A National Academy for Mathematical Sciences

A Green Paper

December 2021

Foreword

This Green Paper has been prepared to offer a bold vision for a new National Academy for Mathematical Sciences. It is a consultation document containing enough concrete details for stakeholders inside our community and outside to offer both specific and general feedback.

The idea for an Academy for Mathematical Sciences was first mooted by Professor Philip Bond in the "*Era of Mathematics – an Independent Review of Knowledge Exchange in the Mathematical Sciences*" published in 2018. To paraphrase the points in that document, the Academy will, for the first time, offer a body which spans the whole of the mathematical sciences, from those in mathematics education, through researchers and lecturers in academia, to practitioners, including end-users, in industry and commerce. First and foremost it will be external facing, with advocacy at its heart, offering a single powerful voice that reinforces and amplifies the work of the many learned and professional bodies supporting the mathematical sciences. Such a national voice in the UK is critically important, for example to provide a unified response to new government initiatives or to promote the importance and successes of mathematical sciences research and education.

As the Royal Academy of Engineering has shown, substantial benefits accrue from having a single Academy connecting and speaking for education, research and industry, and which interacts with government to generate effective policy. We argue herein that a new Academy for the Mathematical Sciences would create a more coherent framework for the mathematical sciences in the UK, by working with existing learned societies, and by providing new engagement mechanisms with industry, with all levels of education and with government. Owing to the ubiquity, reach and significance of the mathematical sciences, we would strive over time for the National Academy to gain parity of recognition with other Academies; this would allow us to play a much greater role than hitherto on advising government and policy makers, and ensure that we are resourced at a level commensurate with our value and scale.

I would like to thank all those who have worked diligently on this project since the Bond Review. First, I am most grateful to all members of the Council for Mathematical Sciences' Implementation Group and Strategic Committee, and their respective chairs, Professor Sir

Bernard Silverman and Dr Claire Craig. This Green Paper is essentially the detailed realisation of the ideas posed by these two groups after a great deal of consideration by and consultation with individuals and groups from within the mathematical sciences and outside.

Second, I thank all those who have looked over early versions of the document or provided detailed expert knowledge or insight into various aspects of the proposal. In particular I am grateful to Dr Jenefer Golding, Professor Andrew Noyes, Professor Sir Martin Taylor and colleagues from the Royal Society who expertly guided us through the issues associated with mathematical sciences education.

Finally, I offer especial thanks to my colleagues on the Working Group who authored this document, Professor Ken Brown, Professor Christine Currie, Professor Dame Celia Hoyles, Professor David Leslie, and the secretariat, Mrs Kathryn de Ridder and Dr Matt Butchers.

We seek your input to all aspects of the proposed National Academy for Mathematical Sciences, but ask that you particularly consider the following questions.

- Does the Academy vision reflect the needs of all elements of the mathematical sciences community (educators, researchers and practitioners)?
- Do the present proposals provide a pathway to implement this vision?
- Are there any ways that the proposed structure of the Academy might be improved?
- Is the overarching focus of the Academy, to unify the broad mathematical sciences community and engage in external advocacy on its behalf, the right one?
- Is the proposed roadmap achievable and optimum to realise a successful Academy? Is there a better route to realise the desired outcome?
- How should the proposed Connected Centres Network for Knowledge Exchange be integrated into a National Academy?

We welcome your input on these questions by 21st January 2021. Please complete the following short form: https://tinyurl.com/UK-MATHS-ACADEMY

Should you have any specific queries please email national.academy@newton.ac.uk

David Abrahams (University of Cambridge) – December 2021

Executive summary

The creation of a **National Academy for Mathematical Sciences** is proposed with the mission to promote, and ensure the health of, **the mathematical sciences across the UK.** The primary focus of the National Academy will be external advocacy, enhancing connections across the broad mathematical sciences community in order to support and enhance its impact within the UK and beyond.

1. The purpose of this Green Paper is to present a roadmap and narrative by which a National Academy for Mathematical Sciences might be created and might operate. The concrete proposals in this Green Paper are presented to stimulate detailed debate across the community, leading, it is hoped, to agreement on and implementation of a version of the proposals presented herein.

2. This document is aimed at all stakeholders, both within the broad mathematical sciences community and outside, for consultation and response.

3. This Green Paper builds on the work of the 'Big Mathematics Initiative' (BMI), a period of activity carried out through 2019 and 2020, and is designed to be the foundation of comprehensive discussion through late autumn and winter 2021.

4. The Authors of this Green Paper, formed to reflect the breadth of the community, can be found in *Annex 1. Green Paper Contributors.*

5. INI and ICMS (henceforth referred to as the mathematical sciences infrastructure) will be tasked with providing limited support for the new Academy in this present consultation stage as well as during the proposed set-up and proto-Academy phases.

The case for the mathematical sciences

6. *"We live in the era of mathematics. Its influence permeates economic and social activity and its influence and impact are profound. Yet its role is not well understood, we are not using it as well as we could and should, and we are investing too little […] There can be fewer more productive, creative and exciting investments than investing in mathematics."*[1]

7. The case for mathematical sciences encompasses the benefits of good primary and secondary education, the crucial role of teaching and research undertaken at higher education institutes (HEIs), and the invaluable mathematical sciences activity undertaken by practitioners[2] in industry and commerce, broadly interpreted, for economic and social good.

8. A strong mathematical sciences education has a profound impact on future employment and productivity. "*Higher levels of achievement in mathematics are associated with higher earnings for individuals and higher productivity*"[3]. Raising technical and analytical skills is non-negotiable for UK plc to remain agile and productive in this data-driven and connected world.

9. The impact of mathematical sciences research and development is varied and profound, in roles which are often hidden or obscure. "*Financial services, security, defence, health, manufacturing, transport, film-making, and many other sectors require the use not only of existing mathematical methods, but also the development of new, more powerful mathematical tools to continually spur advances and innovation.*"[1]

10. The overspill benefits of mathematical sciences research extend across all aspects of the UK economy. It is estimated that the number of individuals in mathematical sciences occupations in 2012 was 2.8 million (10% of all jobs in the UK) and there

[1] Preface by Lord Stern: The Era of Mathematics https://epsrc.ukri.org/newsevents/pubs/era-of-maths/

[2] In this Green Paper, the term 'practitioner' is used to mean any practicing mathematical scientist, or 'user' of mathematics, who is employed outside of an HEI or an educational setting, i.e. in industry, commerce, government, policy, finance, NGOs etc.

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/630488/AS_review_report.pdf

was a direct gross value added (GVA) associated with mathematical sciences research of £208 billion (16% of the total UK GVA).[4]

The need for an Academy

11. *"The importance of the mathematical sciences to global society continues to grow; however, nationally the voice of the UK mathematical sciences community does not sing clearly or loudly."*[5]

12. Training and teaching in mathematical sciences has never been more important for the prosperity of the UK. There is a need to properly **resource and coordinate** the organisations who provide a forum for **educational innovation in the mathematical sciences**, and to enhance links with those who undertake policy interventions in these areas.

13. Despite the existence in the UK of many excellent specialist professional and learned societies, the community fails to have a clearly identified, authoritative and effective body that represents the entire discipline externally. The Academy will **bring together** the subjects' diverse voices from pure mathematics through industrial and applied mathematics to statistics and operational research, from academic scholars and teachers of mathematics to practitioners outside academia who use mathematics in their work. Thus, the Academy will **provide a single voice**, with **opportunities for interaction and parity of recognition** afforded to all.

14. The Academy will provide a forum to **coordinate** mathematical scientists across the wide spectrum of careers, to ensure that pressing societal, economic and technological challenges are addressed with the most effective mathematical and statistical tools, and that education and research are informed and enriched by these developments.

15. The interface between mathematical sciences and decision makers has never been more important. Seismic changes in the research landscape and agenda, driven by

[4] https://epsrc.ukri.org/newsevents/pubs/deloitte-measuring-the-economic-benefits-of-mathematical-science-research-in-the-uk/

[5] http://www.cms.ac.uk/wp/wp-content/uploads/2020/06/The-case-for-a-National-Academy.pdf

socio-economic trends and disruptions, mean that there is an urgent need for the mathematical sciences to **provide scientific leadership** in critical policy discussions. The proposed Academy will provide a vehicle for such interventions.

16. The Academy will offer a **strong unified voice** covering the spectrum of schools, colleges, universities and employer bodies to address vital issues in the take up of mathematics and assessment in education, with a constant endeavour to strive for equality of opportunity, diversity and inclusivity (ED&I) and staunch the *"leaky pipeline"*[6].

