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REPORT OF THE EPSRC REVIEW OF HUMAN COMPUTER INTERACTION RESEARCH IN THE UK

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Foreword

Human-Computer Interaction is a multi-disciplinary domain of research which seeks to investigate the relationships between computational systems and human actors and action. The purpose of the research may be to design and develop new technologies, or it may be for the purpose of deepening our theoretical understandings.

Since its inception, the nature of the domain has altered significantly as new applications, devices and infrastructures have become part of the fabric of everyday life.

The "H" or "Human" in HCI no longer simply refers to a single user engaged with a personal computer. People are nowadays as much consumers, creators and players as they are users of computers. Further, rather than focussing only on individuals, HCI specialists now routinely study and design for groups or even crowds of people. HCI research also encompasses user groups far from the confines of the office and now considers people as users of technology, from every walk of life with many different capabilities, and at home, work and play.

The "C" or "Computer" has changed radically, too, and is often unrecognisable as such in today's world. Computational devices may be embedded in everyday objects from clothing to appliances to cars. We may ingest them, or have them embedded within our bodies. At the other end of the spectrum, they may be in the built structures around us, or even in the natural landscape, creating a physical-digital ecosystem. This means that HCI may involve the design or investigation of anything from a single device to a more complex system, including the spaces and infrastructures in which these technologies reside.

It follows too that the "I" in HCI—Interaction—has changed dramatically in recent years. There are many sites of interaction researchers now consider: these include not just the interaction between bodies and technological systems, but also interaction on and in the body, between bodies, between bodies and everyday objects, and at the scale of kiosks, rooms, buildings, streets and public spaces. In a world of sensors, where a wide range of people's activities can now trigger interaction, we need to consider not only deliberate engagement with computing technology, but also passive, unwitting or even unwilling interaction. At the same time, digital technologies will continue to be used in more deliberate and engaged ways for a variety of activities, such as self-expression, community building, and interpersonal relations.

The review panel

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Executive Summary

This report is based on the Review of Human Computer Interaction (HCI) research in the UK which was instigated by the EPSRC and undertaken by a panel of experts from academia and industry throughout the autumn and winter of 2011-2012. The report is organised to reflect the process the review panel went through; first identifying and discussing the major sub-areas of the field of HCI and then describing the panels' assessments of UK HCI research based on six key questions which have framed this review.

The panel were very pleased with the quality and stature of UK HCI research. By some metrics the UK is second in the world, behind the US. This is a great credit to the UK, as the capacity of the research base is much larger in the US. The report highlights that the UK has a strong culture of cross-disciplinary research and a history of developing new research initiatives. This is a real asset as the community looks to tackle future societal and technological challenges such as dealing with the current collection of 'big data' and understanding how technological intervention might influence behavioural change in domains such as energy and education. The panel also notes the opportunity for the HCI community to address challenges in manufacturing.

The report raises an issue regarding the exploitation and impact of HCI research. The transfer of research results into action is of major concern for researchers and there is a big challenge for the HCI community in building on the innovative research agenda and maximising the impact of their work. The report recommends that there is widespread dissemination and adoption of best practice in order to more fully exploit the potential of publically-funded research.

