

<p>Institution: University of Reading</p>
<p>Unit of Assessment: 16 Architecture, Built Environment and Planning</p>
<p>a. Overview</p> <p>Research submitted in this unit of assessment is undertaken within two Schools in different faculties: Construction Management and Engineering (CME) (Faculty of Science) and Real Estate and Planning (REP) (Henley Business School (HBS) Faculty). The description which follows reflects each School's distinctive research strategy and institutional context as well as their common processes and structures.</p> <p>Research in CME is organised primarily into three <u>established</u> groups. The <i>Innovative and Sustainable Technologies (IST)</i> group focuses on environmental sustainability. The <i>Business Innovation in Construction (BIC)</i> group centres on competitiveness, productivity and performance. The <i>Transition Pathways to a Low-Carbon Economy (TPLCE)</i> group addresses energy economics, policy and organisational issues associated with the low-carbon agenda. CME also has two <u>emerging</u> research groups prioritised for future growth. The <i>Digital Practices (DP)</i> group focuses on the practices which emerge from the application of digital technologies to the design, construction and operation of complex buildings and infrastructure. The <i>Healthcare Infrastructure (HI)</i> group concentrates on the role of built infrastructure in the delivery of healthcare. CME hosts the EPSRC Industrial Doctorate Centre <i>Technologies for Sustainable Built Environments (TSBE)</i>. TSBE promotes collaborative research with industry through Engineering Doctorates (EngD).</p> <p>Research in REP is organised into four groups. The <i>Real Estate Investment and Finance (REIF)</i> group focuses on applied industry research into commercial direct and indirect real estate markets. The <i>Real Estate Valuation, Leasing and Market Practice (REVLMP)</i> group concentrates on commercial real estate appraisal/valuation, commercial lease policy and practice, and property management. The <i>Environment, Sustainability and Participation (ESP)</i> group engages with the policy and practice research agenda around governance, regulation, community planning and public involvement. The <i>Housing (HO)</i> group covers housing economics, housing policy, housing supply and house-building, planning policy, financial market linkages and social policy issues.</p>
<p>b. Research strategy</p> <p>Both Schools have been at the forefront of research into the built environment for 40 years, specialising in areas where they have a world-class reputation and track record. They have had a major impact on the development of research in the construction and real estate/planning domains with a long tradition of close collaboration with industry, policy and professional practice. The research strategies of both Schools combine a strong orientation towards 'real world' problems with a commitment to high-quality interdisciplinary research that has sustained impact on practice.</p> <p>Strategic research directions in CME are determined by the School Strategy Committee chaired by the Head of School (Green), while research strategy in REP is closely aligned with HBS strategic aims. Responsibility for the implementation of the respective strategies lies with the School Directors of Research (SDoR) (Sexton, Pain) under the guidance of the School Research Committees which meet once a term. The School Directors of Postgraduate Research Studies (SDoPGRS) (Larsen, Marcato) have responsibility for postgraduate research students. The SDoRs and SDoPGRSs are <i>ex-officio</i> members of the Faculty of Science/HBS Research Boards and Postgraduate Research Boards respectively.</p> <p>Within CME the period since RAE 2008 has been a time of renewal and rejuvenation in the structure and direction of the School's research. CME undertakes underpinning and applied research relating to the design, construction and operation of the built environment. The focus is primarily on commercial and domestic buildings, but increasingly extends to complex infrastructure. The research activity is underpinned by an interdisciplinary socio-technical systems philosophy that stresses the reciprocal relationship between people and the built environment. This philosophy has led to the incubation of a research culture within CME where engineers, designers, management specialists and social scientists work in close collaboration. The five-year research strategy described in the RAE 2008 submission was for the School to 'develop its areas of competitive advantage in sustainability research by recruiting new staff, to replace those retiring and to grow areas of strength.' This strategy has been implemented through a series of planned developments. Of particular note are the four expansion appointments funded through the UoR's Academic Investment Programme (AIP) to strengthen capability in the area of climate change and the built environment (Dixon, Peters, Shao, Smith). The extent of renewal and rejuvenation is further demonstrated by the evolution of the School's research groups and the establishment of new</p>

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patterns of funding. The overriding strategy is to build on areas of strength whilst ensuring alignment with external funding priorities and built environment policy and practice objectives both within the UK and internationally.

