

EPSRC

Engineering and Physical Sciences
Research Council

EPSRC Review of Mechanical Engineering 2011 Executive Summary



EPSRC Review of Mechanical Engineering 2011

Dr. Louise Tillman

Portfolio Manager:

Mechanical Engineering

Dr. Chloe Heywood

Portfolio Manager:

Medical Engineering

Dr. Derek Gillespie

Portfolio Manager:

*Manufacturing Technologies &
Engineering Design*

EPSRC is the main UK government agency for funding research and training in engineering and the physical sciences, investing more than £800 million a year in a broad range of subjects – from mathematics to materials science, and from information technology to structural engineering.

Foreword

This is a vitally important time for engineering research, with opportunities for the best engineers to address long-term fundamental questions which will help shape society over the remainder of this century. At the same time, we in the UK face significant challenges arising both from increasing international competition and some current perceptions of engineering research.

This review makes an important contribution to the dialogue on the future direction and long-term sustainability of mechanical engineering research. It is constructed around the three goals of EPSRC's Strategic Plan and makes recommendations in turn on the importance, quality and capability of mechanical engineering research and training in the UK. As an overall observation, the findings show much mechanical engineering research and training to be vibrant within the UK but with an important cautionary note on the need to continue to focus attention on future challenges, where excellent mechanical engineering research is critical to success.

EPSRC would like to thank the panel for their substantial help over many months and for their insight in helping to deliver such a comprehensive assessment. Thanks are also due to the many Heads of Department for the time and effort they have put into providing detailed submissions. Comments received *via* the online surveys have also provided a useful further input.

EPSRC has recently released a map of its full research portfolio, alongside specific actions to shape capabilities. The recommendations in this review will inform strategy, most immediately in mechanical engineering but they also have wider applicability across the whole Engineering theme and beyond. This is the first stage of an ongoing dialogue, with greater engagement and discussion planned over the remainder of this year to continue to advance mechanical engineering research within the UK.



Dr. Kedar Pandya
Engineering Theme Leader
EPSRC

Introduction

As a new delivery plan period begins, EPSRC faces the challenge of shaping the UK research landscape for the future benefit of the UK. To do this, a deeper understanding of the quality, importance and capability of the research areas that EPSRC supports needs to be developed in conjunction with the research community.

Mechanical engineering is an underpinning discipline, which is not only significant in its own right as one of the traditional pillars of engineering, but also due to the contribution that mechanical engineers have made – and continue to make – in other fields. EPSRC has recently conducted a number of reviews and evaluations that have touched on elements of the portfolio, however to date, there has not been a focused review looking at the health of the mechanical engineering research base in the UK.

With the assistance of a national panel of UK experts and the wider mechanical engineering community, EPSRC have conducted a review that has aimed to obtain a coherent view of the research and training performed by the UK mechanical engineering community and to look specifically at:

The importance of mechanical engineering research and training in terms of:

- The benefits to industry
- The key future societal and technological challenges where mechanical engineering can make a significant contribution
- Relationships with other disciplines and multi-disciplinary research

The quality of mechanical engineering academic research in terms of:

- The quality and international profile of groups and individuals
- Areas of current and future strength
- The balance between fundamental and applied research

The capability of the mechanical engineering community in terms of:

- The supply of talented researchers, from doctoral students to established research leaders
- The current and future infrastructure and equipment needs

Importance of mechanical engineering research and training

Although the level of R&D intensity (relative to GDP) in the UK is lower than that in other major economies, such as the USA, France, Japan and Germany, the United Kingdom still remains one of the premier countries in the world for conducting research and development.¹ The UK industrial R&D landscape is currently dominated by a small number of sectors, many of which have good relationships with the mechanical engineering academic community. The UK engineering research base appears narrow in terms of sector focus and in the future, research activities should look to address challenges applicable to a broader spread of industrial sectors.

¹ The R&D scoreboard is no longer supported by the Department for Business, Innovation and Skills. Archived content for the last (2009) exercise is available [online](#), courtesy of the National Archives.