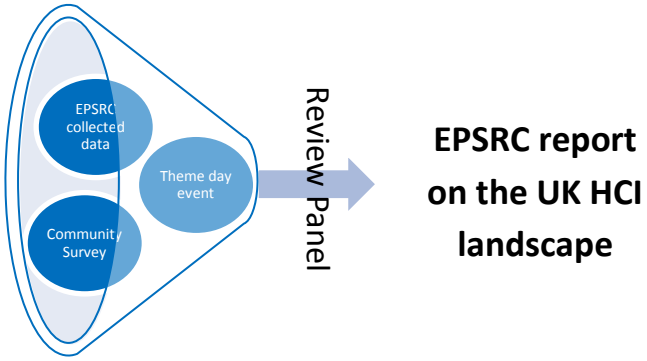
Background

In December 2009 the EPSRC launched it Strategic Plan for the period 2011-2014, setting out three strategic goals: Shaping Capability; Developing Leaders and Delivering Impact. In order to shape the UK research landscape and achieve the first of these goals, throughout 2011 and into 2012, the EPSRC have been investigating the relative quality and importance of research areas from across the whole remit and judgements are being made on future funding trajectories for each area of research. This view of the portfolio is being published on the EPSRC website and is due to be completed by the end of March 2012. Discussions with the EPSRC ICT Strategic Advisory Team raised questions over the breadth of research being funded in HCI. It was recognised that this area underpins a large part of the portfolio funded by the RCUK Digital Economy Programme. In light of the breadth and size of the HCI portfolio and the cross-cutting nature of the research, the Review of HCI research was initiated in September 2011 in order to gain an understanding of the breadth, quality and importance of HCI research in the UK. The remit of the review did not include providing specific advice on the funding levels EPSRC should invest in this area in the future. The results of the review have been used as an input into the EPSRC's assessment of the whole portfolio which has been done with the help and advice of the EPSRC Strategic Advisory Teams.

In order to steer the planning and lead the review the EPSRC convened the following panel of experts:

Dave Robertson – chair (University of Edinburgh);
Anne Anderson (University of Glasgow);
Bob Anderson (University of Nottingham);
Mike Evans (BBC R&D);
Matt Jones (University of Swansea);
Youn-Kyung Lim (KAIST, South Korea);
Eamonn O'Neill (University of Bath);
Yvonne Rogers (University College London);
Abigail Sellen (Microsoft Research Cambridge);
Jason Williams (Orange);
Steve Whittaker (University of California Santa Cruz).

The review consisted of two planning meetings of the review panel, an EPSRC data collection exercise, a community survey, a community Theme Day and a third meeting of the review panel in which the evidence and comments arising from these activities were analysed. The Theme Day took place on Thursday 19th January at the Mercure Manchester Piccadilly Hotel and was followed by the third review panel meeting on the 20th January in the same location. A separate report of the HCI Theme Day and Survey is also available.



Sub-areas of HCI – identification and analysis

HCI is a diverse field and in order to investigate the strengths and weaknesses of HCI research, it was considered important to identify its core research themes. A list of 6 sub-areas was produced by the panel in an attempt to capture the wide range of activities and foci present in the HCI research landscape.

1. **Theories and methods**
   The development of new theories, models, paradigms and frameworks for analysis, design and application;
2. **Evaluation**
   The use of experiments, studies, envisionment workshops and other forms of user engagement to understand or evaluate proposed designs or prototype technologies;
3. **Understanding users**
   Studies of different target groups and settings to inform the invention and design of new technologies;
4. **Building**
   The development and evaluation of platforms, architectures or component technologies, that underpin the interaction between human actors and ICT systems;
5. **Extending interaction**
   The development and evaluation of new techniques of interaction and use, including new modalities of input and output, and new sensors and devices.
6. **Ethics and implications**
   The identification of possible individual and/or societal implications and consequences of innovative technologies or novel uses of ICT.

The attendees at the Theme Day on the 19th January explored the strengths, weaknesses, opportunities and threats relevant to UK HCI research in each of the six sub-areas. Summaries of these discussions can be found in the *Report of the EPSRC Human Computer Interaction Theme Day and Survey*. The survey invited comments on the sub-area framework devised by the panel and there were many positive comments offered on the validity of the framework as well as the interrelated nature of the sub-areas. The main criticism of the categorisation was the view that the division into sub-areas was not helpful as all of these aspects of HCI research are important and they cannot exist in isolation. The panel agree that the majority of high quality HCI research does incorporate many or all of the sub-areas and it is important to emphasise that the categorisation is mainly intended to provide a structure and descriptive texture to what is a broad and diverse field. It is encouraging that the quantitative data in the survey shows how all six sub-areas (particularly numbers 1-5) are closely interconnected in the research activities of respondents[1]. However, in addition, the categorisation gives a sense of where different researchers place the emphasis in their work. Again, it is encouraging that, with the possible exception of "Ethics and Implications", there was a fairly even distribution of primary research interests across all six sub-areas.

"[Theories and Methods] is my own main area, but I work in a team and – for good work – I require connections with all other areas [of HCI]"

Survey response

[1] *Report of the EPSRC Human Computer Interaction Theme Day and Survey*, March 2012, pp.5-7

Key Review Questions

The review was driven by six key questions about the HCI research landscape in the UK. The panel's conclusions and answers to these questions were informed by discussions at the EPSRC HCI Theme Day along with data provided by the EPSRC and a researcher survey conducted by the EPSRC via Bristol Online Surveys. An analysis of the survey results can be found in the *Report of the EPSRC Human Computer Interaction Theme Day and Survey*.