The RAE 2008 submission described three research divisions within CME: Innovative Construction (IC), Sustainable Environments (SE) and Sustainable and Innovative Technologies (SIT). The IC division was dominated by the EPSRC-funded 'Innovative manufacturing research centre' (IMRC) which has since evolved into the BIC research group which was formally constituted in 2010 (leader Green). The SE and SIT divisions were similarly consolidated into an expanded IST research group in 2009 (leader Yao). Several new academic appointments have strengthened expertise in building physics (Smith), energy supply (Coker), energy in buildings (Shao), sustainable technologies (Essah) and urban microclimates (Luo). These core areas of expertise are benefiting, in particular, from research collaborations with leading Chinese universities, with an especially strong collaborative link with Chongqing University including various joint projects. The strategy is to build complementary collaborative partnerships in Europe. A strong foundation is already in place with a recently secured FP7-Energy project (started September 2013) involving nine institutions from six European countries. A similar strategy of renewal has been applied within the BIC group where new appointments have strengthened expertise in sustainable construction (Connaughton) and organisational behaviour and corporate social responsibility (Phua). Within BIC, the strategy is to focus on applied research in collaboration with industry and other academic centres of excellence.

Perhaps the most important development since the RAE 2008 has been the establishment of the TPLCE research group (leader Sexton). Capacity building had previously taken place within the EPSRC-funded IMRC. Several new appointments further enhanced capability in a range of areas: low-carbon innovation (Lu, Sexton), sustainable urban futures (Dixon), energy policy (Peters, Torriti) and the institutional frameworks governing transition pathways (Schweber). These investments have led to a unique interdisciplinary research group which is beginning to compete strongly for funding. Research activity funded by EPSRC and ESRC has directly informed the work of the Zero Carbon Hub and the National House Building Council Foundation (NHBC), both of which advise the government on the specification and implementation of zero-carbon policy.

The development of the DP and HI emerging research areas was likewise supported through capacity-building within the IMRC. The two embryonic groups have since been highly successful in securing their own dedicated funding streams. The DP research group (leader Whyte) aligns with and contributes to UK Government construction sector priorities regarding the adoption of Building Information Modelling. The activity is centred on the EPSRC-funded 'Design innovation research centre'. The group has been recently strengthened with a new appointment in the area of digital architecture (Nikolic). The group works closely with a range of industry partners (including Arup, Halcrow and Fulcro). The distinctive contribution of the group has been to shift the policy and research agendas away from digital technologies *per se* towards the interaction between digital technologies and organisational practices. The DP group collaborates closely with several leading comparative international research groups, including Stanford and Case Western.

The HI group (leader Harty) has developed the cross-cutting theme of healthcare infrastructure systems identified in RAE 2008. The strategy is to build upon the activity relating to socio-technical innovation systems in healthcare within the EPSRC-funded 'Health and care infrastructure research and innovation centre' (HaCIRIC). This Centre was a four-way collaboration between Imperial College London and the universities of Loughborough, Reading and Salford. Ewart's recently awarded ESRC Future Research Leaders Fellowship is extending the group's work in health in the home. The HI research programme is positioned against the UK Government's agenda to deliver more responsive and cost-effective healthcare systems that extend to telecare and telehealth. The on-going strategy is to pursue interdisciplinary collaboration with other schools within UoR (in particular, School of Psychology and Clinical Language Sciences, School of Systems Engineering) and elsewhere (e.g. Copenhagen Business School).

The strategic evolution of the research groups has been supported by decentralised leadership of those groups across the School. The flexible management structure gives us the ability to develop and lead in specific research areas. It also provides focused channels of communication to academia, government and industry to ensure our research impacts at the highest level. Research capacity has been grown through new academic appointments and enhanced interconnectivity with other research groups. In an increasingly competitive research environment, the aim has been to

develop a greater diversity of funding sources than that which prevailed in 2008 (see Section D).

For the next five years, the aim is to continue to build critical mass within the DP and HI emerging research areas so that they become established research groups. Additional investment within the BIC group will also be necessary to sustain its success. Building upon established expertise within the IST group and TSBE plans are in place to strengthen the cross-cutting theme of 'energy management in the built environment'. Continued investment in this area will see the emergence of a dedicated research group drawing together expertise from several UoR schools, including Meteorology and Systems Engineering.

REP's overall aim is to undertake world-class leading-edge research into real estate and planning. The integration of planning and real estate has long been a distinctive feature of Reading. Over the last six years we have widened our international land and property development and investment research agenda. In addition, we have consolidated strengths in governance studies and sustained existing strengths in real estate appraisal, investment and finance.

