This submission is on behalf of the Council for Mathematical Sciences (see Section B below).

A: The Submission

We will focus our attention on issues related to research in the mathematical sciences.

The pattern of research in the mathematical sciences is generally rather different from the experimental sciences. This places our emphasis on the people conducting research, on the time for people to do research, on networks, collaboration and training of people. Furthermore individual projects and research groups tend to be smaller than in experimental sciences. These factors influence our emphasis on the movement of people below.

1.**Academic staff.** The UK has benefitted greatly from the talent, cross-fertilization and expertise of many EU nationals moving to the UK as permanent academic staff (the 33 departments responding to our poll showed an average of 31% of academic staff from EU (non UK)). For the last 40 years the UK-based mathematical sciences research groups have been built on the assumption that EU nationals and their families are not distinguishable from UK nationals, and cross-institutional collaborations have been built on the assumption that national borders within the EU should be disregarded. This has resulted in the high proportion of EU staff, and an environment that is flourishing and effective. It takes several years to build a team and a reputation, and at least 10 years to train a mathematician, so other capacity certainly can't replace EU capacity in the short term. It is striking how swiftly the confidence of EU national staff has been undermined by the Brexit vote, and there are already examples of staff who are seeking to return to their own country or other continuing EU countries. There is a risk that UK nationals will follow them to a better-funded environment with a more reliable long-term future and more respect for multi-national teams.

It is essential that the long term status of EU nationals currently in academic positions is made clear, guaranteeing the rights and security that have up to now been guaranteed through our common membership of the EU.

As for the future, the EU has a special status in this respect because of its geographical proximity and cultural congruence: this makes the UK more attractive for the best EU candidates than for those from elsewhere.

It is highly desirable that the obstacles to EU nationals moving to academic positions in the UK are minimized, and that arrangements are in place to settle the long term security of their residency status within a short period from appointment.

2.**Postdoctoral researchers (movement).** The UK has benefitted greatly from the talent, cross-fertilization and expertise of many EU nationals moving to the UK for postdoctoral positions in the UK.

It is valuable to have postdocs from around the world, but the long term value of relationships built up are greater when facilitated by geographical proximity of the home country. Geography and cultural congruence of the UK to postdocs from nearby means we attract especially talented people from the EU; the length and rigour of their training makes them highly competitive. The number of top quality UK candidates is limited, and if we reduce the number of EU candidates we would have to take lower quality UK candidates or none at all.

It is highly desirable that the obstacles to EU nationals moving to postdoctoral positions in the UK are minimized.

3. **Visas.** While the focus at present is on maintaining the links with EU nationals and networks as in 1 and 2 above, CMS would like to see this as part of a unified system of visas and work permits for all researchers. Issues related to short term visits are covered in Paragraph 5 below.

Any improved system of work permits/visas needs to be consistent with the way the academic system operates: for example, making it easy for overseas researchers to move along the career pipeline without being forced to restart applications from scratch at every step PhD/postdoc/probation/tenure.

4.**Postdoctoral researchers (funding).** For UK mathematicians, the postdoctoral stage is a particular bottleneck: at least 150 postdoctoral researchers need to be supported each year to maintain our research

infrastructure, but only a small fraction of this number are funded through RCUK (as detailed in the CMS People Pipeline Project). The positions funded through the ERC in the UK have played an important part, and the opportunities to take positions elsewhere in Europe have been invaluable in building the experience and networks of our early career researchers.

It is very important that substitutes for both of these are found: the first requires additional funding through RCUK, and the second requires suitable arrangements with the EU, both for movement of people and eligibility to hold these positions.

5.**Research collaboration.** Postdoctoral researchers have been discussed above. Research collaboration involves UK academics making visits of a few months to places in Europe and vice versa. This requires suitable arrangements with the EU, both for movement of people and eligibility to hold these positions. At present numerous academic visitors and conference speakers have had to cancel visits because visas applications have not been decided in a timely way.

This should be part of a general solution. The CMS would like to see the visa system making it as simple as possible for overseas researchers to visit for short-term purposes such as invited lectures, seminars, conferences, workshops, sabbaticals, with reasonable flexibility on locally funded fees and expenses.

6.**Research grants A.** Fellowships funded through the EC and ERC grants that have been invaluable to mathematicians. Fellowships have been available through the ERC at various levels; those at the senior level are useful, but it is the Marie Curie Fellowships for early career researchers that are most important. There are counterparts for both of these through RCUK, but those funded through the ERC are comparable in number with those through RCUK.

To maintain this resource we need either an arrangement permitting continued access to the EU funding, or else a substantial uplift to that available through RCUK. The former is preferable, because of the greater diversity in funding that it brings.

7.**Research grants B.** Another invaluable source of funding has been the

research training networks. There has been some element of postdoctoral funding, but principally these have supported PhD students. The funding itself is extremely useful, but the opportunity for PhD students to travel between several research centres and gain an international perspective on mathematics is fundamental.

It is hard to imagine replacing the second element without an arrangement allowing access to EU funding. Similarly the second has been a mechanism for UK mathematicians to avoid the dangers of overconcentration that can result from some RCUK policies.

