**Institution: University of Cambridge**

**Unit of Assessment: B11 Computer Science & Informatics**

**a. Context**

The Computer Laboratory's key non-academic user groups are the local, national, and international companies in the broad IT sector. In particular, the Laboratory's research has benefitted the economy by generating a number of spinout companies including RealVNC, Ubisense (both from the Digital Technology Group) and XenSource (from the Systems Research Group). The Laboratory also has impact on national and trans-national governments through advice on IT policy (particularly from the Security Group). Indeed, the Laboratory's approach to collaboration with business was commended as long ago as the 2003 Lambert Review. The Laboratory further influences the general public, society, and schools through outreach.

The context was summarised by Bill Gates, co-founder of Microsoft, in his testimonial on the occasion of the Computer Laboratory's 75th anniversary in April 2013: "A key factor in Microsoft's choice for the location of its first research center outside of the United States, was the proximity to Cambridge. As one of the world's best teaching and research universities, with historical links to the founding of computer science, Cambridge University's Computer Laboratory has been the hub for major advances in computing, including original work in building complete computers and the development of programming languages and operating systems. The technologies developed by the University, Microsoft Research and other leading technology companies in Cambridge will be fundamental in addressing some of the greatest challenges of this century."

**b. Approach to impact**

The principal output of the Computer Laboratory is know-how. That is, the Laboratory produces people who have deep, specialised understanding of advanced areas of IT. These include graduates of the BA, Masters, and PhD programmes; contract post-doctoral researchers; research fellows; and members of academic staff. The principal way in which the Laboratory achieves impact, therefore, is to support these people in using their know-how by providing **opportunities to engage with the UoA's excellent network of contacts and giving them sufficient time and freedom to pursue these ideas**. The Laboratory's approach is that it is far more important to make the results of research available to interested parties and potential developers (including the researchers themselves) than to try to get a return on IPR. The Laboratory recognises that IP is of limited value in the computer industry, where the spoils tend to go to the first to get the idea to market rather than to the ones who use valuable time trying to agree IP protection and IP rights. The University provides various aids to commercialisation (see below) but also supports and protects the academic's right to publish research openly. The open source model of dissemination has proved extremely successful for the Laboratory. For example, the thriving companies RealVNC and XenSource both gained their excellent positions in their respective markets by releasing open source code, deriving substantial business income from services provided on top of open source functionality. The Laboratory has benefitted from this both indirectly, through good continuing relationships with these companies, and directly. In the case of XenSource, the Laboratory has received almost £100,000 (to December 2011) in equity distribution.

**Interaction/engagement with key users, beneficiaries and audiences**

The Laboratory recognises the importance of having strong relationships with companies to enable impact to arise from its staff's research and know how. It actively encourages such relationships and, in late 2013, employed a Research Facilitator to further enable these interactions. It maintains key relationships with several multinational companies, including Microsoft, Google, Qualcomm and Jane Street Capital, attracting significant sponsorship of work in the Laboratory by these. For example, Jane Street has provided over £1M for research in the OCamL programming language.

Complementing this, since 1980, the Laboratory has had a strong Industrial Supporters Club (ISC), a group of companies that engage with the Laboratory on a number of levels. For example, members have access to the Computer Laboratory building so that company staff can meet with members of academic staff to discuss potential collaborations or receive a small amount of free technical consultancy. The central aim of the club is to develop a forum through which companies can engage with the Laboratory. Another attraction to the companies is that they can recruit good graduates through the ISC's annual graduate recruitment fair. This event is strongly linked to the UoA's academic research engagement with companies, by arranging the ISC's annual dinner in

the same week. This dinner is a key event where senior representatives of each company meet with academic staff from the Laboratory. In addition, the long-established weekly academic seminar series in the Computer Laboratory, and the individual research groups' seminars, are open to company representatives, who attend when appropriate to their businesses.

The Laboratory also invests in its alumni association, "*The Ring*", which forms an effective business club. A dedicated member of staff manages both the alumni association and Industrial Supporters club to ensure that there is co-ordination between the activities of the two. *The Ring*'s success came to the attention of the UK Government in the Lambert Review of Business-University Collaboration (2003) and was commended as an excellent model for creating new business ventures. The annual alumni dinner, an event distinct from the ISC dinner, is where alumni, entrepreneurs or otherwise, interact with staff, again facilitating the exchange of ideas, which ultimately result in new businesses and products. *The Ring* has run annual Company of the Year and Product of the Year awards, since 2005, to encourage entrepreneurship in the Laboratory. The association has had a great deal of success in creating entrepreneurs and successful corporate employees amongst graduates of the Laboratory. At 15 October 2013, the Laboratory knew of 205 companies started by Laboratory graduates.

The Laboratory also encourages secondments by industrial visitors to facilitate rapid and immediate routes for knowledge exchange between academic staff and industrial experts. For example, Jack Lang, sometime Entrepreneur in Residence at the Cambridge Judge Business School, has office space in the Lab, advises potential entrepreneurs, and teaches a business course to final year undergraduates in Computer Science. Amongst recent industrial visitors are Pilgrim Beart (Founder Director of AlertMe.com) and William Webb (CTO, Neul).