Key Question 1: To what extent is the UK HCI research portfolio internationally leading?

The panel found that UK HCI research is internationally highly competitive and the data they were presented with provided evidence that the UK is among the leading HCI research communities. The data also highlighted that there has been an apparent increase in the profile of UK HCI internationally over the last five years.

In the top 50 cited HCI articles[2] since 2007 the UK (20%) is second only to the US (52%), performing particularly well given the size difference in the numbers of practitioners working in the field in the two countries. This also demonstrates the growth in the performance of HCI research in the UK in recent years when compared with the top 100 most cited articles since 2001, where again the UK (12%) is second only to the US (69%). The UK share of top HCI citations is increasing and this is very encouraging.

In the field of HCI, conference presence and publication is particularly important. The UK is consistently second to the US at the largest and most prestigious international conferences, such as the *ACM Conference on Human Factors in Computing Systems (CHI).* The panel felt this to be a particularly good measure of international excellence, especially given the relative sizes of the US and UK research communities. In the period 2007-2010, an average of 10.4% papers at CHI had UK authors, level with Canada, and second only to the US (56.3%), far out-performing other European nations with Germany (4th) at 3.5% and France (5th) at 2.9%.

In the period 2006-2010, an average of 18.5% papers at the *ACM International Conference on Ubiquitous Computing* (*Ubicomp)* had UK authors, second only to the US (51.9%), with Canada in third with 6.9%.

The ACM Special Interest Group on Computer Human Interaction (SIGCHI) identifies and honours international leaders and shapers of the field of human-computer interaction with the SIGCHI Awards, recognising individuals internationally who have contributed to the advancement of the field of human-computer interaction through election to the CHI Academy amongst other things. Twelve of the seventy-seven current members of the CHI Academy are based in the UK, second to the US (54). Canada is third with four members. British researchers are also recipients of prestigious SIGCHI Lifetime achievement awards (1/17) and SIGCHI Social Impact Awards (2/8).

The panel had reservations about the robustness of any conclusions that might be drawn from these bibliometrics, but felt that the data painted a strong picture of the UK HCI's performance internationally. The most notable feature of the data is the increase in the international presence of UK HCI over the last five years with strong indications that it is now amongst the leading few nations.

[2] Source: Web of Knowledge. Nationality of articles is determined by the location of authors' institutions

Key Question 2: How innovative is the UK HCI community in developing new research and research methods to identify challenges, engage others, stimulate creativity, innovate and work across boundaries?

The panel report that the UK HCI community is distinctively innovative, developing new research and research methods to identify challenges, engaging others, stimulating creativity, innovating and working across boundaries. A major strength of the UK community is its diversity and depth of multi-disciplinary work. Innovation in commercialising research outputs is viewed as a weakness coupled with a lack of understanding of, and opportunity to engage with, commercialisation mechanisms.

In developing new research and research methods to identify challenges

The UK HCI community has been actively involved with the various grand challenge initiatives. These include engagement with the *Wired and wireless intelligent networked systems (WINES)* initiative involving HCI researchers in which EPSRC has invested a total of £22M (17 projects). The Digital Economy *Research in the Wild* initiative was informed and supported by the UK HCI community – this grew from the success of prior HCI research.

Within the past 15 years, the UK HCI community has been instrumental in setting up new international sub-conferences such as Ubicomp (formerly the *International Symposium on Handheld and Ubiquitous Computing*); the *International Conference Series on Human Computer Interaction with Mobile Devices and Services (MobileHCI)*; and the *ACM SIGCAPH Conference on Assistive Technologies (ASSETS)*. Two of the first three *Most Influential Paper* awards for 10-year old papers at MobileHCI were awarded to UK based teams. UK researchers have also been instrumental in the development and study of many new methods including the use of crowdsourcing in HCI and large scale evaluative techniques. High international impact has been achieved through citation of the *'Being Human' HCI 2020* report which was led by an international team with strong UK representation. Over 20,000 hard copies were distributed worldwide, plus many more downloads. The panel recognised that this is a manifesto that stimulated lots of new innovation in HCI and other research worldwide.