Core functions of the Academy

17. The overarching benefit of an Academy model is to provide a **single voice** through the **connectivity** between the functions listed below. Whilst these are presented separately, the various operating committees will be organised to encourage **exchange and communication** between them (at the committee and individual level) and **interface** with external bodies**.**

18. Consultation with the community (during the BMI discussions) on the aforementioned needs has resulted in the identification of the following core functions of the Academy.

a. **Policy Affairs –** to enhance and further professionalise the interaction that mathematical sciences has with policy makers and government. To enhance and amplify the voice of existing mathematical sciences societies and interest groups. To collaborate with these groups to coordinate a coherent voice to provide mathematical sciences leadership in government decision making.
b. **Equality, Diversity and Inclusivity** – to position ED&I at the heart of Academy strategy, so it frames activities and moulds goals at every level. To collect data, monitor and improve gender balance, equality of opportunity and diversity (geographical, social, ethnic) across the mathematical sciences.

[6] https://www.lms.ac.uk/sites/default/files/files/Benchmarking%20Report%20FINAL.pdf

c. **Practitioner Affairs function –** to bring the community of mathematical scientists across the workforce together, support training of mathematical practitioners, and connect capability with need.
d. **Educational Affairs function** – to add value by helping coordinate and support the various parties with an interest in mathematical sciences education and connect with the life-long learning agenda. To provide resource and identify and help resolve critical issues of concern to teachers in the classroom.
e. **Academic Affairs function** – to provide a rich source of data and a unifying voice in support of the crucial role of academic teaching and research in the mathematical sciences. To work closely with the national learned societies and to develop policy on maintenance of the health of discipline and impact.

Form of the Academy

19. Following extensive advice the following is the proposed form:
    a. **Fellowship** – will be conferred on those who are recognised for major contributions, either directly or indirectly, to the mathematical sciences and for those who progress the health of the discipline across all environments. The Academy will ensure that conferment of Fellowship is recognised as a duty rather than a reward, and acceptance will be an agreement to contribute to the Academy's aims, thus recognising the central importance of ED&I. Fellows will represent the Academy and constitute (along with other domain experts as appropriate) the various committees that will draw together disparate activity across the UK.
    b. **Executive** - a Chief Executive Officer (CEO), an external Chair of Council, and a President appointed from within the Academy's Fellowship.
    c. **Governance** – each committee, constituted for the various activities and responsibilities of the Academy, will be overseen and chaired by a Vice-President reporting to the President. The Vice-Presidents, President, and others with specific key skills (such as policy or finance specialism), will constitute a Council with an independent external Chair.
    d. **Finance –** funding support would be sought from both government and philanthropy. In a 'fully-fledged' state it is envisaged that in the region of £5

million per year would be required to fund a suitable professional secretariat and headquarters, as well as the various activities of a National Academy.

Roadmap – how to get there?

20. Whilst the intention is to work towards a fully-fledged Academy within 5 years (from January 2022), a three-step approach is proposed. In the initial, **set-up** phase (2022) modest support from the Isaac Newton Institute (INI) and International Centre for Mathematical Sciences (ICMS) will incubate the basic functions. In addition:

- A small number of appointments will be made - a Founding President, a CEO, and a number of policy professionals.
- A small group of Founding Trustees will be appointed with time limited remit.
- Discussions with government and philanthropists shall be initiated.

21. In the second, '**proto-Academy**' phase (2023 - 2025/26), establishment of further governance and operating structures will be undertaken.

- The Council constituted of the Founding Trustees, the Executive, and external experts shall be established, alongside the recruitment of senior key Academy staff.
- This Council will be charged with creating and setting into operation the various committees and drafting Terms of Reference.
- The first cohorts of Fellows will be recruited.
- The initial operating and governance committees will commence their business, and in parallel discussions on the detailed constitution will be undertaken.
- These constitutional discussions will include the long-term relationship between the Academy and extant mathematical sciences organisations, such as CMS, the learned societies, ACME, JMC, ATI, HIMR, ATI, INI and ICMS.
- Options for suitable premises to establish the fully-fledged Academy, including staffing, post-incubation shall be explored, along with a plan for a sustainable funding model.

22. The fully-fledged Academy will begin operation under its own auspices during 2026. Additional operating and governance structures will be formed, some running

alongside existing entities, to complement and enhance activity, until such time as merger with the Academy may be seen as appropriate.

How to respond to this Green Paper

23. In the lead up to and in the production of this Green Paper, the authors and the two predecessor CMS Committees, engaged with, and drew upon the opinion of, hundreds of stakeholders and organisations through discussion and workshops[7].

24. In the next stage, responses are invited to this Green Paper with the aim that the final version is published in early 2022. To ease the process of assimilation of feedback, responders are principally requested to address the questions set out below.

25. Responses should be made online via the short form: https://tinyurl.com/UK-MATHS-ACADEMY by 21st January 2022.
This email address national.academy@newton.ac.uk can also be used to offer comments or ask questions for clarification purposes.

Questions for response

- Does the Academy vision reflect the needs of all elements of the mathematical sciences community (educators, researchers and practitioners)?
- Do the present proposals provide a pathway to implement this vision?
- Are there any ways that the proposed structure of the Academy might be improved?
- Is the overarching focus of the Academy, to unify the broad mathematical sciences community and engage in external advocacy on its behalf, the right one?
- Is the proposed roadmap achievable and optimum to realise a successful Academy? Is there a better route to realise the desired outcome?
- How should the proposed Connected Centres Network[8] for Knowledge Exchange be integrated into a National Academy?
- Do you have any other comments, concerns or suggestions?

[7] http://www.cms.ac.uk/wp/wp-content/uploads/2020/08/BMI-Event-Summary-Report-PDF.pdf

[8] A Consultation Paper on the proposed Connected Centres Network is also available at http://www.cms.ac.uk/wp/national-academy/

Timeline

2021/2

Consultation response to Green Paper to be received by 21st January 2022. Final version will be published early 2022.

2022

Set-up Phase
INI / ICMS Support

- A small number of appointments to be made; specifically, a Founding President, Chair and a number of policy professionals.
- A small group of time limited Founding Trustees will be appointed.
- Discussions with government and philanthropists shall commence to secure ~ £1 million to support the proto-Academy over a three years operating lifetime.

2023 – 2025/6

Proto-Academy Phase

- The Council constituted of the Founding Trustees, the Executive, and external experts shall be established, alongside the recruitment of senior key Academy staff.
- This Council will be charged with creating and setting in motion the various operating and governance committees and drafting Terms of Reference.
- The initial operating and governance committees will commence their business, and in parallel discussions on the detailed constitution will be undertaken.
- Options for suitable premises to establish the fully-fledged Academy shall be explored along with a plan for a sustainable funding model.
- Initial cohorts of Fellows will be recruited.

2026

Fully-fledged National Academy for the Mathematical Sciences.

Introduction

Making Mathematics Count

26. In his 2017 review of post-16 mathematics, Professor Sir Adrian Smith noted "*there is strong demand for mathematical and quantitative skills in the labour market at all levels and consistent under-supply. The quantitative demands of university courses in both STEM (science, technology, engineering, and mathematics) and non-STEM subjects are increasing and are set to increase further."*[2]

27. Smith further added: *"adults with basic numeracy skills earn higher wages and are more likely to be employed than those who fail to master basic quantitative skills. Higher levels of achievement in mathematics are associated with higher earnings for individuals and higher productivity. Increased productivity is a key determinant of economic growth."*

28. Raising the technical and analytical skills is non-negotiable for UK plc to remain agile and productive in this modern data-driven and connected world.

The Era of Mathematics

29. The increasing recognition of the efficacy, relevance and intrinsic value of mathematical sciences research has led, in recent years, to a variety of initiatives, undertaken both to quantify its value and to offer a number of recommendations; the latter included, in particular, an Independent Review of Knowledge Exchange in the Mathematical Sciences authored by Professor Philip Bond[1].

30. Mathematical sciences research makes a big impact on the economy and jobs; contributing over £200 billion annually to the UK economy in 2010, and it is estimated that that there were over 2.8 million individuals in employment directly due to mathematical sciences research in the UK, a figure that is still rising, with 6.9 million individuals in employment due to the wider ripple effects of mathematical sciences research in the UK[4].

31. *"Mathematical science research generates wealth for society; for every £1 spent on maths research results in £588 worth of economic benefit"*[9].

32. *"The demand for mathematically skilled people is high. Skilled mathematicians of a high calibre are needed, and they are in short supply. […] Demand for mathematical expertise across a wide range of subjects is booming in addition to perennial demand for first-rate mathematical talent from financial markets, developing fields such as AI and machine learning, genomics, autonomous vehicle development, robotics, data science, the digital economy and many others are creating highly paid jobs for appropriately skilled people."*[1]

33. *"New inventions and technologies will need mathematics; the world requires 21st century mathematics to create 21st century technologies, and from smart cities to personalised medicine, new mathematics will lie at the heart of every major innovation."*[1]

What is the added value of an Academy?