Cambridge is "one of the top four regions in Europe in terms of total institutional investment into innovative start-ups and is number one in Europe in terms of investment per capita" (East of England Technopole Report, 2009). The Cambridge Cluster comprises thousands of companies, including several hundred in IT. The Laboratory has relationships with many of these, ranging from those that were spun out of the Laboratory, through companies that actively collaborate with the Laboratory, to the Industrial Supporters Club, companies founded by graduates and companies with which the Laboratory has a good working relationship. Amongst the active collaborators is Microsoft Research (MSR) Cambridge, the first Microsoft research centre outside the USA. The first Head of MSR Cambridge was recruited directly from being Head of the Computer Laboratory.

While industry is the main locus for non-academic impact of the Laboratory's research, members of the Laboratory are active in advising government on IT policy (see below for highlights and the Environment Template for a longer list).

**Evidence and examples of follow-through from these activities to identify resulting impacts**
Over the past forty years, the Computer Laboratory has been the source of a large number of start-up companies, 205 at the last count. Of these, 25 were founded between 2008 and 2013.

Several members of staff work for or run companies that exploit their research expertise. Hopper has founded fourteen companies and is Chairman of RealVNC and Ubisense, both of which commercialised research that came from his lab. Daugman was Chief Scientist for Iris Recognition at L-1 (2006–09). ARM actively collaborates with the Computer Architecture group, with a member of staff (Jones) embedded at ARM one day a week; Jane Street fund a large research project, OCamLabs, under the direction of a member of staff (Madhavapeddy). Greaves ran his own company, Tenison Tech EDA, until it was acquired in 2007 by ARC International. Greaves continued for some time as ARC's Chief Technology Officer. Murdoch is Chief Security Architect of Cronto, which was acquired in May 2013 for £17M by VASCO Data Security International. Robinson's research on recognising human mental state from facial expression was published in the public domain, built on in collaboration with MIT and then spun out, as Affectiva, under the leadership of Robinson's former PhD student, Rana el Kaliouby.

The UoA recognises the important role its staff have to play in influencing policy. In particular, through the Centre for Science and Policy (CSaP) – hosted by the University of Cambridge – members of the Computer Laboratory have had a significant number of engagements (over 120 in the REF period) with policy makers, such as members of the UK Government (83), European Commission (10), and industry (32) around IT policy. Following on from this, there have been two

workshops on Cyber Security led by the Laboratory: "NATO and Global Cyber Defence" (Oct 2011, led by Crowcroft) and "Reducing the Exposure of National Infrastructure to Cyber Attack" (Apr 2012, led by Leslie). These engaged government and industry decision-makers with the University. With strong support from the UoA, Anderson and Hopper have been particularly active in engaging with IT policy via other avenues. Anderson's research has impacted the UK Government through select committees and reviews relating to Cybersecurity and Communications, as well as impact on the FSA, the European Commission and the US Federal Reserve. Hopper used his presidency of the IET (2012–13) to argue for a more flexible interface between the HE sector and businesses.

**Public Engagement**
The Laboratory was a founding supporter of the hugely successful Raspberry Pi initiative, which works to inspire and educate the next generation of programmers. In particular, the Laboratory underwrote some of the initial funding and provided Mullins and Mycroft with time, resources, and office space to pursue work on the Pi. The Laboratory has worked, with colleagues from Microsoft Research, in influencing the school curriculum in computer science. Harle sits on Cambridge Assessment's (OCR) consultative forum on the new GCSE and A-level syllabuses in computer science. Blackwell has been influential in organising several technology/art programmes involving public performance and works with the eight Cambridge University museums on future technology.

**Evidence of an agile approach to opportunities**
The Laboratory has a flexible approach to working conditions, which allows staff to respond quickly to opportunities (see below). It is also able to handle more dramatic requests. For example, Pratt, Hand and Fraser were all able to take significant unpaid leave to spin-out XenSource, with the Laboratory committing to covering their academic duties from other resources. XenSource is an example of the rapid time scales involved in computer science spin-outs. XenSource was founded, by Pratt and colleagues, in 2004 and sold to Citrix for $500 million in late 2007. While this spin-out approach works for some types of research, especially from the Systems and Digital Technology groups, other groups take different approaches. The Natural Language group, for example, has entered a long-term relationship with Cambridge Assessment, where the research funded by the company directly relates to the company's core business. As another example, the Graphics & Interaction group has entered relationships for direct funding of specific research (e.g., Boeing, Huawei) and for funding of PhD students with considerable freedom on topic area (e.g., Thales, Kodak). The Laboratory also aims, through the Industrial Supporters Club and an openness to approaches from industry, to provide an environment that fosters serendipitous interactions.