The 2008-13 objectives stated in RAE 2008 were as follows: to increase the internationalisation of our activity; to respond to developments in the market maintaining our engagement with and impact on industry; and, to increase the community of PhD students with a view to building future capacity in real estate academe. All of these objectives have been achieved. First, REP has made significant progress in internationalising its research agenda and staff. This is especially evident in the area of development studies. Previously established research activity included the economics of sustainability, development appraisal, community-led planning and housing supply. The international orientation of the ESP research group has been significantly strengthened by the appointment of Pain whose interest is the connectivity and sustainability of global and globalizing world cities. Other new international initiatives within this group include: community planning and public involvement in planning in rural and urban regeneration contexts (Parker, Doak, Street, Nunes) and solid waste management and food security in developing countries (Chettiparamb). Within the REIF and HO groups, new international areas of study include research into the pricing of derivatives (Marcato) and new appointment Nanda has brought with him a research agenda into real estate brokerage in the USA. This body of work has attracted funding from ESRC, ESPON, Government and industry.

Second, REP has contributed to a number of emerging policy and practice research agendas in real estate and planning. Of particular note within the REVLMP research group is the measurement of development viability issues within the new UK Government policy approach to planning (Wyatt, Crosby with McAllister (UCL)). This has become a major theme funded by ESRC, CLG and RICS. Research into the impact of sustainability and certification of buildings on property values has developed and we intend to expand this topic (Wyatt, Van de Wetering with Fuerst (Cambs) and McAllister (UCL)). REVLMP has also responded to DECC's policy initiative on the reduction of energy use in domestic and non-domestic real estate (Wyatt) and to property valuation issues raised by the financial crisis (Crosby, Hughes). These emerging areas build on longer-standing areas of expertise. For example, REVLMP has continued to investigate client influence on valuations (Crosby, Lizieri, McAllister), depreciation (Crosby, Devaney) and commercial leases for the Government (Crosby, Hughes). Within REIF we contributed to on-going debates on Real Estate Investment Trusts (REITs) (Stevenson, Ro, Gallimore); indices (Marcato, Devaney, Crosby); portfolio construction and decision making (Baum, Byrne, Marcato, Stevenson, Gallimore). In the HO group, Ball (with Meen and others in Economics) made well publicised contributions to issues of housing supply and the cost of the planning system and new members of the HO team included Nanda (whose work includes aspects of international housing market dynamics) and Clapham (work includes homelessness, happiness, well-being and housing policy). In ESP Parker continued his work into neighbourhood planning. Much of the work identified above addresses the objective of industry engagement and impact. The objective to expand the research student community is addressed in Section C.

REP strategic aims for the next five years are to continue to grow the internationalisation of School research; maintain research leadership in core areas of activity, both in the UK and overseas; and develop and/or respond to emerging or new areas of interest. The international agenda is based on three initiatives. The first is to support the University's new overseas campus development activity by focussing on real estate and planning research issues in those countries; for example, the new campus in Malaysia. The second is to develop activity in South American markets, where joint bids have been orchestrated for collaborative research seminars with three

universities in Brazil, Argentina and Columbia around a development agenda (the first seminar was held in September 2013 in Sao Paulo). Third, the exploration of new research collaborations with partner institutions involved with the new MSc in International Planning; current initiatives surround the theme of Governance of Local Communities in India and Sri Lanka. The creation of the HBS provides opportunities to maintain leadership in established areas such as real estate appraisal and finance. For example, developing the collaboration with the UoR International Capital Market Association (ICMA) Centre with a joint REP/ICMA Centre appointment at Chair level (Tsolacos). It also provides an opportunity to develop new areas of expertise, for example, through linkage with the new HBS research centre in Governance, Accountability and Responsible Investment (GARI).

Other newer areas of interest to be targeted and developed include research into global cities and international markets building off the work of recent appointments (Pain) and the South American initiative; exploiting UK and European funding opportunities in these fields. As indicated above, we aim to bring the work in the area of governance in real estate and planning, currently being undertaken individually within the REP research groups, together to create a coherent theory-led approach, which integrates GARI with HBS. Finally, we will build on the linkage between REP and the ICMA Centre within the theme of pricing of direct and indirect real estate. The development of this linkage will bring together the largest cluster of appraisal, finance and investment academics in the UK with expertise in the pricing of REITs and derivatives and other indirect real estate based products, as well as pricing direct real estate.

Both Schools will continue to build activity in the field of sustainability. Critical mass for this endeavour has been enhanced by the establishment in 2012 of a cross-University research initiative on *Sustainability in the Built Environment*. This will continue to be developed to realise new directions in interdisciplinary research across school and faculty boundaries, including CME and REP. Prioritisation will continue to be given to the cross-cutting theme of 'climate change in the built environment' with a view to fostering a more extensive research programme in association with the Walker Institute for Climate System Research. Underpinning strength is provided by the *TSBE* which is playing an important role in building interdisciplinary research capacity through the joint supervision of EngDs.

c. People, including:

(i) Staff.