34. *"Disembodied, the mathematical science discipline has failed to be recognised nationally for its research excellence, its utility and its transformative power: mathematics underpins a vast array of the immense technological innovations that are shaping our daily lives. As a result, our discipline has not harnessed opportunities that would have a profound effect on research, the wider economy and society as a whole, as well as ensuring its long- term health in the UK."*[10]

35. Unified, there is the ability to do things differently, more coherently. The Academy will consider the whole of a mathematician's career, by drawing on expertise in education, universities and practitioner organisations. With this coverage the Academy can address the issues of the 'leaky pipeline', inclusivity across geographies, background, gender and other ED&I factors.

[9] This analysis has been taken from a letter by Sir Adrian Smith to Professor Philip Nelson, EPSRC CEO, in 2016

[10] http://www.cms.ac.uk/wp/wp-content/uploads/2020/06/The-case-for-a-National-Academy.pdf

36. The existing learned societies and representative bodies fill important roles in their own niches, but often fail collectively to provide a recognisable voice after the fashion of the Royal Academy of Engineering or the Academy of Medical Sciences, for example.

37. The education community is vast, complex and fragmented, the academic community requires coordination to speak with a clear authoritative voice, and the practitioner community lacks a broad-based representative body. The proposed Academy will uniquely provide connectivity and interface mechanisms across the three facets, to realise the potential of a holistic unified discipline for tackling societal, economic and technological challenges and underpinning the drive towards a high-wage high-skill economy.

38. As the Royal Academy of Engineering has shown, it is arguably neither necessary nor desirable to merge existing societies, but substantial benefits accrue from having a single Academy covering education, research and industry, which interacts with government to generate effective policy. This new body would also be better placed to ensure the long-term health of the discipline, broadly interpreted.

39. The work of the BMI helped articulate the various desired activities of an Academy - these are summarised here, and expanded on throughout this Green Paper[11].

- **Advocate for the whole of the mathematical sciences**
- **Develop the mathematical sciences brand**
- **Strengthen and amplify the work of the existing societies**
- **Connect the mathematical science community and add value at the interface**
- **Coordinate discipline-wide and life-long mathematical sciences education**
- **Support mathematicians at all career stages and in all areas of employment**
- **Recognise distinction through conferment of Fellowship**

[11] http://www.cms.ac.uk/wp/wp-content/uploads/2019/11/An-Academy-of-Mathematical-Sciences-Discussion-document-by-the-BMI.pdf

Chapter 1: The Function

The National Academy will have a primary focus on connecting the mathematical sciences community and developing its external interfaces. It will achieve this by operating the functions listed below.

- **Policy Affairs function – concerned with the professionalisation and enhancement of the mathematical science interaction with policy makers and government.**
- **ED&I Affairs function – concerned with driving equality, diversity and inclusion throughout the mathematical sciences.**
- **Practitioner Affairs function – concerned with bringing the community of mathematical scientists across the workforce together.**
- **Educational Affairs function – concerned with enhancing effectiveness of mathematical science education and the life-long learning agenda.**
- **Academic Affairs function – concerned with advocating and supporting all matters related to mathematical sciences within the higher education sector.**

40. There are currently a plethora of active organisations (see Figure *1* for a non-exhaustive list) performing many of the above functions. The Academy does not seek to replace or subsume these, but primarily to coordinate, strengthen and advocate.

41. The functions of the Academy are expanded in the following sections. The gaps in present coverage by key mathematical sciences bodies are identified, and opportunities articulated.

42. Each function will be an area of key concern of the Academy, and shall be served by a committee, chaired by a Vice-President, and appropriate subcommittees. Other standing committees of the Academy shall address internal/operational functions.

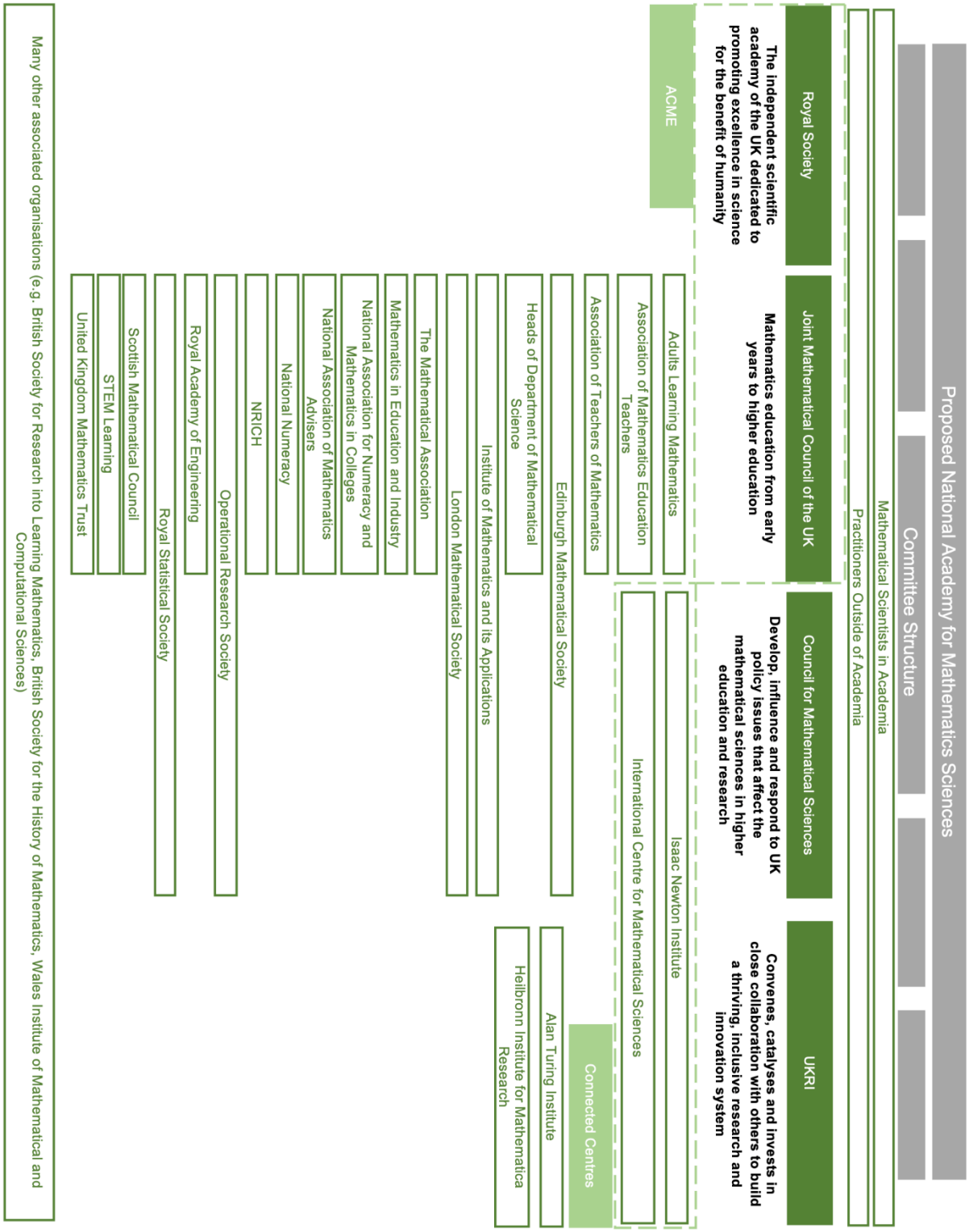


Figure 1. Summary of current mathematical sciences landscape – the landscape is complex, under-resourced, uncoordinated and unconnected.

Policy Unit

Imperative

43. The interface between science and decision makers has never been more important. Seismic changes in the research landscape and agenda, driven by socio-economic trends and disruptions, mean that there is an urgent need for the mathematical sciences to provide scientific leadership in critical policy discussions.

44. Climate change and the Covid-19 pandemic has shown the need for mathematical scientists to engage in policy debates and input meaningfully into the conversation. More widely, this is not done nearly as loudly, or in as coordinated a fashion, across the whole mathematical sciences landscape as it could be.

45. Changes to the educational and research landscape driven by economic and political trends and external shocks need timely, proactive and authoritative input to ensure the prosperity of the mathematical science discipline.

Current situation

46. The Joint Mathematical Council (JMC) has an interface with the Royal Society (via ACME) which provides a strategic policy facing group for the area of mathematics education, and demonstrates the value of such a relationship in its work around data science skills, teacher development and other matters. Note that JMC, and its constituent members, also engage with policy, but typically in a ‘bottom-up‘ fashion.

47. The Council for Mathematical Sciences (CMS) exists to provide an authoritative and objective body to develop, influence and respond to UK policy issues that affect the mathematical sciences in higher education and research.

48. Since its creation in 2001, the CMS has made important contributions to policy discussions around the Research Excellence Framework (REF), Brexit consultations, and EPSRC funding practices amongst others. Policy submissions from the CMS are, however, rare and will only be made if consensus can be reached amongst the constituent societies.

