Institution: University College London

Unit of Assessment: 14 – Civil and Construction Engineering

a. Context - UCL's submission to UoA14 comes primarily from its multi-disciplinary Department of Civil, Environmental and Geomatic Engineering (CEGE), the work and impacts of which are shaped by a commitment to tackling big issues within the framework of the departmental theme of **"Engineering a Better World"**. Work addressing this theme encompasses topics from city design, transport infrastructure and managing an ageing population, to materials, water and energy resource management. The Unit's work is used by and provides benefits for the following groups: **Industry**; **Government, NGOs and Policy-Makers**; **Educational Professionals**; **Professional Institutions**. Engagement with **industry** ranges from strategic partnerships with companies that span both teaching and research activities, to industry-tailored small research projects. We partner with **large corporations** such as Atkins, Arup, Network Rail, Airbus and Petroleos de Venezuela SA, where our research in advanced structures, rail transport, metrology, water resources and waste management support the making of informed decisions and feed into CPD. Our track record in infrastructure finance and engineering risk support activities in **insurance and international finance**, with partners such as the European Investment Bank, Willis Reinsurance and AIR Worldwide, where we help in the evaluation of risk and develop policy. Research in areas such as transport infrastructure and accessibility has been used by **transport service providers,** such as Transport for London, London Underground and the Olympic Delivery Authority, to enhance the quality of transport services and improve customer experience. We also work with SMEs such as Arius3D (2010 winner of UCL SME Partner Award) where we developed cutting-edge 3D digital exhibitions for the creative and heritage industries. Our research has informed local, national and international **governments, NGOs and policy-makers**, including the Peruvian Government, Habitat For Humanity and Care International. We have also conducted fundamental materials research for the Environment Agency; studies of waste reuse and sustainable community infrastructure for local authorities and NGOs; and water resources modelling for the water regulators. This engagement has facilitated the delivery of tools for planning urban development and evaluating post-disaster resource needs and shelter provision. A longstanding relationship with NASA has led to more accurate satellite orbit models for global positioning and 3D sensing for the non-destructive testing of the next generation of air and spacecraft. **Educational professionals** in schools, learned institutions, societies, and charities have benefitted from the use of our research in fields such as water, accessibility and healthy infrastructure to produce and run science and education-orientated festivals and events for audiences of school children, academics and government. International examples include Nazarbayev University in Kazakhstan and more recently UDP in Santiago, Chile, where our advice to helps develop their curricula and research base. Our educational and engagement impact is extended to the **general public** through activities responding to and supporting community empowerment, digital exhibition, transport policy and child health. We contribute to the professionalism and the public perception of engineering through **professional institution chartership schemes** (ICE, IStructE, ICES, CIWEM and RICS) and co-promotion of our discipline both nationally and internationally, including by hosting UCL's "Engineers Without Borders" work in sanitation projects in Brazil, Mexico and Mozambique.

b. Approach to impact - Our current research focus on "**Engineering a Better World**" translates into proactive and stimulating engagement with our broad user base in an approach that particularly promotes a policy of ***knowledge exchange and directed engagement.*** However, the UoA has a much longer tradition of promoting research interest through its backbone of ***professional communication and knowledge exchange***, instigated in the early 1990s in the form of MSc Project collaborations and through our Professional Tutorial System, which cultivates the direct engagement of every academic with at least one of our beneficiary groups. This system is facilitated by our Knowledge Exchange Director (KED) (*Richard Simons*) and CPD officer (*Raul Fuentes*) who seed partnerships and stimulate communication, understanding and co-research between professionals and academics. Since 2008, the success of this approach is most evident in the design and delivery of EngD projects, each partnered with industry to address real world engineering problems, develop partner IP and train the next generation of inter-disciplinary engineers. Won against strong annual institutional competition through our £6M EPSRC Urban Sustainability and Resilience Centre (**USAR**), projects have a broad remit across our "Engineering a Better World" activity and include: Responsive Adaptive Building Structures [Expedition Ltd]; Facility Design for Biosafety and Biosecurity [Laing O'Rourke]; Assessing the impact of seismic