Our staffing policy is to recruit, develop, motivate and retain high quality people to execute our research priorities. A common theme within both Schools is to create and maintain a supportive and collegiate environment enabling individuals to develop their own research interests within the context of the preceding strategy. There is an annual Personal Research Plans (PRP) system in place to assist staff to prioritise their research goals. Funding is available to support staff development. Examples include: UoR Research Endowment Trust Fund and the UoR Travel Awards for Staff and Students scheme; internal funding from taught PG income for the purchase of data sets and other small scale research needs; and, the use of Staff Development Accounts to fund personal research. In addition we have a staff sabbatical system and use of School-funded sessional lecturers to facilitate teaching release. Over the REF period, nine members of academic staff have been granted sabbatical leave and/or a secondment to other universities or industry. Both Schools have Promotion Committees to ensure all cases submitted to the Head of School are treated fairly, transparently and in accordance with University equality and diversity best practice. Given the professional orientation of both Schools together with the research-led teaching philosophy, the common aim is to recruit staff on teaching and research (TR) contracts. This recruitment strategy is to underpin applied research and dissemination in core areas of the academic and professional curriculum.

CME has 32 members of academic staff, 28 of whom are on TR contracts. There is also one teaching fellow and five research fellows, all of whom are on fixed-term contracts. One further research fellow is on a permanent contract. Barlow is currently seconded to CME from the Department of Meteorology on a 0.5FTE appointment as Director of the *TSBE*. A part-time research manager is responsible for the co-ordination and implementation of strategic initiatives. A PGR administrator provides support to the PhD programme. Research support staff within *TSBE* includes a centre manager, an administrator and a business development officer (responsible for securing industry participation in EngD projects). The School received the Athena Swan (Charter for Women in Science) Silver Award in May 2009, subsequently renewed in May 2013, thereby demonstrating continued commitment to equality and diversity. The percentage of female staff

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increased from 40% in 2008 to 58% in 2012. The staff profile has changed significantly with approximately 50% of the current staff being new appointments. Eight professorial staff submitted to the RAE 2008 have since retired (Atkins, Awbi, Chaplin, Clements-Croome, Fisher, Gray, Jeronimidis, Lansley). Five academic staff have left to take up posts elsewhere (Bonser, Cockerill, Luck, Mann, Shipworth). The 13 replacements include two professors (Connaughton, Sexton), two readers (Phua, Schweber), ten lecturers (Coker, Essah, Harty (now Reader), Hyde, Lu, Luo, Nikolic, Torriti, Tutt, Vahdati) and one teaching fellow. In addition, there have been four new expansion appointments through the UoR £50 million Academic Investment Programme (AIP) (Professors Dixon and Shao, and Lecturers Peters and Smith). All AIP appointments have been allocated light teaching loads to enable them to focus on research.

REP comprises 21 full time and five part time academic staff. This includes 16 full time and three part time TR contracts, one research only and three teaching only full time contracts and two part time only contracts. There is one full-time research officer part funded by the Reading Real Estate Foundation (RREF) in addition to project specific research officers. (RREF is a registered charity with the aim of supporting real estate and planning education at the UoR.) RREF is funding a full time research administrator from 2013 onwards. The School employs a part time PGR student administrator, although much of the PG student administration takes place within the HBS. The period since RAE 2008 has similarly been a time of rejuvenation and growth of staff. Around two-thirds of the current staff have been appointed since 2008. Two professorial staff have retired (Baum, Matysiak). Six staff have left to take up posts elsewhere (Allmendinger, Congreve, Fuerst, Lizieri, McAllister, Ro), three of which went to Cambridge (Allmendinger, Fuerst, Lizieri). Gibson and Gibbard have transferred from REP to the Deputy and Associate Deanships of HBS respectively. Foster has retired. The 11 replacements and six additional staff include four professors (Clapham, Gallimore, Pain, Stevenson), two readers/senior lecturers (Chettiparamb, Wyatt (now Professor)), nine lecturers (Devaney, Gabrieli, Nanda (now Senior Lecturer), Nunes, Ro, Van de Wetering, Street, Bouchouicha, Milcheva), one teaching only and two part time teaching fellow. In addition, there has also been one new expansion appointment through the UoR AIP (Tsolacos, Joint REP/ICMA). REP has successfully transformed the age, gender (12% to 28% female) and international (18% to 40%) profile of the School.