49. Several of the Learned Societies which constitute CMS engage more proactively on policy matters. For example, the Royal Statistical Society (RSS) regularly participates in conversations around data science, national statistics and more recently on the Covid-19 pandemic.

50. The Academy would not seek to, nor wish to, replace or subsume any of these excellent existing policy activities, but rather add to them by coordinating across the breadth of the community, and providing the same level of resource for areas of the mathematical sciences which currently lack a policy voice.

Added value of the Academy

51. The Academy, when constructing its Policy Unit, shall seek input and advice from professionals such as the Campaign for Science and Policy (CSaP). If appropriate, the Unit could act as a 'think tank' which acts as a focal point for a network of other policy professionals and groups.

52. It is recognised that there are three principal functions of the Policy Unit. First is 'maths for policy', i.e. to ensure that mathematical sciences inputs to government policy across all areas, bringing rigorous evidence-based analysis to decision making. Second, 'policy for maths', aims to develop strong policy papers, driven by data, consideration of ED&I, key stakeholders etc., to ensure the health and vitality of the whole mathematical sciences community. Finally, there is a need to create a broad base of 'mathematicians for policy', willing and able to demonstrate the underpinning rationale and arguments for the policy papers.

53. The ability to influence within government circles is driven by having a strong presence in the science policy landscape. An Academy which provides clarity through a recognised and respected voice will help position mathematical sciences at the 'top table' of decision makers, a position currently enjoyed by the Academy of Medical Sciences, the RAEng, the British Academy, and the Royal Society[12].

[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/731507/research-innovation-funding-allocation-2017-2021.pdf

54. The Presidents of the aforementioned Academies sit on the Council for Science and Technology (CST). The CST advises the Prime Minister on science and technology issues across government and is supported by a secretariat in the Government Office for Science[13].

55. With a well-resourced and professional Policy Unit, the Academy will respond rapidly to political trends and shocks which affect the entire mathematical sciences. Additionally, the Academy will proactively lead discussions on policy topics around broader areas which require mathematical sciences input, e.g. AI, Net Zero, quantum computing, circular economy, biodiversity, ethics, etc.

ED&I Affairs

56. Equality, Diversity and Inclusivity will be at the heart of the Academy. The establishment of a new organisation offers a unique opportunity to embed ED&I in all of its processes and decision-making functions from the outset. There are a number of extant groups active in ED&I across the mathematical sciences community, and so it will be desirable for the Academy to seek detailed input from these on an ongoing basis. The Academy will create opportunities to strengthen these voices, and help effect change across the whole of the mathematical sciences landscape.

57. The Academy's ED&I committee will draw its membership from ED&I champions representing its various other committees. This committee will be chaired by the President or a Vice-President.

58. As well as external advocacy on ED&I, the committee will have oversight of and input to all of the Academy's internal affairs; for example, Fellowship selection and

[13] https://www.gov.uk/government/organisations/council-for-science-and-technology Additionally, a strong presence at the recently announced Office for Technology Science Strategy will be necessary to advocate at the highest levels of government https://www.gov.uk/government/news/prime-minister-sets-out-plans-to-realise-and-maximise-the-opportunities-of-scientific-and-technological-breakthroughs

induction, ensuring good practice regarding recruitment onto the Academy's working groups, policy and communications activity etc.

59. An advantage of the Academy will be its ability to gather, monitor and interpret comprehensive data from across the community; it will also provide forums for all voices, from across the different stages of a mathematical sciences career, to be heard, and to provide a holistic set of interventions.

60. The Academy will use the information it gathers to campaign for changes of policy and for novel or enhanced support for individuals and groups seeking to address inequalities of access to education, training and long-term careers.

Practitioner Affairs

Background and imperative

61. The UK has an outstanding record in the application and deployment of mathematical sciences in industry, commerce and government. The Bond Review and the REF2014 Impact Case Stories offer excellent examples of novel and timely applications of the broad subject and indication of the profound impact these have had.

62. In this Green Paper, the term 'practitioner' is used to mean any practicing mathematical scientist or 'user' of mathematics, who is employed outside of an HEI or an educational setting, i.e. in industry, commerce, government, policy, finance, charities, NGOs, SMEs, etc. These practitioners often need to be broad in their scientific interests, and so the current interfaces with learned societies are often too narrow to provide the breadth of scientific input practitioners require.

63. Generating impact requires that mathematical scientists in universities and practitioners outside academia are supported, and that connections between these two groups are facilitated.

64. The UK infrastructure which coordinates the engagement between academia and the various practitioner groups is somewhat fragmented, with pockets of excellence often existing in local regions, in specific institutions, or specialised towards specific areas of the mathematical sciences. Infrastructure serving the broad base includes the Newton Gateway to Mathematics (the knowledge exchange (KE) arm of the Isaac Newton Institute), ICMS, and active groups within several learned societies.

Connectivity across the UK

65. Whilst the latter elements of infrastructure, which connect across and serve the whole UK community, have done a very effective job on historically limited resources, what is lacking is a well-supported and well-organised network to realise the potential of the comprehensive capability of academics and practitioners that already exists across the UK.

66. The existing mathematical sciences infrastructure (INI and ICMS), guided by the community, will help create, and initially support, a scalable and flexible network of mathematical sciences 'Connected Centres'[14], which aims to produce a step change in scale, breadth and quality of national KE activity. It will be open to all from industry and academia, from academics, through KE professionals, to practitioners and policy makers. The Connected Centres Network (CCN) will initially be independent of the Academy, but it is envisaged that it will work closely with/for the Practitioner Affairs function of the fully-fledged Academy and eventually come under its jurisdiction

67. The Connected Centres Network will have a comprehensive schedule of activities, both physical and virtual, a shared technology platform for interaction, and dedicated personnel for curating the Network.

68. Building on existing infrastructure, the Connected Centres Network will also have regional cohesion, which will allow the sharing of good practice, resource and facilities, to reflect geographic strengths and priorities. It will also enable university

[14] A Consultation Paper on a proposed KE Connected Centres Network for the Mathematical Sciences is available at http://www.cms.ac.uk/wp/national-academy/

mathematical sciences departments with limited KE experience, to engage whilst building critical mass and experience.

69. The Connected Centres Network will also facilitate interdisciplinary links to cognate disciplines, and those more distant, and by this means widen the pool of practitioners and areas of industry, commerce etc., that academics can engage with.

Practitioner engagement

70. For the Academy to function well, it will require practitioners to fully engage with its activities; to do this it needs to provide benefits to practitioners beyond those presently offered via their own learned and professional societies.

71. Better practitioner engagement will be accomplished by two assemblies, a 'Practitioner Forum' and a 'Corporate Members and Affiliates Forum'. The former will be curated and managed by the Connected Centres Network, which will bring together those working at the 'coal face' in industry, government, commerce etc., and establish links with training, brokerage, and mobility activities. Fellowship will be offered to Practitioners who make exceptional contributions to the health of the mathematical sciences.

72. Where appropriate, other committees across the Academy will draw on the Practitioner Forum, to provide input to and oversight of the Academy's various other functions.

73. A 'Corporate Members and Affiliates Forum' will be created, aimed at bringing the experience, credibility and wise-counsel of senior (C-level) executives, and leading figures in their sectors, to the Academy. This Forum will be broad-based, with affiliation ranging from smaller organisations such as SMEs, and individuals in senior government departmental positions, through to membership of large corporations. The Corporate Members and Affiliates Forum would serve under the Practitioner Affairs Committee.

74. The Academy would act as an important beacon for corporate bodies in highlighting the mathematical sciences that is undertaken both in the academic world and in other

organisations and sectors, and help advocate for them as places where excellent science is done.

75. This Corporate Members and Affiliates Forum will allow board-level representatives of industrial and governmental organisations to interface with the Academy functions and help steer the Academy's working groups on topics important to the health of the mathematical sciences for the broader practitioner community. Some possible areas are detailed below.

Horizon scanning and emerging trends

76. Keeping on top of research trends and emerging areas in HEIs and education is hard for practitioners. To engage practitioners in such topics, the Academy will create influential, authoritative and insightful thought-piece perspectives drawn from the Fellowship and the Practitioner Forum. These areas could be identified from within the Fellowship or by the Corporate Members and Affiliates.

77. Working with the various Academy functions and Policy Unit, the Corporate Members and Affiliates Forum and the Practitioner Forum will initiate public policy debates on emerging opportunities, trends, threats and other issues. These debates could focus on emerging research, on education and skills, and on application, or on science policy and will draw on the Academy staff, the Fellowship, the Practitioner Forum and others from the community.

Continuing Professional Development (CPD) and skills

78. Areas requiring bespoke training, beyond what is available through existing routes, will be identified and links to trainers will be made with, and for the benefit of, those in the Practitioner Forum. The broader skills and life-long learning agendas will have an interface with the Academy and its various functions, especially Educational Affairs, through the Corporate Members and Affiliates.