shocks to urban infrastructure networks [Willis Research Network]; and Integrated Production of Algal Biomass [Varicon Aqua]. Success has been recognised through *prestigious "1851" awards* to *Patrick Cottam* and *Alessandro Lizzul*, each won by taking prototypes towards commercialisation. Our diverse UoA thrives on its interdisciplinarity and significant growth following a staff recruitment policy with the ***strategic aim to develop a broad base of expertise with the cross sector communication skills necessary to address complex issues***. For instance newly recruited *John Twigg* led a project (2008-09) with six international relief and development NGOs (ActionAid, British Red Cross, Christian Aid, Plan International, Practical Action and Tearfund) to deliver a Disaster-Resilience tool for government and civil society organisations. Similarly recently recruited *Lena Ciric* has led our Healthy Infrastructure Research Centre (**HIRC**) combining people-pathogen interaction with air flow and building information modelling to incorporate environmental measures into new contact screening policy for the Health Protection Agency. This is changing NHS policy to improve public health, welfare and quality of life, for example through local government interest in mitigating pathogen persistence following natural and manmade disasters. A similar approach has resulted in two knowledge transfer fellowships with Willis Reinsurance (*Tiziana Rossetto)* to understand complex interdisciplinary factors necessary to mitigate insurance risk from tsunamis.

Provision of expert advice to policy-makers, including membership of strategic and advisory boards is central to the approach taken within our *Quantitative and Applied Spatial Economic Research Laboratory* (**QASER**). As a result, *Francesca Medda* is an economic adviser to DEFRA and is seconded to the Infrastructure Strategy Unit at HM Treasury. Internationally **QASER** was the first EU recipient of consecutive European Investment Bank grants and contributes risk and financial resilience expertise as a member of the Global Land Tool Network Secretariat for the UN and World Bank. Networking and policy strategies are well developed in our *Centre for Transport Studies* (**CTS**), wherein *Peter Jones* has given evidence to the House of Commons Environmental Audit Committee in their inquiry into Transport and the Accessibility of Public Services; *Roger Mackett* gave an invited seminar on Concessionary bus travel at the University of Sydney promoting discussion on the targeting of New South Wales taxpayer funded travel concessions; and *Nicola Christie* was invited by MP Barry Sheerman to join a national Transport Safety Commission on key issues about safety related to roads, rail, maritime and aviation transport. *Nick Tyler* has drafted a "Roadmap for Sustainable Mobility and Transportation in Lima and Callao by 2025" for the Peruvian government and a 'National Strategy for Transport in Low Carbon Cities' for the Colombian Government and is involved in several UK FCO commissions to develop transport energy and accessibility policy in China and Japan. Our **EPICentre** research hub has undertaken eight earthquake field missions, including in China, Japan (2), Chile, Italy (3) and Samoa, reporting back findings on engineering resilience to the UK's IStructE and the Cabinet Office, thus stimulating effective international aid decision making. *Richard Simons* has input to MMO Guidelines for Environmental Statements activity on Marine Aggregate Dredging. This ***exchange of expert knowledge and advice*** also typifies our approach with professional institutions. Staff serve on the BSI Committee BS525/8 (Structures in Seismic Regions) and CPW/172 (Optics and Photonics); *Stuart Robson* FRICS and *Nick Tyler* FICE are respectively on the Editorial Boards of the RICS's "Geomatics World" and the ICE "Engineering Sustainability" Journal, whilst *Richard Simons* is on the ICE Maritime Engineering Editorial Panel and *Julia Stegemann* is European Editor of "Environmental Engineering Science".

A ***policy of harnessing industry expertise*** to maintain our industry relevance is evident in the professorial appointment of leading industry professionals into our team. Closer links with the civil engineering industry and its professional bodies have been achieved through our appointment of *Chris Wise* [Expedition Engineering], opening opportunities for our research to inform commercial innovative structures. Prototype testing of novel responsive adaptive building structures, for example, will adopt new structural test instrumentation and protocols developed during our 2008-14 advanced optical metrology programme with Airbus and NPL, culminating in the successful 2013 pre-flight structural test certification of the next generation composite A350 aircraft (*Stuart Robson*). Further appointments include: *Keith Robinson* (2004-12) [Managing Director Lockheed Martin UKGS and divisional director for GEC Systems] with a remit in the field of integrated systems design; *Brian Collins* (2011) [DfT Chief Scientific Adviser] and *Jeremy Watson* (2012) [Arup Global Research Director], who will achieve impact in the next funding cycle through our newly instigated Department of Science, Technology, Engineering and Public Policy (STEaPP).