The net effect of the strategic staff changes across **both Schools** since RAE 2008 has been to increase the academic staff contingent and re-energise research capabilities in established and new research areas. The staff changes have acted to re-balance the age structure of both Schools. The age structure has reduced because the majority of the departures were either retirements or more experienced staff, and most of new recruits have been early career researchers (ECRs). The demographic shift will allow long-term continuity in staffing and research activity.

In **both Schools** equality of opportunity and career progression guidance and support for academic and research staff is prioritised and implemented through a range of School and University mechanisms. The Heads of School ensure full implementation of the Local Concordant to Support the Career Development of Researchers and the University's Code of Good Practice in Research. The Concordant and the Code ensure the thorough induction and performance management of research staff. Both Schools' Research Committees have contract research staff and PGRS representation. The UoR was one of the first ten HEIs to receive the European Commission award for HR Excellence in Research.

Staff development best practice is enshrined from recruitment onwards. There is mandatory training for interview panel members (with a particular focus on equality and diversity). Newly-appointed academic and research staff are allocated a senior academic mentor and are required to attend central and personalised School-level induction programmes. ECRs are appointed on probationary contracts and are provided with full support to achieve clear objectives agreed with the respective Heads of School, and monitored by the respective Deans. ECRs are allocated light teaching loads in their first two years. Research staff are typically on two-year fixed-term contracts, are guaranteed five days personal development activity per year and are expected to participate in an annual University-wide Research Staff Conference. All other academic staff are on permanent contracts after probation. Staff Development Reviews are conducted annually and staff prepare a PRP and are encouraged to set their own objectives. Appropriate training needs are identified and training is provided by the Centre for Quality Support and Development (CQSD).

The strong focus on supporting career progression is evidenced by 80% of CME and 100% of REP non-professorial staff submitted to RAE 2008 being promoted in the REF period. Examples

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from CME include: Yao (lecturer to professor) and Harty and Schweber (senior research fellows to readers); and from REP: Hughes, C. (lecturer to senior lecturer) and Marcato (lecturer to reader).

(ii) Research students.

Postgraduate research students (PGRs) are an integral and celebrated part of **both Schools'** communities. The PGRs include PhD students aligned with specific research groups and CME EngD candidates based within TSBE (with some joint supervision from REP). There is PGRS representation on both Schools' research committees. The PGRS community strongly contribute to and benefit from the Schools' vibrant research cultures and represent the future of the built environment and planning disciplines. In both cases there is a deliberate policy to create and nurture an environment that inspires PGRs to stretch themselves academically. Both Schools offer funded research studentships through the University Research Studentships scheme and manage students within the University Code of Practice on Research Students.

Application procedures are similar in **both Schools**. Applicants are required to develop a convincing research proposal prior to an offer being made. Both SDoPGRS support the applicant through this process with detailed feedback on initial drafts. The iterative process further benefits from input from potential supervisors. Upon arrival, PGRs undertake induction programmes within CME/REP and the UoR Graduate School to ensure they are able to access the full range of academic and student services available. The TSBE runs additional induction procedures in accordance with the specific needs of EngD students. PGRs in both CME and REP are located in dedicated postgraduate research space with fully-equipped individual workstations. In addition to the primary supervisor, each student also has a secondary supervisor (and in some cases, two secondary supervisors) so that he/she has additional expertise to call upon. The supervision policy has the further benefit of ensuring continuity of supervision in the event of retirements/departures while providing a support mechanism for inexperienced secondary supervisors. Policies are in place to limit individual academics to a maximum of six PGRs as primary supervisor, thereby ensuring that the quality of supervision is not compromised. PGRs are subject to an annual review of academic progress involving two independent academic assessors. The assessment process is overseen by the SDoPGRS and reviewed by the UoR Graduate School. The Graduate School runs a comprehensive range of training courses focused on transferable skills. Career guidance seminars and career development courses are provided by CQSD.

In **CME**, there are 52 FT and 5 PT PhD and 34 FT EngD students. The University-level doctoral training is complemented at School level with monthly seminars focusing on how research methodologies can be applied in the specific context of built environment research. PGRs also participate in the well-established CME Thursday lunchtime research seminar series which has been running for over 10 years. Of further note are the more formal monthly research presentations by invited external academics under the auspices of the Research Institute of the Built Environment. *Ad-hoc* seminars are given by visiting researchers, thereby further enriching the research culture. CME has for the last ten years run a full-day annual postgraduate research conference, thereby providing students with additional feedback. There is a full set of conference proceedings and prizes for the best paper and presentation awarded. The *TSBE* runs a similar one-day conference for EngD students, with the active participation of industry partners.