The panel believe that the attributes mentioned above demonstrate the strength of the UK HCI research base in developing new research agendas and is an acknowledgement of methodological innovation that has characterised the UK HCI community.

The UK HCI community is especially strong in drawing expertise from other disciplines: over 70% of RCUK Digital Economy funded grants with an element of HCI also involve research outside of engineering and the physical sciences.

In working across boundaries and engaging other disciplines and stakeholders

The UK community has a long-standing tradition of involvement in collaborative projects; from large scale programmes such as Equator and the current Digital Economy Hubs, to smaller projects which cut across traditional discipline boundaries. The community also participates in a number of cross-Research Council activities such as: the RCUK Digital Economy Theme and Global Uncertainties Programme; PACCIT; and the Technology Enhanced Learning programme amongst others. Two thirds of the total HCI

research sponsored by the Research Councils is now funded by the Digital Economy Theme.

The EPSRC portfolio demonstrates the cross-disciplinary nature of the field as many projects utilise a broad range of research expertise. At the HCI Theme Day held in January 2012, the attendees and panel expressed the view that the cross-disciplinary culture of HCI is a key strength for the UK across many aspects of the field.

The embedding of the end user in research is a requirement for funding from the RCUK Digital Economy Theme. This research strategy is characteristic of UK HCI research and has been recognised in the large proportion of HCI research funded be the Digital Economy Theme. The panel highlighted that public participation is at the heart of UK HCI research. The HCI community continues to embrace and extend this commitment as is illustrated through the take up of citizen research..

The mid-term review of the Digital Economy Centres for Doctoral Training showed that, across the four centres which have an HCI element (144 students), over 60% of students have a first degree in a non-Engineering and Physical Sciences subject and 54% of students have a multidisciplinary supervision team that includes a member from a non-EPS faculty. One hundred and twenty four end users are engaged in student projects with the centres, including partners such as Microsoft, BT, BBC, Mott Macdonald, the Bank of England, the MET Office, Yorkshire Sculpture Park, London Symphony orchestra, Schools etc. and over 25% students are attracted from outside the UK.

The BCS Interaction group (HCI) is *"the longest-established and largest national group in Europe devoted to HCI."* There is also strong international collaboration through active engagement with international bodies such as the ACM, through which the UK helps to drive the international research agenda as discussed in previous paragraphs.

In stimulating creativity

The UK HCI community is involved in a wide range of interactive activities and collaborations including working with artists and designers; the world leading British design community; disabled people; end users; and the creative industries. Sir Jonathan Ive, senior vice president of industrial design at Apple, and a world renowned designer, was educated in the UK is "keenly aware that [he benefits] from a wonderful tradition in the UK of designing and making"[3].

The panel acknowledged that the creativity of the UK HCI community is evidenced in its many and varied research outputs, not just journal articles, but experiences, prototypes, videos and apps.

EPSRC has been monitoring levels of creativity and transformative potential at Peer Review Panels, asking panel members to categorise proposals. For all ICT panels held in 2011, 75% of successful HCI grants were assessed to fit the most creative/transformative category in which "the entire proposal presents high levels of adventure with a highly creative approach with the potential of the research to be transformative", compared with 43% of other successful ICT grants at the same panels.

[3] http://www.bbc.co.uk/news/technology-16367022

In innovation

There has been some appetite within the UK community for realising the uptake of research outputs, especially through the involvement of user groups in the research. For example, the Digital Economy Research in the Wild initiative supports researchers in developing and testing their research ideas with potential beneficiaries in order to get closer to achieving a viable proposition with potential for transformational impact. Of the portfolio of 19 Research in the Wild projects, 16 involved HCI research.

> *"UK's broad and innovative research community, both in the discipline of HCI itself and in many related fields such as psychology, sociology, design, ubiquitous computing, and electrical engineering, was a driving factor in our decision at Microsoft Research Cambridge to found a research group in HCI. The group's success since its founding in 2004 has drawn heavily on the vibrancy and growth of those research areas in the UK."*
>
> *Ken Wood, Deputy Managing Director*
> *Microsoft Research Cambridge*

However, the HCI Theme Day identified a weakness in the UK HCI community in delivering impact from their research and a lack of entrepreneurial initiative and risk taking in this regard. There does seem to be a desire amongst researchers to connect with the innovation pipeline but there are difficulties and shortcomings in the understanding of the pipeline and in support mechanism to facilitate the route to impact. For further discussion on this issue see Key Question 5.