79. The Academy will also respond to the needs of decision makers by providing professional support in understanding the effective use of mathematical sciences in regulation and policy.

80. Providing training materials for users, whether they are or are not mathematicians, in important aspects of mathematical sciences would be a useful function of the Academy, especially as it would call on its broad range of expertise. Similarly, equipping mathematicians with the tools needed to convey complex mathematical sciences principles to decision makers will be valuable, whether through communication training, visualisation etc.

ED&I and the People Pipeline

81. There is a real need to understand the landscape of talent from schools, universities and into practice. The Academy will enable an improved overarching picture of the 'people pipeline'; hence it can try to formulate strategies to better balance the workforce and present cogent arguments to government for improved resource. This will obviously link closely to the Educational Affairs function to staunch the 'leaky pipeline', and help widen participation by providing positive practitioner role models and showcasing the science that goes on inside the practitioner communities.

Educational Affairs

Imperative and current state of play

82. Education Affairs is concerned with the approximately 10 million young people who are studying mathematics in over 32,000 UK primary and secondary schools, and who, post-16, then follow mathematical sciences pathways across academic and vocational programmes in schools and around 380 further, and 140 higher, education institutions. This vast education project reflects a number of policy priorities, and approaches vary in the four nations of the UK.

83. Many associated regulatory and professional bodies and interest groups comprise a complex landscape of influence and support for mathematics education. Furthermore, recent changes to the local organisation of schools, in England at least (e.g. Multi Academy Trusts), add many other voices to debates about mathematics education. Professional voices include teachers from early years to HE, support professionals for particular mathematics education needs, teacher educators and mathematics education researchers, curriculum and assessment experts, resource

producers, and so on. The (initial and continuing) education of these professionals is a key building block in any effective education system, and so a key concern of Educational Affairs.

84. Given the scale and complexity of, and regional variations in, mathematics education, there are many influencing voices. Bodies such as the Joint Mathematical Council of the UK (JMC, established in 1963) and the Advisory Committee on Mathematics Education (ACME, established by the Council of the Royal Society in 2002 with the support of the JMC, LMS, RSS, IMA and others) have coordinated traditional member bodies and expertise (see Figure 1). There are, however, many individuals and new organisations that are also influential. The JMC and ACME have similar nested structures which have the potential to funnel representation, expertise and experience. JMC has representatives of observing bodies from the four nations, including from the government departments of education, and from organisations such as Ofsted, Ofqual and the Scottish Qualifications Authority. ACME provides a conduit for the production of a single voice for the mathematical community in mathematics education and offers a trusted vehicle of communication to government.

Coordination and Added Value

85. An effective Educational Affairs function of a new Academy would take seriously the challenge of engaging with the large, diverse community of mathematics educators, teacher educators, education researchers, policymakers, regulators and the like. JMC and ACME have accrued substantial experience and expertise, albeit with different structures and support. JMC's model of trustees/members/observers or ACME's committee/contact groups/community of interest, reflect the need for a multi-scale approach to involvement in mathematical sciences education debate and decision making.

86. Educational Affairs in the new Academy could usefully build on, partner, or perhaps eventually merge with these models, subject to long-term discussions at JMC and the Royal Society. Importantly, the nascent Academy will have to find the resource, and decide on the level of commitment, to this substantial mathematical sciences education focus (in addition to the scientific and professional foci) which would

include the mathematical needs of the range of the population, and the structures and approaches necessary to support and enhance those.

87. A well-designed body coordinating mathematics education offers a forum for exchange of ideas across educational phases and between the four nations. The range of concerns that such a group could have is considerable and being able to be relevant and influential, reactive and proactive, in terms of sector influence and policy advice would be contingent upon resources, support and leadership.

88. The Educational Affairs function will interface with other functions so that the critical importance of broad, deep and effective mathematics education is recognised as underpinning other mathematical sciences goals, and is not just the remit of those interested in mathematics education per se.

89. The Academy would be ideally placed, by a coordinated effort of its educational, academic and practitioner affairs communities, to embed life-long learning in mathematical sciences into the workplace.

Fellowship

90. The proposed Academy model assumes that committees are largely populated by its Fellows, so care will be needed to ensure such Fellows cover all strands of the broad mathematics education landscape. It will also be essential to consider carefully the pros and cons of the ACME and JMC models in this area in designing an effective interface between the Educational Affairs function and the complex mathematical sciences education landscape.

Resource

91. The Educational Affairs Committee could build on the tradition of studies and longstanding influencing work undertaken by the JMC and RS/ACME. This would include reactive work (e.g. consultations), short term studies to influence developments in mathematics education in schools and colleges (e.g. maths in the T levels) and longer-term projects (e.g. improving teacher CPD).

ED&I

92. The Educational Affairs committee would be concerned with all aspects of mathematical engagement and attainment as well as post-16 choices from different groups. ED&I issues also include the appropriateness of qualification for different groups of learners. Two key concerns of the group would be a) pathways to advanced mathematics and the pipeline to undergraduate and postgraduate mathematics, and b) the improvement of mathematical literacy of all.

Policy interface

93. The policy interface between mathematical sciences education and Government ministries in the four respective countries will be strengthened by the Academy. For example, arguing the central role of mathematical sciences education in moving to a high-wage, high skills, high productivity economy, will be far more effective with an Academy offering a clear and unified case, made with representation from industry and academia as well as from educators.

94. The high profile of an Academy, with its Fellowship pool and its greater reach, will 'open doors' for greater contact with Government, civil servants and policy makers.

Academic Affairs

Scope and remit

95. In this document, Academic Affairs refers to all matters pertaining to mathematical sciences within higher education, within the UK and beyond. These include for example:

- Interactions with funders (e.g. Research Councils, government agencies, charities);
- Career structure of academic mathematical scientists;
- The mathematical sciences pipeline, through the structure, content and assessment of undergraduate degrees, postgraduate courses, research degrees, through to all careers with a mathematical sciences component;
- ED&I issues in higher education;

- The funding of academic research and of postgraduate training in mathematical sciences in the UK;
- The assessment of academic research in mathematical sciences in the UK.

Current situation and aims for future

96. Current handling of Academic Affairs within the UK mathematical sciences community is somewhat uncoordinated and disjoint. The learned societies each carry out their own work in the area, with the only formal communication regarding their activities taking place through the Council for Mathematical Science (CMS).

97. A number of factors severely limit the impact of the CMS - it has no secretariat independent of the participating societies, it has no funding apart from the support given by the participating societies, and its constitution requires that it can take a position on an issue only when there is uniform agreement on the matter across the participating societies. Much of the work in the area done by the individual societies is excellent, but its impact is restricted due to the limited reach of the societies beyond their own communities, and vulnerability to the criticism that policy positions are not presented from a united front.

98. Through its Academic Affairs Committee the Academy will interact with external bodies on all academic matters relating to mathematical science. Such bodies include, for example, the UK government and the governments of the devolved nations of the UK, UKRI and the subsidiary Research Councils, universities and the HE funding bodies of England and the devolved nations of the UK.

Policy

99. A well-resourced and authoritative Academy, buttressed by access to a substantial body of relevant current data and to a wide range of experts, will be able to respond rapidly to emerging issues and threats. This will thus greatly increase the impact of the mathematical sciences community on policy, and so will substantially enhance the visibility and influence of the discipline.

100. To succeed in its aims, the Academic Affairs Committee must be both nimble and effective. It will thus require to assemble a substantial set of policy papers and data

sets maintained so as to be currently relevant; and its members will have to collectively possess expertise across all of the mathematical sciences and across various policy areas, with reliable and rapid means of communication.

101. This is not the place for detailed review of all the policy areas listed in Paragraph 95, but for illustrative purposes we briefly review two of these areas.

People pipeline

102. Despite sterling work by the learned societies, many pressing problems afflict the mathematical sciences people pipeline in the UK, which a well-resourced Academy could do much to address, working in cooperation with the learned societies. For example:

- The lack of up to date, comprehensive and easily accessible data, including changes over time, on topics such as inequalities of access, support and funding in relation to gender, race and class.
- The funding and availability of postgraduate taught courses and of postgraduate research degrees, both for continuing students and for those seeking to change career, including issues of geographic availability and ED&I issues as above.
- The gathering of evidence of the changing needs of various sectors of the economy for well-trained people emerging from the above routes, and the use of such evidence to argue for new courses (e.g. of an interdisciplinary nature), and new funding channels.
- Difficulties resulting from the unpredictable and hazardous pipeline from higher degree through postdoctoral posts to permanent academic post, with consequent serious effects on ED&I issues.
- The marketing of the mathematical sciences to prospective learners, and providing routes for learners to find their next steps in their mathematical sciences careers.