In **REP** a major objective over the REF period has been to increase the number of PGR students in real estate. The real estate discipline has in the past seen very low levels of PGR-related activity, both from funding bodies and prospective students. In order to build the academic base of the real estate discipline, REP has used its internal funding base, industry collaborations, RREF and its involvement with the newly awarded South East ESRC DTC, to fund a significant increase in the number of PGR students over the 2008-13 period. In the previous RAE period, the average number of students in REP at any one time was 10, but over half of these were part time, and the number of completions was just over one per year. Currently there are 24 FT and six PT PGR students. Completions in the current REF period stand at seven but this is expected to rise significantly in the next REF period as a result of the recent expansion of enrolments. PGRs attend the weekly REP research seminar and the monthly HBS research seminar programme. REP also holds an annual one-day PGRS conference where students present their work and obtain feedback from the academic staff. REP is currently integrating its full time PGRs into the HBS M.Res based doctoral programme.

Both Schools encourage PGRs to present at national and international academic conferences. For example, in 2013 16 CME students presented at the Association of Researchers in

Construction Management (ARCOM) conference and the International Council for Research and Innovation in Building and Construction (CIB) conferences. In 2013 seven REP students presented at Pacific Rim, European and American Real Estate Society conferences. PGRSs routinely apply for funding to support attendance at international conferences. Academic career development is supported through a planned and monitored set of activities. At University level PGRSs attend the Graduate School Researcher Development Programme that offers a comprehensive range of training courses focused on transferable skills. Career guidance seminars and career development courses are provided by CQSD. At School level PGRSs have the opportunity to engage with the Schools' taught PG programmes. This is optional for PhD candidates, but EngD students are required to accumulate a minimum number of credits. PGRSs are also encouraged and supported to contribute to undergraduate and postgraduate taught courses through participation in tutorials and occasional specialist lectures.

d. Income, infrastructure and facilities

(i) Research Income.

The strategy for **both Schools** over the next five years is to continue to build from a strong base of funded activity, to broaden the proportion of staff securing funding and to diversify funding sources. The diversification strategy is, in part, a direct response to the changes in the funding landscape since RAE 2008. EPSRC, for example, has shifted its priorities away from disciplines such as construction management. Similarly, there has been a reduction in evidenced-based Government policy research funding. Funding strategy is overseen by the respective School Research Committees. Despite a highly competitive environment we have maintained strong funding in the REF period from the RCUK (£7.5M); European Commission (£430k), UK central government (£612k) and industry and commercial grants (£405k). Examples of funding success from new sources compared to RAE 2008 include the Technology Strategy Board, the Royal Academy of Engineering and the house building industry (NHBC, McCarthy and Stone); and, from overseas, the African Climate Change Fellowship Programme, the Chinese Ministry of Science and Technology, and ESPON.

In both Schools all funding applications are now subject to a rigorous peer review process co-ordinated by the SDoRs, to ensure high quality threshold standards and to build proposal development capability. Both Schools benefit from central Research and Enterprise Development Managers who provide academics with one-to-one support on all aspects of research funding, from the identification of funding sources through to costing, reviewing and submission of research grant applications. The academic leads of the research groups provide ECRs with additional mentoring and career development support. Both Schools have Ethics Committees to ensure compliance with the University research ethics policies. The diversification strategy in the last five years is evidenced below with examples from the research groups from the two Schools.

CME. The EPSRC-funded *TSBE* (£6m) has provided a strong integrating hub for the *IST* group. New appointments have further led to a diversification of funding and extension of focus into renewable energy and energy demand side management (for example, Torriti, Technology Strategy Board (TSB), £47k). The *BIC* group has built upon three significant EPSRC projects running at the start of the REF period ('Innovative construction research centre' - £3.7m; 'Knowledge and information management through life' - £519k; 'Sustained competitiveness in the construction sector' - £238k). New appointments have complemented and diversified this activity; for example, productivity efficiencies through partnering (Connaughton in partnership with Ryder Levitt Bucknall, TSB, £239k) and near site assembly in flying factories (Harty in partnership with Skanska Technology, TSB, £122k). The *TPLCE* group was established with an initial focus on the transition to low and zero carbon new homes (Sexton, EPSRC, £187k; ESRC, £40k). Further new appointments have extended research interest and funding sources to retrofit (Dixon, EPSRC, £72k), social sustainability (Dixon, Young Foundation, £3k) and the dynamics of energy, mobility and demand (Torriti and Connaughton, £231k). The EPSRC-funded 'Design innovation research centre' (£1m) provides the central springboard for the emerging *DP* research group. Whyte has secured further EPSRC funding (£19k) to grow activity in configuration management in through-life engineering. Further, she has mentored research fellows in the Centre to win their own small grants to build capacity relating to digital business models (Lobo, British Academy, £2.4k). The EPSRC-funded 'Health and care infrastructure research and innovation centre' (HaCIRIC) (£1.2m) and the RAE 2008 period 'Strategic promotion of ageing research capacity' project (SPARC) provided the foundation for the emergent *HI* research group. Follow-on funding to SPARC came