The panel highlighted that the strength of innovation in UK HCI attracts inward investment to the UK, with a number of international companies (Microsoft, Qualcomm, Orange, Google Mobile Design Studios and Nokia Design) choosing to locate creative (HCI) R&D labs in the UK and recruiting a large number of UK HCI PhDs to them.

Key Question 3: To what extent has UK HCI research addressed key societal and technological challenges?

The panel looked at the current portfolio of EPSRC projects with a significant level of HCI research. Many projects have small HCI research components, demonstrating how HCI research has become an enabler for many other aspects of research.

A review of current project plans and objectives identified fifteen domains as the main application areas for current research. Where two or more target domains were specified, all were included. A number of projects have no identified domain within which research results are expected to be applied. A similar number list a broad range of possibilities with none specifically chosen as the lead or target domains. Both projects with no target and those with a very generalised description of possible domains have been excluded from the results presented below.

Domain	Project Count
Manufacturing	0
Digital Economy (including Identity Management & Trust)	13
Healthcare (including Assisted Living)	20
Energy	12
Family & Home	13
Ubiquitous Computing (including Pervasive Computing)	4
Social media	5
Education & Learning	5
Sport & Leisure	3
Cultural Industries	21
Politics & Public Realm	8
Law & Order and Security	12
University (as an organisation)	4
Travel & Transport	4
Financial Services	2
Religious Life	1

The panel wish to point out that there is a lag-effect in the portfolio and this may not reflect current and emerging important application areas accurately. For instance, a cultural and creative industry focus was prevalent a number of years ago and, as such, features strongly in the list.

The panel noted that the most notable absence from the list of active domains is manufacturing. This is an un-mined opportunity for HCI research but this domain has traditionally been of interest to engineering psychology and human factors researchers. HCI can make meaningful contributions in the manufacturing domain but must forge links with the existing engineering design research base to make the most of the existing body of research.

The strong alignment to the Healthcare domain is encouraging and many domains in the list are important to the Digital Economy Theme. This is to be expected as a large proportion of EPSRC funding for HCI research is awarded by the Digital Economy Theme.

Key Question 4: What future challenges can UK HCI contribute to and what are the barriers to success?

The panel considered how UK HCI could encourage bold and transformative research in HCI to exploit the technological opportunities and rapidly changing social and cultural context. The challenge lies in enabling the effective deployment of new technologies from other sectors for economic and social good and the UK community should take a lead in making this happen.

Why UK? The interdisciplinary and self-critical nature of the UK HCI community is a real strength.
Why HCI? The discipline's focus on design and the user/community experience means it is essential that HCI research drive this agenda.

From the discussions at the HCI Theme Day, three major paradigms arose to drive UK HCI research to tackle the multitude of challenges:

HCI thinking Big

HCI is shaping and improving future living as it becomes more digitally enhanced. The lived experience of connected communities, the city and the environment is ripe for exploration. How can HCI think 'big' as part of this agenda? To do so, it needs to theorise this space, make longitudinal studies of those areas and consider question such as: How can HCI support behaviour change through reflecting back personal behaviours? How can HCI gain access to and address the huge volumes of data and information being collected on individuals and make this data personally meaningful and accessible for the individual? What is the role of HCI in investigating the implications and possibilities related to devices for the body and for the environment and explicit and implicit interactions this will involve?

HCI needs to think big if any of these issues are to be tackled. .

Potential barriers to this challenge include the difficulty in working on large agendas across big consortia; the demands of intellectual and managerial coordination can be insurmountable. Another barrier to tackling large problems over a long timescale is the uncertainty of funding. This raises a challenge for the community to be able to develop long term plans based on sustained funding levels and the management of associated risks.

User experience

Understanding and supporting social interactivity in a connected world is a clear goal for HCI research. How can HCI enhance the nature of experience, support multitasking and address issues such as the management of interruption and fragmented engagement? HCI is also well placed to contribute to achieving a balanced approach to the design of technological interventions for behaviour change. HCI offers different models of interactivity and the resources required for it. The ethical aspects of are increasingly central within research responses to this challenge.