**How we specifically support and enable staff to achieve impact from the research**
A key factor in generating impact is providing staff with sufficient time to pursue commercialisation, consultancy, and influencing both politically and socially. Staff in the Computer Laboratory have a relatively light teaching load and great freedom in organising their own time. There are minimal *scheduled* calls on staff time, beyond their 20–40 hours of scheduled lectures each year. This allows staff to devote significant amounts of time either to original research or to generating impact. The Laboratory is supportive of requests for leave to pursue commercialisation. For example, in the REF period, Hand was granted 12 months' leave for this purpose. It is also supportive of staff who have commercial interests in addition to their academic interests (e.g., Hopper, Daugman). As a rule of thumb, a staff member can reasonably take up to a month each year to work on research-related commercial projects, such as directorships, consultancy, and investigating start-ups.

The Laboratory, University and Colleges have discretionary funds that can support staff in various ways. For example, a staff member who is temporarily between research grants can be funded to attend academic and industrial conferences; a staff member needing technical support can use the expertise of the computer officers and technicians; appropriate professional membership fees can be paid by the University. The Laboratory provides world-class infrastructure for computer science research, which allows staff to concentrate on novel ideas rather than on day-to-day minutiae.

**Ways in which staff are recognised/rewarded for achieving impact**
One of the key rewards for achieving industrial impact is the income that can be expected from a successful IT company. The University has no restrictions on such income in addition to the staff member's University stipend, subject to the staff member fulfilling their duties for the University.

Indeed, for several years one staff member donated his entire University stipend back to the University, as his income from his directorships more than met his needs.

Within the University system, recognition and reward is through the Senior Promotions Exercise. The guidelines for the research/scholarship criteria are that "Account may be taken of evidence in relation to research/scholarship, regardless of where it has been undertaken." Therefore, research impact can count towards promotion. In particular, the enhanced international reputation gained from commercialising research can be a significant factor in the promotion case. The advantages and benefits of commercial experience are well understood by the promotions committees in the Computer Laboratory, and in the School of Technology within which the Laboratory sits.

**How University facilities, expertise and resources support these activities**
The University, through its wholly-owned subsidiary *Cambridge Enterprise* (CE), provides facilities to assist staff in commercialisation and consultancy. Particularly relevant to this UoA is CE's support in facilitating consultancy, whereby the University handles all contract negotiation, leaving the academic free to concentrate on technical aspects. Several staff have taken advantage of CE's consultancy facilities. CE also provides training to University staff who act as consultants, again something that has been regularly made use of by several members of staff. The University, along with other investors, established Cambridge Investment Capital, a technology investment company with funds of £50M. This provides follow-on investments in new ventures in the Cambridge area, complementing the healthy angel and seed funding already present in the Cambridge environment.

**c. Strategy and plans**
The Laboratory believes that impact must be generated by enthusiastic individuals pursuing their own goals. Its strategy is to support this by providing an environment in which entrepreneurship can flourish. It will continue to allow staff to use their time flexibly, continue to foster the Industrial Supporters club and alumni association, and continue to provide the infrastructure that allows staff to generate impact. In 2013, the management of the alumni association was brought inside the Laboratory, to enable stronger links to be made with alumni, especially with the entrepreneurs.

The Laboratory has active research collaborations with a range of companies (including BT, Boeing, Cambridge Assessment, GCHQ, Huawei, IBM, Jane Street, Microsoft, Samsung, and SRI). Research impact will be generated through these collaborations and the Laboratory works to maintain and enhance its relationships with such collaborators. In late 2013, a Research Facilitator was appointed for an initial period of three years. This new post was a strategic move to aid management of and transfer of knowledge from research. The first two years of this post are funded from the University's EPSRC Impact Acceleration account. The post is to further enrich the quality of communication with the Laboratory's industrial supporters, increase the quantity of research funding flowing from them, increase the quantity of research funding from UK, EU, and US governments, and further enhance the flow of research from the Laboratory to industry.

**d. Relationship to case studies**
The six submitted impact case studies indicate the variety of approaches to generating impact which are adopted within the Laboratory, from the highly individualised and ad hoc approach of Hopper to the more traditional model pursued by, for example, Daugman, Hand, Fraser and Pratt.

RealVNC and Ubisense were successful spin-outs owing to the permeable interface between the University and Olivetti Research. Prof. Hopper was able to have a foot in both camps and there was an open and productive exchange of ideas between the researchers on both sides.

Anderson's work on security is often in high-profile controversial areas. On several occasions the University has been asked (and has refused) to censor information about Anderson's group's work by, for example, the UK Cards Association. Anderson's work on Security Economics and Electronic Payment Systems is possible only because the University guarantees his academic freedom.

Daugman's work on iris recognition is successful partly because of the flexibility he enjoys as a University employee: he is able to combine his commercial and academic interests.

Hand, Fraser and Pratt all took advantage of the Laboratory's flexible working arrangements when they founded XenSource, to commercialise their research. Within the REF period, Hand has taken unpaid and sabbatical leave (Oct 2012 to Dec 2013) to pursue industrial impact of his research.