Researchers in mechanical engineering disciplines continue to enjoy a relationship with their industrial partners that appears extremely positive. This is despite the current economic situation and the perceived danger that industrial R&D spending is likely to be one of the first areas of company spending to be cut-back. Most major engineering departments in the UK are beginning to explore, or have already formalised, a range of strategic partnerships with key industries that allow strategic discussions about research priorities, and should provide continuity in funding. Industry also continues to sponsor EPSRC-funded research *via* both discovery- and challenge-led opportunities, and overall the community has a good balance of funding sources, that should help alleviate unforeseen gaps in funding from any given financial source. The development of the Technology & Innovation Centres is a new opportunity that will potentially greatly benefit the UK – the research and industrial communities must embrace this positively if it is to be made a success.²

At all levels of the career, from graduate onwards, it is acknowledged as vital that there be a two-way flow of people between academia and industry. In mechanical engineering the academic system is producing, *via* a variety of mechanisms, a steady flow of trained graduates and post-graduates, who continue to view an industrial career as an attractive opportunity. It is equally important, however, that the UK continues to emphasise, as a viable option, the benefits of continuing along an academic career pathway. Making this case is especially important at a time when graduates and post-graduates are likely to be under greater financial pressures than before. There should also be a range of opportunities that facilitate two-way staff movement between industry and academia at all stages of the career path – as present in other research-intensive countries – in order to facilitate effective knowledge exchange.

As a discipline that under-pins a wide variety of subjects, mechanical engineers have the opportunity to have marked impacts upon almost all of the biggest challenges facing society. Though many of these areas are beginning to be tackled by the mechanical engineering community, it is notable that the majority of the research funded by EPSRC focuses on the areas of UK strength in traditional engineering sectors – the portfolio needs a shift towards a greater diversity in application.

Stating “grand vision” societal challenges against which mechanical engineering could make significant impacts is easy, as a paper exercise. The true challenge is to articulate what the emerging technological requirements are related to these challenges, and to generate innovative solutions for them *via* research activity. More work will be required on this front, as the scope of technologies highlighted through the community surveys during this review process were disappointingly conservative. There is an opportunity for mechanical engineering researchers to develop a clear shared vision for the future. This vision should look to link to these identified challenges.

The mechanical engineering academic community in the UK is well-disposed towards the concepts of multi-disciplinary working – perhaps more so than their contemporaries in comparable countries. However, there could be a greater diversity in the fields with which they choose to interact, especially in light of the multi-disciplinary nature of most societal challenges. There are also difficulties in the assessment metrics (from a range of bodies) applied to such work that need to be overcome. An increasing number of academic departments and schools are implementing organisational changes to facilitate a research focus that is increasingly multi-disciplinary in nature, and EPSRC will continue to develop opportunities and procedures that better support such work, where it is carried out with a “best-with-best” ethos.

² Further information on Technology & Innovation Centres is available from the [website](#) of the Technology Strategy Board. Relevant supporting documentation available online includes the [Hauser Review](#), James Dyson’s report [Ingenious Britain](#), and the February 2011 report by the House of Commons [Science and Technology Committee](#).

Quality of mechanical engineering academic research

The current evidence strongly indicates that the UK is internationally competitive in mechanical engineering, with the top groups and institutions showing international leadership in the field and effectively competing and collaborating with their international counterparts. Although many indicators are positive for the future (increasing number of long term strategic partnerships with industrial partners,³ improving citation impact⁴ and improvement in quality since the 2001 RAE⁵), the international competition and the emergence of growing economies such as China and India means that the research landscape is changing and the UK community needs to be able to respond to this.

The UK has academic strength in a number of areas in mechanical engineering, with acknowledged leading groups and centres supported by EPSRC, industry and other funders in aerodynamics, materials engineering and testing, non-destructive evaluation and acoustics, dynamics, tribology and research relating to manufacturing. There is a level of critical mass in these centres in terms of funding, students and researchers that is essential in enabling high quality research to be performed. The capability to work closely with industry, and the level of support that UK academia receives from the user base are also key strengths of mechanical engineering in the UK.