The UK HCI community has an excellent record of addressing issues of digital exclusion in the domains of ageing and disability. Related issues are now appearing in other domains, such as youth unemployment. Areas such as these offer new opportunities for UK HCI research.

A major strength of UK HCI is the design of the user experience. A potential barrier to extending and enhancing this strength lies in the complexity of product value chains. Multiple companies often interact to provide one service (for example, TV service delivery). The industry base for commercial

exploitation or development is fragmented and, combined with the lack of venture capital resources, sets a challenge for the community to ensure the impact of this research.

New techniques

Research is now extending the notion of interaction and experience beyond the traditional frameworks. New interfaces are being developed that claim to be more natural and intuitive than traditional graphical user-interfaces. New materials may be developed that lead to interaction modalities that have not yet been defined. The community needs to build links, with new communities such as hardware designer and materials researchers to integrate HCI thinking into these design processes and make best use of the scientific innovations being made in the UK and the rest of the world.

A potential barrier which the panel identified was the difficulty in engaging across established disciplinary partnerships. UK HCI community can and should lead in developing these partnerships and build new collaborations.

Key Question 5: To what extent does the UK research community maximise the potential impact of HCI research?

This issue featured strongly in the Theme Day discussions. There is a desire in the community to connect to the innovation pipeline[4] but the panel noted the relative weakness of the UK HCI community regarding risk taking and being entrepreneurial. There were criticisms of UK Universities for not promoting a culture of commercialisation and it was felt that there is a distinct difficulty in dealing with micro-businesses and start-ups. This is not the case across all universities and there are examples of good practice in the UK – for instance, the University of Edinburgh offers entrepreneurial training schemes to staff and PhD students to promote a culture of commercialisation.

The panel reported that the UK HCI Community is innovative, but feels that there is not adequate provision of appropriate mechanisms for exploitation of research outputs and productisation/commercialisation. The panel also suggests that TSB funding could be better aligned with university strategies in this regard.

Overall, the UK HCI community has not maximised the potential of UK HCI research. The community needs to reflect on the following issue: How can the UK academic base, university sector and funding landscape respond to ensure the uptake of HCI research outputs?

The panel recommends that universities adopt entrepreneurial training programmes and draw on knowledge of best practise in the domain. This should also involve experience from outside ICT, for example, colleges of Art and Design.

The abolition of regional funding for innovation in many areas has left a large gap in the innovation funding matrix. New funding streams should be considered as well as creative use of EU funding in order to raise capital for start-ups and spin-out companies.

In engaging with the Technology Strategy Board (TSB), the community has an opportunity to try to promote HCI and design as embedded parts of the new Catapult centres being set up.

[4] See SWOT analyses: *Report of the EPSRC Human Computer Interaction Theme Day and Survey*, March 2012

Key Question 6: Is the EPSRC HCI research portfolio appropriately balanced to maximise its potential in terms of quality and impact?

The panel considered the demographics of the EPSRC portfolio, including data on the number, size and institutional profiles of EPSRC grants in HCI and survey results on the balance of the portfolio.

It was felt that the spread across institutions reflects the overall EPSRC profile with 78% of funds being held by 21% of institutions. Whilst this shows concentration in a relatively small number of institutions, there is a long tail with a large number of institutions with active research groups and grants in HCI, demonstrating a wide breadth of portfolio.

The Theme Day discussions exposed a concern that the best students were leaving the field for industry or other destinations and this might lead to a future loss of capability. EPSRC data on the age and career stage of researchers in this field, however, are encouraging and show no lack of young, early career researchers on HCI grants.

The breadth of societal challenges being tackled is positive feature of the portfolio, though there is an opportunity to target the manufacturing sector more strongly.

Of the six sub-areas, many are well represented in the UK and they are often closely interlinked. However, there was an indication from the survey and Theme Day that Theory and Methods is underrepresented in the UK funding landscape. The *Report of the EPSRC Human Computer Interaction Theme Day and Survey*, shows that there are many opportunities for UK HCI which require innovation across all sub-areas of HCI and Theory and Methods should be encouraged for funding on an equal footing with all sub-areas.