ED&I

103. ED&I matters affect the people pipeline for those passing through HE. However, these issues also permeate the pipeline before and after HE. Thus, the Academy will

gather and monitor comprehensive and continuous data as needed on the drain of mathematical sciences talent at each stage of the path through education to career.

104. The Academy will use this information to campaign for changes of policy (in research grant applications for example) and for increased support for individuals and groups seeking to address inequalities of access to education, training and careers.

105. A visible, authoritative Academy will develop role models to champion and campaign for ED&I in the various environments in which mathematical sciences has a significant presence in the UK.

Relationships with UK learned societies and other organisations

106. The UK is fortunate in having strong representation of its academic community by five excellent membership societies, namely Edinburgh Mathematical Society (EMS), Institute of Mathematics and Its Applications (IMA), London Mathematical Society (LMS), Operational Research Society (ORS) and Royal Statistical Society (RSS). The Academy must maintain excellent lines of communication with these learned societies, both via its Academic Affairs Committee and by other routes. Indeed, there will be a need not only to communicate but to collaborate on matters of mutual interest.

107. Similarly, networks of communication should be developed and maintained between the Academy and the UK mathematical sciences research infrastructure, specifically with ICMS and the INI, and with ATI, CMI and HIMR. Indeed, long-term, there is a strong role for the Academy in better connecting INI and ICMS to the community, through a direct link within the Academic Affairs Committee.

108. In a similar vein, communication and collaboration channels will be developed with cognate societies, such as the Institute of Physics (IOP) and Royal Society of Chemistry (RSC). Moreover, in due course it is anticipated that the Academy will develop close and effective relations with our sister societies in other countries.

109. The UK learned societies in the mathematical sciences are all currently engaged in the activities listed in Paragraph 94, and it is certainly not the purpose of the

Academy to replace their vital contributions. Rather, the Academic Affairs Committee will seek to unify and coordinate this work, currently scattered across the different parts of the community, and thereby amplify its influence on policy. It will achieve this by providing a clear and easily accessed source of data, information and examples on the scale and importance of the contribution the mathematical sciences make, coupled with robust arguments explaining how this contribution can and should be increased.

110. It is proposed that the present forum for interchange between the learned societies, the Council for Mathematical Sciences (CMS), will cease to exist once the Academy is fully operational, since its activities will have been absorbed fully into those of the Academy.

111. As the Academy develops, it can increasingly play a broad coordinating, communicating and connecting role between the many other organisations serving the mathematical sciences academic community. To give just one such example, the Academy can foster interaction between the Committee of Heads of Departments of Mathematical Sciences (HoDoMS), and the activities undertaken at INI, ICMS, ATI, CMI and HIMR.

Chapter 2: The Form

It is proposed that the national Academy achieves its stated aims and objectives by operating the following operational functions. Some of these will be performed by committees, others undertaken by core staff employed by the Academy.

- **Governance**
- **Fellowships**
- **Finance and Operations**

High-level structure of the Academy

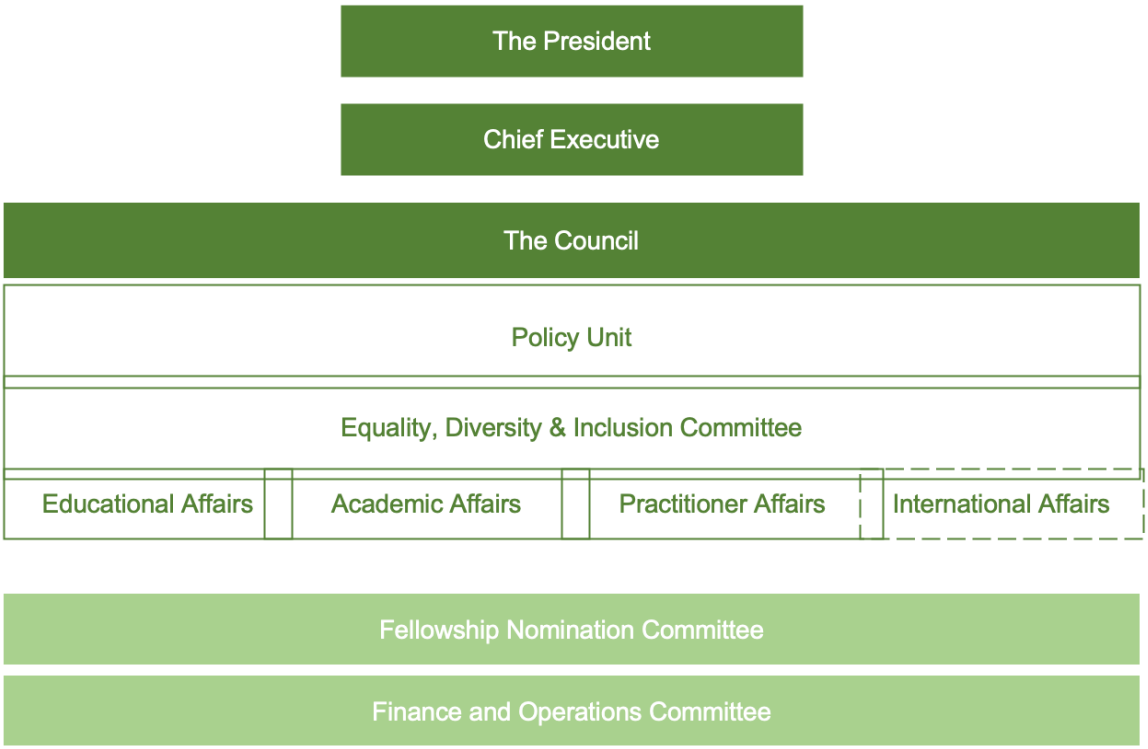


Figure 2. Proposed structure for the National Academy. The functions are detailed below.

Governance

112. Every other STEM discipline in the UK has its own version of an academy and its effective voice. Each has its own governance, specific to the needs and traditions of

its discipline. A National Academy for Mathematical Sciences might follow a similar model to the Royal Academy of Engineering, which coexists very effectively within a community of strong, highly successful and diverse engineering societies and institutions.

113. There would be a strong but small and effective governing Council and, in due course, a high-level professional secretariat.[5]

114. The governance and structure of the academy could operate under the following suggested form and principles[15]

a. The President and seven Vice-Presidents (VPs) would be elected by, and from within, the Fellowship on four-year terms (non-renewable in the case of the President).
b. A Chief Executive Officer (CEO) would be appointed to lead the staff in its support of the aims and vision of the Academy.
c. The day-to-day running of the Academy would be managed by a small Executive, consisting of the President, CEO, other senior members of staff such as Finance and Policy Directors, and key VPs.
d. The Council (13-15 members, including the President, the VPs, an independent Chair and external experts) would be the Trustees.
e. At least three Council members, not necessarily Fellows, would be chosen to ensure that the Council includes the full range of expertise necessary for good governance, including charitable law, finance and operations.
f. The Council would elect its Chair, who would usually be from outside of the Academy, to ensure independence, and selected for their standing and expertise.
g. The Executive would report to Council, and be guided by them on direction and strategy.
h. Key committees, shown in Figure 2 and detailed below, would report directly to the Council, with further subcommittees formed under these.

[15] http://www.cms.ac.uk/wp/wp-content/uploads/2020/06/Governance-and-structure.pdf

115. The relationship of the Academy with existing societies should be considered carefully. Clear guidance for where it is appropriate for the Academy to defer to an existing society and vice versa should be articulated, and agreed, in the consultation and set-up phases.

116. The Council has ultimate authority on Academy business, below which sit a range of committees. Each committee would have a VP whose roles have been partially detailed in previous chapters. These committees, shown schematically in Figure 2, are listed below for convenience[16].

- Policy Unit – concerned with improving interactions between policy makers and the mathematical sciences community by connecting experts in mathematical sciences with policy makers and advocating for the mathematical sciences within government. The Policy Unit will also lead on public engagement demonstrating the importance of the mathematical sciences to society.
- ED&I – concerned with the inclusive, diverse and equitable function of all aspects of the mathematical sciences.
- Practitioner Affairs – concerned principally with the community of mathematical scientists who sit outside HEIs and educational establishments, i.e. practitioners.
- Educational Affairs – concerned with primary, secondary, further and higher education, as well as life-long learning and the people pipeline.
- Academic affairs – concerned with all matters associated with university research, teaching and promotion of mathematical sciences.
- Fellowship Nomination Committee - concerned with the coordination of the various sectional nomination subcommittees to produce long-term a balanced and effective Fellowship.
- Finance and Operations Committee - concerned with the effecting running of the Academy to realise its aims and objectives.

[16] An International Affairs committee may well be an early priority beyond the basic structure outlined here. Before its creation, however, international relations will be managed by one or more of the other committees (e.g. Academic Affairs and Policy).