Our policy of participatory engagement and community intervention seeks to maximise the societal relevance and benefits of our work by directly involving the public in interdisciplinary participatory research. To that end, our £2M EPSRC Challenging Risk Project (2013-18) uses crowd sourcing, big data and targeted community engagement to combine citizen science and earthquake engineering knowledge in intervention studies designed to improve earthquake mitigation in Seattle. Our *Accessibility Research Group* (**ARG**) also routinely uses public participation in interaction experiments at its unique "PAMELA" laboratory to generate strong empirical evidence used to improve transport services. This evidence is used by: companies such as Arup, Mott MacDonald, Network Rail, London Underground, HS1, HS2; local authorities (Camden, Kensington & Chelsea); and charities (Guide Dogs for the Blind, ASPIRE). Activity in the museum sector combines our Photogrammetry, 3D Imaging and Metrology Hub (**P3DM**) with Science Museum experts to exploit metrology, colour scanning and 3D printing for physical exhibition (*Watt Workshop*) and virtual exhibition (*Shipping Gallery*). Evaluation of feedback from public web surveys through UCL's Digital Humanities Department drives our future research agenda and ensures the relevance of future engagement activities to our audiences. **ExCiteS**, the unit's Extreme Citizen Science hub is ***founded on a proactive participatory impact policy*** designed to build the mutual trust necessary to empower communities through social media, open access publications and community activities. Examples include our work with some 100 public and expert users in a 2007-11 EPSRC/Arup funded project "Trust in Web GIS for Public Engagement". The community defined the project, collected and analysed evidence, before acting to achieve an outcome regardless of their levels of literacy or education; the resulting guidelines promote the rational perception necessary to help the public make well-informed decisions on local issues. Outputs from such projects stimulate interest in activities such as our outreach officer *Lena Ciric's* promotion of engineering in schools aligned to the national Women in Engineering initiative, and contribute to lectures at national events such as the BS Science Festival (*Sarah Bell*).

Consultancy activity is encouraged through flexibility in the consultancy business model allowing staff to make investment decisions using these funds to enhance facilities, generate self-funded research projects and public engagement activities. Over the review period, CEGE has benefited from some 129 projects totalling £707K, all of which have been supported by UCL Consultants, an independent business providing tailor-made administrative, financial and legal support.

The CEGE ***Senior Management Team*** (SMT) has instituted several internal structures, staff posts and promotional activities to support impact. Chief among these is a balancing of individual staff workload to provide capacity for impact as an integral part of departmental activity. The SMT includes our KED (*Richard Simons*) who in 2009 instigated a formal **Industrial Advisory Panel** comprising consultants, contractors, regulators and representatives of NGOs. Arup, Atkins, CH2M Hill, CIWEM, Corbil, DEFRA, HR Wallingford, Laing O'Rourke, London Sustainability Exchange, Steer Davies Gleave, and Webb Yates. The panel meets once or twice a year to ensure the on-going external relevance and utility of our work. It was, for instance, partly on the Advisory Panel's recommendation that the department set up its innovative **Atkins Masters programme in Rail Integrated Design Management** in 2012. The programme, which is delivered part-time over three years, is aimed at engineers aspiring to take leadership roles in the rail industry. Specialist modules are taught largely by experienced engineers working for Atkins plc, and research projects are agreed jointly between practising engineers and UCL academic supervisors. We have also worked with Arup on the "Arup University" concept, which fosters its senior staff's direct engagement with the UoA at a doctoral or equivalent level. The KED has also worked with the Research Director (*Nicola Christie*) to develop annual CEGE **Open House Days**, bringing both industry and the public to seminars, lectures and posters publicising the impact and research relevance, not just of the department but also new activity in UCL's Grand Challenges (one of which, Human Wellbeing, *Nick Tyler* directs). During the review period SMT have developed ***a policy of increasing use of online and social media to maximise awareness and impact from our research***. For example: we have publicly promoted our Geomatics activity via the UCL Geomatics website and Twitter (Geomatics @ UCL), and publicised our industry-supported exhibition and research seminar series "Innovations in 3D", the most recent of which (July 2013) attracted 250 participants. Our ***professional services team***, including a Departmental Manager and a Communications Officer, maintain our ***SharePoint Portal*** to track impact-related activities and provide content management for our externally facing on-line presence which have all been updated in both style and content since 2008. Hosted at www.cege.ucl.ac.uk, these include a

