008. In terms of Visiting Professorships, **ARG** researchers have held 12 roles as Visiting Professors, including at the Aarhus School of Architecture, University of Calgary, RMIT and Seoul National University. Staff members in **C&PMRG** act as programme external examiners for the Universities of Cambridge, Reading, Manchester and Brighton. They have also been 'Innovator-in-Residence' at the University of Queensland Business School (A. Davies), Visiting Professor at the University of Toulouse (Teerikangas), Visiting Professor at Åbo Akademi University in Finland (Smyth), and Visiting Professor at Reading University (Broyd).