8. **Nervous friends.** There is anecdotal evidence of researchers planning to leave and of UK researchers being disinvited from European grant applications.

9. **Two dangerous gaps: funding and networking**. The EU Research and Innovation Programmes have traditionally provided substantial funding opportunities to UK maths researchers. Recent examples of these opportunities are the HORIZON 2020, the SESAR, and the European Research Council programmes.

The size of this programme provides the opportunity to fund large scale projects and to involve multinational interdisciplinary teams. The quality of the results of this programme is high since the selection process and the project assessment adhere to very high review standards. This applies across the HORIZON 2020 Programme.

One striking example, is the case of the SESAR programme which brings together 3,000 experts around Europe and beyond in order to develop the new generation of the Air Traffic Management System. The quality of SESAR Joint Undertaking is very high, as it involves the European Commission and EUROCONTROL as its founding members, numerous representatives of European industry and policy stakeholders, and a 12-member Scientific Committee

Whilst we hope that the funding gap will be addressed, in line with Government policy to maintain the science budget in real terms, we do not think that merely uplifting the RCUK budget is the best way: the benefits of European funding are in the networking and collaboration.

Specifically, the multinational, multicultural, and interdisciplinary aspects of the European programmes enhance and expand the research horizon of UK based researchers and increase their international exposure and visibility. This international collaboration with high calibre research teams contributes to the cross-fertilization of ideas that cannot happen when researchers are working only in nationally based teams.

These characteristics of the European research programmes and the associated economies of scale and scope increase significantly the effectiveness of the research investments

The CMS would like to see attention paid to how we can preserve the benefits of European research involvement through a secure role in the Common European Research Area.

10. **Diffusion of innovation and impact:** The international collaborative research environment fostered by the EU Research and Innovation Programmes provides an ideal setting for the accelerated diffusion of innovation among research groups originating from different countries. Based on their participation in International Research Consortia, UK researchers contribute and in turn have direct and unrestricted access to research findings, which would otherwise be impossible. This proximity to the international research community allows UK researchers to capitalize on innovative ideas and results developed and tested at European level. Furthermore, the scale and scope of European Innovation projects provides UK scientists with the opportunity to work on big societal challenges and thus generate significant socio-economic impacts at national and international level.

11. **Ambitions and engagement.** We are not dictating solutions but articulating risks, priorities and requirements. The CMS Societies collectively fund a wide range of international links and stand ready to maintain and develop these activities. We expect that the societies and their members will be responding for example to the Global Challenges.

We are ready and willing to cooperate with Government and agencies in developing those solutions, with the Select Committee in developing the tests by which they can assess them, and to contribute to any national dialogue to stress the benefits of international collaborative research.

B: About the Council for the Mathematical Sciences (CMS)

The Council for the Mathematical Sciences (CMS) was established in 2001 by the Institute of Mathematics and its Applications (IMA), the London Mathematical Society (LMS) and the Royal Statistical Society (RSS). In 2008 the Edinburgh Mathematical Society (EMS) and the Operational Research Society (ORS) also became members of the CMS. The CMS comprises representatives and observers from the mathematical sciences community, including the Presidents and Chief Executives of these societies.

The CMS provides an authoritative and objective body that exists to develop, influence and respond to UK policy issues that affect the mathematical sciences in higher education and research, and therefore the UK economy and society in general.

The objectives of the Council for the Mathematical Sciences are:

- to provide an expert advisory group on matters affecting the mathematical sciences in higher education and research in the UK.
- to engage (proactively and responsively) with government and other decision-makers and to respond coherently and effectively to proposals in which the mathematical sciences in higher education and research in the UK have a role, or may be affected.
- to engage with funding agencies for higher education and research on maintaining and improving a strong mathematics base in the UK.
- to bring together the mathematical sciences community and facilitate communication between the community and other stakeholders to explore common issues and potential solutions.

C: The importance of the Mathematical Sciences.

(i) The mathematical sciences form the foundation of all the science and data disciplines; finance, engineering, life sciences, pharmaceutical and medicine; the low carbon economy.

(ii) The mathematical sciences are crucial to the UK economy currently contributing 16% of UK GVA and 10% of jobs (Deloitte Report)

(iii) The CMS Chair, Professor Sir Adrian Smith writes “It is worth noting that in addition to the evidence from the Deloitte report on the Economic Impact of Mathematical Sciences research, recent EPSRC reports show that Mathematical Sciences research produces an outstanding rate of return on investment. EPSRC cited reports show the headline annual Economic Benefit for several disciplines principally within its brief to be Engineering £280bn, Physics £77bn, Chemistry £258bn, Mathematical Sciences £208bn. The EPSRC report ‘*Investing in excellence, delivering impact for the UK - Insights from the Research Excellence Framework 2014*’ reports that national spends on research are Engineering £3194m, Physics £2494m, Chemistry £1049m, Mathematical Sciences £354m.

Although these numbers come from a range of reports we can estimate a rate of return on investment as benefit /cost which are then: Engineering 88, Physics 31, Chemistry 246, and Mathematical Sciences 588.”