weekly newsletter, website and twitter feeds e.g. @CEGE_UCL with some 350 followers and CEGE groups on *LinkedIn* and *Facebook.* The SharePoint Portal also provides connectivity across our diverse international network, enabling us to target publicity and future impact partnerships, and includes an ***alumni database*** with connections into ***UCL Built Environment Clubs*** in major cities across South-East Asia (Hong Kong, Shanghai, Singapore, Seoul). It supports network leadership activities, such as *Dina D'Alaya's* leadership of EU FP1101 ***Cost Action on Assessment, Strengthening and Monitoring of Existing Timber Structures*** (170 participants from 21 EU member countries), records visiting professors, e.g. David Johnston from Massey University & N.Z. Government GNS Science, and supports strategic exchanges with international institutions on resilience and disaster reduction through MOUs with the University of Illinois and with Avero University in Portugal.

c. Strategy and plans - Constant review and improvement of the reach of our research impact is fundamental to our strategy and plans. Future impact strategy will promote our brand "Engineering a Better World" to realise our goal of being the go-to place for collaborative, innovative and high impact research. We will achieve this through our 2014-2016 *Research Continuum* policy which, following on from our Open House Days, will commence with a "September 2013 Festival of Research" event highlighting best practice in research and impact generation across our diverse portfolio. Our Research and Industrial Engagement Directors will work with each Hub Leader to highlight successful research and impact approaches within each discipline area as a starting point to develop and share best practice examples across the UoA. Lessons learned will be embedded in our Red Teaming process, whereby research grant applications are reviewed internally prior to submission. In parallel with departmental growth, an impact activity database connecting the Research Hubs will support the identification of synergies in our outreach and provide the information necessary to sustainably increase the number and range of our external partners. Key actions include: ***Appointing a new Business Development Manager*** (Spring 2014) who will work with our academic Industrial Engagement Director to: promote academic participation in industry-focused exhibitions and conferences; coordinate research fellowships for senior industry staff; enhance industry contact in the environmental sector; explore the need for and develop CPD courses [commencing in February Geotechnics with UC San Diego]; and source training for academic and industrial staff engaging with the unit, targeting initial activity towards those briefing Government, Industry and NGOs. ***Redefining the role of our Publicity Manager*** to raise public and industry awareness of our research by strengthening our weekly on-line newsletter with a quarterly research theme developed in consultation with our Industrial Advisory Panel to target key industry sectors, and instigating regular press releases about research and related events of interest to non-academic audiences. ***Making more effective use of the Internet to increase our public profile***, improve communication with non-academic audiences, and increase the level of our collaborative engagement with industry across all areas of activity. We intend to redesign and re-launch our website in autumn 2014 centred on our Research Continuum activities and interconnected to industry orientated networking sites such as Linked-in. Finally, we also plan to ***expand our cross-disciplinary research*** to take on increasingly challenging real world problems as a means of increasing the audiences for and beneficiaries of research. For example, a recent £1.6M ERC award (Tiziana Rossetto will bring together coastal engineering and structural dynamics to improve coastal defence structure resilience against tsunami. **P3DM** is working with UCL Computing Science (UCL/MIT Touch Lab) as part of a 2013 £3M EPSRC robotics and tele-operation award aimed at meeting government targets for rapid impact in the bio-nano, medical surgery and large volume manufacturing sectors including aerospace and nuclear industries.

d. Relationship to case studies – Our Case Studies exemplify various aspects of our approach to impact. Case Study *UCL14-HAK* from our **ExCiteS** research hub demonstrates our emphasis on **participatory engagement and direct community intervention** to empower communities through social media, open access publications and community activities. Participatory research in interaction experiments also characterises much of the work described in *UCL14-TYL*, which outlines impacts arising from "PAMELA". *UCL14-ZIE* describes impact from our Space Geodesy and Navigation Hub (**SGNL**) founded on **mutual understanding and personal rapport over extended periods of close working** and instigated within a US government framework supporting global positioning. *UCL14-MAC* and *UCL14-JON* from our **CTS** research hub, describe impacts generated through our provision of **expert advice to policy-makers** including national and local government to develop far-reaching transport policy.