Fellowships

117. Fellowship will be offered to those who are recognised for major contributions which, either directly or indirectly, progress **the health of UK mathematical sciences.** The Fellowship Nomination Committee will advise on the best mechanisms and measures to use for the selection process.

118. Fellowship will be conferred by distinction to anyone across the breadth of the Academy's functions, whether in education, research or practitioner communities. Parity between the achievements in teaching, academia and in industry/government is a key concept of Fellowship of the Academy.

119. No matter how eminent, Fellows (wherever resident) would be expected to make an explicit commitment to support mathematical sciences in the UK, and recognise the enabling importance of ED&I. Acceptance of Fellowship must be seen as a duty rather than an award, and an agreement to contribute to the Academy's aims.

120. Fellows will represent the Academy and constitute the various committees that will draw together disparate activity across the UK. They will support the election of new Fellows and will also be called on to provide policy advice if requested by the Policy Unit.

121. The selection process for the initial elections of Fellows will be critical to the long-term Academy objectives of quality, plurality and vitality. If the initial cohorts of Fellows are not representative of the desired long-term structure and mix of the academy, then there will be difficulty in its long-term ability to function. As discussed in the Roadmap, the proto-Academy will have some three years to ensure that the Fellowship process is successful, and pays full and careful consideration of ED&I.

122. Fellows will be conferred with post-nominals to reflect the final name of the Academy, such as FAMS or FRAMS. The name is a secondary concern for present discussions, but will be considered by community response at the start up and/or proto-Academy phases.

Finance and Operations

123. It is anticipated that funding support would be sought from both government and philanthropy. Fellowship fees would provide a modest but vital element of core funding, with rates in line with the other national academies.

124. In its nascent and proto-Academy phases, the National Academy would require significantly less funding and could begin with the support of other mathematical sciences infrastructure in the UK, such as the use of ICMS and INI facilities and INI secretariat.[17]

125. In a fully-fledged state it is envisaged that in the region of £5 million per year would be required to fund a suitable professional secretariat and headquarters, as well as the various activities of a national Academy all of which would be focused on the Academy's mission. In time, the success of the Academy would bring increased funding opportunities to the discipline as a whole.

126. Stability is important, combining long-term predictable grants and programme support from a range of sources. Funding for specific activities might include targeting knowledge exchange and education, as well as policy work to raise the standing of mathematical sciences. Over time, the Academy might aim to build an endowment to secure more independent income.

127. The operations function would support the Academy achieving its mission, and includes staffing, finance, budgeting, annual reporting and accounts.

128. A CEO would have day-to-day responsibility for all operational, HR and financial matters in partnership with the VP of Finance and Operations.

- The professional staff envisaged to be required would include the following:

[17] http://www.cms.ac.uk/wp/wp-content/uploads/2020/06/The-case-for-a-National-Academy.pdf

- A small team managed by the CEO to evolve the Academy's funding and all activities;
- staff to support Council and committee meetings, the Fellowship election process, and all of the Academy's operating committees;
- a small team of policy professionals, including a senior Director of Policy, to provide professional support for the Policy Unit.

- To achieve the Academy's aims, an active communications team will be vital.
- Legal and finance support will be important as the Academy model develops.

129. The Academy might take the opportunity to design its operations in a more virtual and dispersed fashion than has been characteristic of older academies.

130. The Academy would almost certainly need capacity for the Executive, Council and members of the Fellowship to meet regularly, including with external partners such as businesses, government, regulators, academia, and benefactors. As such, suitable short-term and long-term premises for the Academy will be explored during the initial phases.

Chapter 3: The Roadmap

Whilst the intention is to work towards a fully-fledged Academy within 5 years from early 2022, with an expected turnover of £5 million per year, a three-step approach is proposed. In the initial set-up phase during 2022, modest support from INI and ICMS will help incubate the basic functions:

1. **A small number of appointments will be made - a CEO, Founding President, and number of policy professionals.**
2. **A small group of Founding Trustees will be appointed, with a time limited mandate.**
3. **Discussions with Government and philanthropists shall continue.**

In the second 'proto-Academy' phase (2023 – 2025/6), establishment of further governance and operating structures will be undertaken, as well as initiation of specific activities and operations:

4. **The Council constituted of the Founding Trustees, the Executive, and external experts shall be established.**
5. **This Council will be charged with drafting Terms of Reference and commencing the various committees.**
6. **The initial committees (Policy, Finance etc) will form, alongside the recruitment of other senior key Academy staff.**
7. **Discussions on, and drafting of, the Constitution will be undertaken.**
8. **Discussions will take place about bringing the function of the Council for Mathematical Sciences into the Academy, and developing the desired long-term relationship with ACME and JMC.**
9. **Premises to establish the fully-fledged Academy shall be sought, along with a plan for a sustainable funding model.**
10. **Initial Fellows will be recruited.**

The fully-fledged Academy will begin operation under its own steam by the end of 2026. Additional operating and governance structures will form, or be integrated from outside, as the model develops.

Background

131. The Isaac Newton Institute for Mathematical Sciences (INI) and International Centre for Mathematical Sciences (ICMS) collectively form the national research infrastructure for the whole of the UK Mathematical Sciences and are funded from a variety of sources, principally UKRI. INI might be in a position to provide some underpinning administrative and advisory support for the set-up and proto-Academy phases and, with ICMS, offer suitable venues for Council and other small meetings, and for workshops and conferences.

132. Whilst the intention is to work towards a fully-fledged Academy by the end of 2026 with an expected operating cost of £5 million per year, a realisable three-step approach, which can initiate early activities, is proposed. These are: set-up phase (2022); proto-Academy phase (2023-2025/6); full-scale National Academy (2026).

133. It is anticipated that the fully-fledged Academy will begin independent operation by the end of 2026. However, its final form, adding in additional operating and governance structures as other extant committees and bodies within the mathematical sciences converge with those of the Academy, and can thence be brought under its jurisdiction, will likely not emerge until 2030 or so.

Set-up phase

134. The initial key step in the set-up phase will be to establish a Founding President and a small group of time-limited Founding Trustees, who will open lines of communication with the key stakeholder organisations, create a detailed early phase roadmap, and initiate discussions with government, research councils and philanthropists to cover the short-term running costs of the proto-Academy, estimated at some £1m over three years.

135. The team will work out the priority functions of the proto-Academy informed closely by the broad community (e.g. to include all mathematicians in academia, industry, commerce, primary, secondary and tertiary education) via: CMS and the learned

societies; ACME and JMC; professional affairs committees and business forums etc; and any other representative bodies (e.g. HoDoMS).

136. Early stage funding will allow the appointment of a Chief Executive Office and number of policy professionals.

137. Administrative support will be provided by INI, to a level to be decided as appropriate. As advised, INI and ICMS will help organise, and provide in-house space for, meetings of working parties/scoping workshops/town meetings etc.

138. INI and ICMS could cover ancillary costs such as travel for the core academic group at (small) scoping meetings etc., and essential overnight accommodation. Prior to the above staff appointments, INI and ICMS will undertake limited research projects, as capacity allows, for those charged with developing early position or advisory papers, such as creating the detailed Academy roadmap, defining the proto-Academy's *modus operandi*, and setting in train elements such as the Constitution and Charter.

139. The Institutes will advertise the progress of this phase through social and traditional media, and through their usual networks of communication.

140. The proposed structure at the end of the set-up phase can be seen in Figure 3.

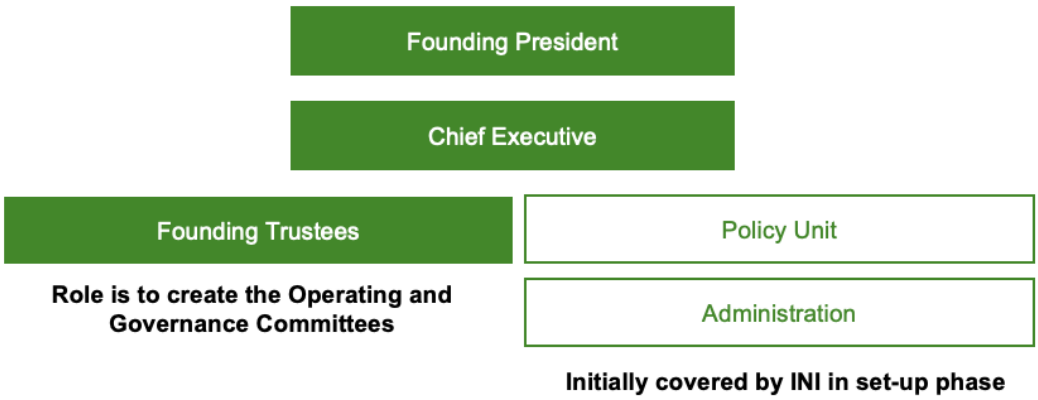


Figure 3. Possible set-up phase concluding structure.