through 'KT-EQUAL: putting ageing and disability research into practice' project (Lansley, £200k). Following his appointment in 2009, Harty progressed rapidly to lead the UoR component of the EPSRC extension to HaCIRIC (£1m). Ewart's ESRC Future Research Leaders Fellowship is extending the group's work in health in the home (£182k, three years from October 2013).

REP. As a consequence of the changing staff profile and the reduction in evidenced based Government policy research, REP has diversified its funding stream over the current REF period; for example, maintaining existing industry, Government and ESRC funding within the REVLMP group. ESPON and CLG are new sources of funding for the emerging world cities and housing agendas within the ESP and HO groups. The REVLMP and REIF groups have continued to link with agenda setting bodies in Government, industry and academia and attract funding from ESRC, Government, industry and professional institutions. Examples include CLG and Investment Property Forum (IPF) funding for work on commercial leases and rents (Crosby, Hughes, Devaney, £60k), IPF funding of investment property depreciation (Crosby, Devaney, Nanda, £70k) and liquidity (Devaney, Marcato, £50k), ESRC/CLG/RICS funding for the emerging Development Viability Assessment research agenda (Wyatt, Crosby, McAllister, £100k). Department of Environment and Climate Change (DECC) funding has also been secured for the joint research with Cambridge on energy efficiency and prices (Wyatt, Nanda, McAllister, Fuerst, £20k). A number of REF 2 outputs from, for example, Crosby, Wyatt and Devaney can be specifically linked to these funded projects. Smaller scale funding examples for investment based projects include the value of designer buildings (Nuffield) and using sentiment surveys as leading indicators (Marcato, RICS). The ESP group has attracted European collaborative funding with six European Universities in the ESPON TIGER project ('Territorial impact of globalization for Europe and its regions'), partly financed by the European Regional Development Fund (Pain, £165k). Street, in collaboration with Oxford Brookes, West of England and Southampton universities, is part of the EPSRC £1.2m 'Promoting independent cycling for enhancing later life experience and social synergy through design' project (£300k). Parker is currently co-ordinating a large part of the CLG 'Supporting communities in neighbourhood planning' programme (c£20m) while on a two year secondment to RTP/Planning Aid England. The HO group attracted around £375k of funding from ESRC, CLG, National Planning Advice Unit, RICS and industry for a number of projects connected with housing supply, planning delay, infrastructure and retirement housing (Ball, Nanda).

(ii) Infrastructure and facilities.

CME has 300m² of laboratory space. Facilities include a dedicated environmental chamber, a grey water facility and a recently refurbished wind tunnel. The laboratories are especially important in supporting the experimental work of PGRSs. There is also an extensive range of materials-testing facilities which are slowly being phased out as the pattern of research activity within the School. CME has access to the 3D immersive VR facility located within the School of Systems Engineering (SSE); the facility is jointly managed by School of Systems Engineering and CME. The Design Innovation Research Centre also possesses a dedicated innovation lab which utilises a range of digital technologies. Dedicated space is also provided for the TSBE.

REP has moved to the new purpose built Henley Business School building supporting the HBS Academic Resource Centre, which has a full suite of investment and finance research data resources (datastream, SNL, IPD). It was originally designed to support REP before extending its resource materials to the wider HBS. REP has two dedicated computer labs within the building and individual work stations in purpose designed space for the expanded PhD programme.

e. Collaboration or contribution to the discipline or research base

Contribution to the discipline / research base.

Both Schools provide strong, distinctive contributions to the built environment discipline. Our approach to research is inherently interdisciplinary, as evidenced by the diversity of disciplines within the Schools and the breadth of our national and international collaborations. In addition to the funded project-based collaboration detailed in Section D, we have strategic relationships with leading research networks, research funders, universities, policy bodies, research users and professional institutions.