Additionally, researchers in the UK are active participants in programmes involving international collaborations. Such work is acknowledged as being vital to the health of the research base in the UK, and there are a variety of collaboration mechanisms in place to enable such work to occur. Largely, such work takes place with Europe and the USA, though interactions with the Far East are increasing over recent years.

The community has a diverse range of research incomes and on the whole appears broadly happy with the current balance of incremental and more adventurous and novel research supported and performed in the UK. EPSRC is only one of a number of sponsors who support research in mechanical engineering but has an important and unique role in funding and encouraging fundamental mechanical engineering research at TRL 1-3. Recent EPSRC investments in mechanical engineering are evenly balanced between research that builds on current understanding and research that shows high levels of creativity and adventure. Evidence from EPSRC panels clearly indicates that creative and adventurous mechanical engineering proposals with well-managed risk are more successful in peer review.

Mechanical engineers have the potential to be integrators in multi-disciplinary research projects, and in the future should build on the track record they have for doing this in bio-engineering and healthcare areas. The community has highlighted that being involved in energy related research areas, especially in the investigation of renewable and alternative energy sources will become increasingly important and should be an area of future strength for the UK. However the current EPSRC mechanical engineering portfolio does not reflect this and difficulty in attracting new recruits in related areas such as nuclear engineering indicates that further work is needed to encourage researchers to explore this field.

³ Outputs from a survey of Heads of Department performed as part of this review.

⁴ Bibliometric data on the research volume (number of publications) and research impact (the ratio of number of citation to the number of articles published) was produced using Thomson Reuters' InCites tool.

⁵ The report is available [online](#) via the website of the Research Assessment exercise.

Capability of the mechanical engineering community

In general, the supply of doctoral students has been maintained over recent years, with a high concentration of students in the top institutions. However the difficulty that exists in recruiting and retaining UK-trained doctoral students raises serious concerns for the future.

Although much of the doctoral training in the past has been focused around the traditional Ph.D., there is now a strong culture of applying the Engineering Doctorate model to studentship training in mechanical engineering. Although EPSRC only funds approximately 25% of doctoral students in mechanical engineering, changes to EPSRC support for studentships will have an impact in the future. The community will need to actively consider any new doctoral training opportunities that arise over the coming years and explore different models for doctoral training.

In mechanical engineering, there have been a number of concerns raised anecdotally over the last five to ten years about the demographics and future supply of early career researchers in the academic community. For example, community concerns about the future supply of researchers in tribology led to a call in 2007 for a Science and Innovation Centre in the area, resulting in the setting up of the National Centre for Advanced Tribology at Southampton (nCATs). However, although HESA and EPSRC data show that there is an older age profile of researchers in mechanical engineering relative to other academic communities in engineering and physical sciences neither the 2008 RAE, nor EPSRC surveys to Heads of Department raised this as major concern. Overall recruitment of early career academics was not seen as problematic and, although there are a low number of UK applicants applying for these roles, excellent overseas researchers are currently filling available positions.

The quality of early career researchers was felt to be relatively high by most Heads of Department, with research leadership being seen as an important quality. Engagement from industry and funding agencies, in addition to strong mentoring from senior colleagues from an early career stage, were seen as essential to the development of future leaders in the UK. Engagement of early career researchers with programmes aligned to key societal challenges is also extremely important.

Mechanical engineering research is heavily dependent on having access to cutting edge equipment and infrastructure, from high performance computing to test facilities. Although current indicators show that there has been strong recent investment in equipment, facilities and infrastructure, with cuts to capital spending and the implementation of the Wakeham review's recommendations⁶, key institutions and groups will need to work together to ensure that the community have the equipment that they require to perform internationally recognised and leading research.

Maximising usage of current equipment, especially that sponsored by EPSRC will be essential to this and greater levels of equipment sharing, pooling and collaboration will be necessary. The community will also need to be able to clearly articulate the large facilities and capital investments that are required to maintain a world leading position.

⁶ *Financial Sustainability and Efficiency in Full Economic Costing of Research in UK Higher Education Institutions*, Universities UK and Research Councils UK, June 2010 – report available [online](#).