Proto-Academy

141. This phase will see the Academy opening, with an active Policy Unit and a small Executive and Council. In its early years, as it creates its constitution and elects new Fellows to serve on its various committees, it will continue to: look at good practice elsewhere; decide on the international role of a National Academy; specify the precise shape and priorities of the fully-fledged National Academy; see through the adoption of its Charter and Terms of Reference; seek options for headquarters location; and look for sources of long-term funds.

142. Once the Academy opens for business, albeit in limited (proto-Academy) roles, the duties/commitment of INI and ICMS will start to diminish. The Academy will obtain funding so that it can increasingly provide its own resources and administrative support. The Institutes would still provide space and organisational support for meetings in Cambridge, Edinburgh or elsewhere, as required.

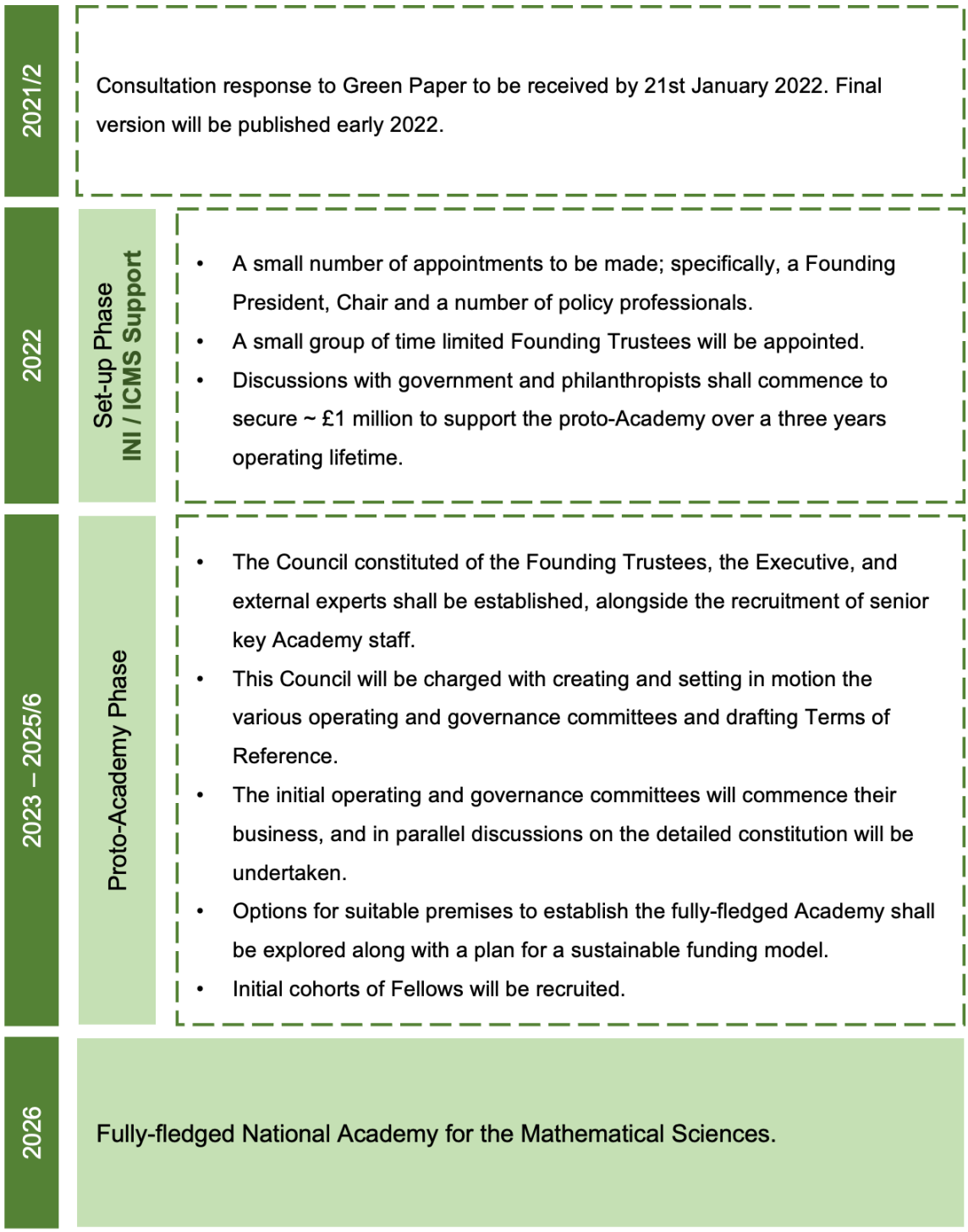
143. An aspiration for the Academy is that its primary funding will be provided from Government in the same manner as the other National Academies. For information, during 2020 to 2021, the Royal Society, Royal Academy of Engineering, British Academy and Academy of Medical Sciences received a combined £230 million from the Department for Business, Energy and Industrial Strategy (BEIS).

144. In summary, the proto-Academy phase (2023 - 2025/6) will see the Academy from being led initially by a small appointed, and time-limited, team through to a fully functioning entity with a strong Council of Fellows and a clear set of functions and mandate. The summary steps to achieve this are as follows.

- The Council constituted of the Founding Trustees, the Executive, and external experts shall be established, alongside the recruitment of senior key Academy staff.
- This Council will be charged with creating and setting in motion the various committees and drafting Terms of Reference.
- The first cohorts of Fellows will be recruited.

- The initial committees will commence their business, and in parallel discussions on the detailed constitution will be undertaken.
- These constitutional discussions will include the long-term relationship between the Academy and extant mathematical sciences organisations, such as the CMS, the learned societies, HoDoMS, JMC and ACME / RS, and ATI, CMI, HIMR, INI, ICMS etc.
- Options for suitable premises to establish the fully-fledged Academy, including staffing post-incubation, shall be explored, along with a plan for a sustainable funding model.

Timeline


2021/2
Consultation response to Green Paper to be received by 21st January 2022. Final version will be published early 2022.
2022
Set-up Phase
INI / ICMS Support
• A small number of appointments to be made; specifically, a Founding President, Chair and a number of policy professionals.
• A small group of time limited Founding Trustees will be appointed.
• Discussions with government and philanthropists shall commence to secure ~ £1 million to support the proto-Academy over a three years operating lifetime.
2023 – 2025/6
Proto-Academy Phase
• The Council constituted of the Founding Trustees, the Executive, and external experts shall be established, alongside the recruitment of senior key Academy staff.
• This Council will be charged with creating and setting in motion the various operating and governance committees and drafting Terms of Reference.
• The initial operating and governance committees will commence their business, and in parallel discussions on the detailed constitution will be undertaken.
• Options for suitable premises to establish the fully-fledged Academy shall be explored along with a plan for a sustainable funding model.
• Initial cohorts of Fellows will be recruited.
2026
Fully-fledged National Academy for the Mathematical Sciences.

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Consultation

We are grateful for valuable discussions with representatives from the following organisations, and other interested parties:

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Institute of Mathematics and its Applications
London Mathematical Society
Ministry of Defence
Mondelez International
Morrison Supermarket
National Centre for Universities and Business
National Physical Laboratory
PepsiCo
Royal Society
Royal Statistical Society
Smith Institute
Syngenta
The British Academy
The International Centre for Mathematical Sciences
The Joint Mathematical Council of the UK
The Operational Research Society
Unilever
University College London
University of Bristol
University of Edinburgh
University of Nottingham
University of Oxford

Annex 2. Acronyms

ACME	Advisory Committee on Mathematics Education
ATI	Alan Turing Institute
BA	British Academy
BEIS	Department for Business, Energy and Industrial Strategy
BMI	Big Maths Initiative
CMI	Clay Mathematics Institute
CMS	Council for Mathematical Sciences
CST	Council for Science and Technology
CPD	Continuing Professional Development
DfE	Department for Education
ED&I	Equality, Diversity & Inclusion
EMS	Edinburgh Mathematical Society
EPSRC	Engineering and Physical Sciences Research Council
GVA	Gross Value Added
HE	Higher Education
HEI	Higher Education Institutes
HoDoMS	Heads of Departments of Mathematical Sciences
HIMR	Heilbronn Institute for Mathematical Researcj
ICMS	International Centre for Mathematical Sciences
IMA	Institute for Mathematics and its Applications
INI	Isaac Newton Institute for Mathematical Sciences
JMC	Joint Mathematical Council
KE	Knowledge Exchange
KTN	Knowledge Transfer Network
LMS	London Mathematical Society
NCETM	National Centre for Excellence in the Teaching of Mathematics
ORS	Operational Research Society
RAEng	Royal Academy of Engineering
RS	Royal Society
RSS	Royal Statistical Society
STEM	Science, Technology, Engineering and Mathematics
UKRI	UK Research & Innovation

Annex 3: Historical Timeline