Research networks. We consistently play a leading role in the co-ordination of leading international and national research networks. Evidence of our engagement include: CIB Management Board member (Radosavljevic); CIB Working Commission joint-coordinator (Sexton); ARCOM committee members (Harty, Hughes, Lu, Radosavljevic); Director of Applied Studies in the Globalization and World Cities Network (Pain); and, European Real Estate Society (ERES) PGR student networks

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and establishment of International Real Estate Societies in Asia, Africa and Latin America (D'Arcy, Tsolacos). Hughes W. is editor-in-chief of Construction Management and Economics which is widely recognised as one of the leading journals in the field. UoR hosted the 29th ARCOM annual conference (2013) and has been chosen to host the AREUEA international conference in 2014.

Research funders. We consistently play an active role in shaping funders priorities and activities. Evidence includes: (i) membership of EPSRC Manufacturing Advisory Group (Green, 2010-11) and the EPSRC Innovative Manufacturing Strategic Advisory Group (Green, 2003-4); (ii) staff regularly refereeing proposals for three of the UK research councils (EPSRC, ESRC, NERC), TSB, EU, ESF and the Leverhulme Trust; (iii) 18 staff act as assessors for research councils across five continents, such as the US National Science Foundation, the Hong Kong University Grants Committee and the Netherlands Organization for Scientific Research; and, (iv) nine staff are currently members of UK research council peer review colleges (EPSRC - Cook, Dixon, Flanagan, Green, Shao, Whyte, Pain, Yao; ESRC – Schweber, Pain).

Universities. We have long-term collaborative relationships with leading-edge international universities through funded projects and 14 visiting professorships. Furthermore, specific agendas are progressed through collaboration. **CME** examples include: VTT and Stanford (Whyte, digital practices); Copenhagen Business School (Harty, healthcare infrastructure); National University of Singapore and Hong Kong University (Green, construction sector industry reform); Chongqing University (Yao, energy management). **REP** examples include Auckland University (Stevenson, residential sales), University of Connecticut (Nanda, residential brokerage), Seoul University (Tsolacis, pricing), University of Tokyo (Parker, local planning) and Université Libre de Bruxelles, Bucknell University, USA and the Chinese Academy of Social Sciences (Pain, TIGER and Global Urban Competitiveness projects) and University of Cincinnati (Marcato, smoothing).

Policy bodies and professional institutions. We engage with government and professional policy arenas with a view to shaping the industry research needs. Government connectivity includes: economic advisor to DEFRA (Torriti); housing advisor to CLG (Ball); British Standards committees (Whyte, Cook, Hughes); Advisory Board for Construction Exports of UK Trade and Investment (Flanagan). Professional institutional collaboration includes: chair of the CIOB Innovation and Research Panel (Green); Advisory Board of the Association for Consultancy and Engineering (Flanagan); RICS Sustainability Task Force (Dixon); RICS UK World Regional Board (Flanagan); chair of the CIRIA Executive Board (Connaughton); ICE Information Systems Panel (Whyte); RICS Asset Valuation Standards Committee (Crosby); CIBSE and ASHRAE design guide committees (Yao); RICS/IVS valuation guidance note steering groups (Crosby, Wyatt); Investment Property Forum and EPRA research committee (Devaney, D'Arcy). CME continues to work closely with Construction Excellence. In REP, Parker has a two year secondment (0.8FTE) to the Royal Town Planning Institute from 2012 to 2014; Marcato is an advisor to the Bank of Italy; Street is Secretary of the Joint Planning and Environment Research Group Royal Geographical Society / Institute of British Geographers; Parker chaired the Community Council for Berkshire.

Arrangements for supporting collaboration.

Pump-priming to support collaboration activities is made available to staff, particularly for ECRs, through a variety of University and School mechanisms; as well as the staff sabbatical and academic workload allocation systems (see People (i) section). The principal support for collaboration is through externally-funded research (see Section D for exemplars). The Schools' research group structure is important to enable the development of collaboration in specific core areas. The TSBE, the Sustainability in the Built Environment initiative and the Walker Institute for Climate System Research provide additional support for cross-University collaboration.

Research environment enrichment.

The research environment is constantly enriched by CME and REP staff and students bringing back new ideas, approaches and good practice from, for example, research projects and conferences. Enrichment in both Schools also comes from the exceptional quality, quantity and diversity of visiting researchers engaged in research projects, seminars, and the development of joint research bids / publications. Sabbatical visitors are provided with dedicated office space. Examples of evidence: **CME** - Tyggestad (Copenhagen Business School), Hargadon (University of California), Dougherty (Rutgers Business School), Sacks (Technion University). **REP** - Ling (University of Florida), Hartzell (University of North Carolina), Chang Min (Pyeongtaek University in Korea), Menghini (Lausanne University).