**Submission**

# 2016 National Research Infrastructure Roadmap
# Capability Issues Paper

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Question 1: Are there other capability areas that should be considered?

There is a wide and deep mathematical sciences capability gap. It is the "at scale", flexible engagement of mathematical sciences researchers with our innovation system in the age of data and computation. Reliance on the mathematical and statistical capacity of end users in the Science and Research Priority areas, government agencies and in Australian businesses is inadequate to the task of dealing with the major mathematical challenges of disruptive technologies and those that come with new and emerging areas of science.

AMSI believes that mathematical sciences capability needs the support of NCRIS infrastructure. In particular, we contend that this direct engagement with the mathematical sciences needs to be an explicit capability in NCRIS. We will elaborate on this point throughout our response. Appendix A contains AMSI's argued case *"The capability gap and how to address it: NCRIS Mathematical Sciences Centre"* along with examples of major scientific breakthroughs delivered by mathematical collaborations and international examples of the sorts of infrastructure we have in mind.

The discipline's 2016 Decadal Plan, "The Mathematical Sciences in Australian: Vision for 2025", identified the need to (urgently) establish a national research centre to facilitate connections between researchers at both a domestic and international level and between researchers and industry. The discipline has actively worked toward filling this gap through AMSI's research and research training programs along with ACEMS, CEED and MASCOS Centres of Excellence, the Mathematics and Statistics Industry Study Group and the ATN's Industrial Doctoral Training Centre. However, the pervasiveness and critical importance of mathematical sciences to Australia's future requires national recognition of this fundamental research capability and its support through NCRIS.

AMSI endorses the new MATRIX initiative led by Monash and Melbourne as a promising and important step in establishing vital new infrastructure in the form of a venue for residential research programs that exists in most OECD countries. Supported through NCRIS it will become a long lasting national asset of benefit to the discipline, significantly enhancing Australia's capability for international and industry collaboration in the mathematical sciences.

Question 2: Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure.

We agree that these characteristics are appropriate and the mathematical sciences are in a good position to deliver an effective governance structure for research infrastructure through AMSI, its national peak body.

Question 3: Should national research infrastructure investment assist with access to international facilities?

Yes, investment should assist with access especially through the engagement with Australian infrastructure facilities. In other words, by supporting direct facility to facility engagement. For example, shared programs and exchange of expert personnel would bring considerable benefit to mathematical sciences infrastructure and hence to research. Rapid adoption of research outcomes will also be facilitated.

Question 4: What are the conditions or scenarios where access to international facilities should be prioritised over developing national facilities?

For the mathematical sciences access to international facilities should not be prioritised over national facilities because this undermines the critical need to raise domestic collaborations and capability.

Question 5: Should research workforce skills be considered a research infrastructure issue?

Yes. The need for mathematical and statistical sophistication and an ability to deal with models and interpret data and other outputs is becoming a key skill for researchers in a range of fields. This needs to be linked to “mathematics” in the capacity area “Advanced Physics, Chemistry, Mathematics and Materials” in the same manner as which “data” – interpreted from a user prospective – in other capacity areas is linked to “data” in the capacity area “Data for Research and Discoverability”. Also see our response to Question 6.

Question 6: How can national research infrastructure assist in training and skills development?

PhD training should continue to take place under the auspices of the universities but there is significant benefit to be had in PhD students undertaking (optional) .internships at research infrastructure facilities. Similarly, industry doctoral training students can naturally be employed as research support staff. We mention both AMSI Intern and the ATN’s Industrial Doctoral training Centre in this regard.

Question 7: What responsibility should research institutions have in supporting the development of infrastructure ready researchers and technical specialists?

See the response to Question 6 above.

Question 8: What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?

AMSI endorses the current arrangements as they apply at NCI for example.

Question 9: What should the criteria and funding arrangements for defunding or decommissioning look like?

AMSI agrees with the general position in the Issues paper but has no comments on the specifics.

Question 10: What financing models should the Government consider to support investment in national research infrastructure?

The mathematical sciences infrastructure we are envisaging would raise some funds from industry collaboration. Potential host universities would make a cost contributions and AMSI would contribute. From these sources we would expect to co-fund up to 50%.

Question 11: When should capabilities be expected to address standard and accreditation requirements?

We would expect mathematical sciences products to meet international standards for mathematical and statistical software. Naturally ethics standards would also be met by all supported research collaborations.

Question 12: Are there international or global models that represent best practice for national research infrastructure that could be considered?

There are many diverse examples of best practice in mathematical sciences research engagement to be found around the world. We have identified many in the argued case *"The capability gap and how to address it: NCRIS Mathematical Sciences Centre"* in Appendix A.

Best practice in the provision of research institute infrastructure includes the Banff International Research Station, Mathematisches Forschungsinstitut Oberwolfach and the Newton Institute. We refer the reader to Appendix B of the 2016 Decadal Plan, "The Mathematical Sciences in Australian: Vision for 2025".

Question 13: In considering whole of life investment including decommissioning or defunding for national research infrastructure are there examples domestic or international that should be examined?

No comment.

Question 14: Are there alternative financing options, including international models that the Government could consider to support investment in national research infrastructure?

See our response to Question 10.

**Health and Medical Sciences**

Question 15: Are the identified emerging directions and research infrastructure capabilities for Health and Medical Sciences right? Are there any missing or additional needed?

Question 16: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 17: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Health and Medical Sciences capability area?

The mathematical and statistical needs of the Health and Medical Sciences must be explicitly assessed, especially in ensuring the agile response of this area to disruptive medical technologies. Active, structural collaborations with statisticians and mathematicians are a sound means of mitigating future shock in this respect.

**Environment and Natural Resource Management**

Question 18: Are the identified emerging directions and research infrastructure capabilities for Environment and Natural Resource Management right? Are there any missing or additional needed?

Question 19: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 20: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Environment and Natural Resource Management capability area?

The mathematical and statistical needs of the Environment and Natural Resource Management are significant from biosecurity to tsunami modelling. It is our strong view that new infrastructure to support mathematical collaborations with end users in these domains will have immediate and long lasting benefit.

**Advanced Physics, Chemistry, Mathematics and Materials**

Question 21: Are the identified emerging directions and research infrastructure capabilities for Advanced Physics, Chemistry, Mathematics and Materials right? Are there any missing or additional needed?

Yes, the omission of mathematics in this section and in the whole issues paper is stark. It is our strong view that the mathematical sciences are a fundamental capability both in their own right and as part of the Underpinning Research Infrastructure. The NCRIS Roadmap must ensure the provision of mathematical sciences capability across the entire NCRIS enterprise if for no other reason than to mitigate the risk of failure in areas such as national security and public health.

The text on p.12 of the Issues paper reads:

*"In framing the capability focus areas a number of common themes have emerged. As a result some themes will appear under more than one capability focus area. This reflects the pervasive nature of national research infrastructure capability across the research landscape.*

*As you might expect, data is everywhere and dealt with from both a user perspective within the capability areas and as an enabling national infrastructure itself in Chapter 11 – Data for Research and Discoverability."*

Mathematical and statistical modelling and analysis could and should be considered in the same light.

Indeed there should be many more ticks in the row *"Advanced Physics, Chemistry, Mathematics and Materials"* of the table on page 56 of the Issues paper. The study *"The importance of advanced physical and mathematical sciences to the Australian economy"* commissioned by the AAS and OCS paints a very different picture of the importance and pervasiveness of the mathematical sciences. An excerpt has been included in the appendices.

AMSI urges the appointment of a mathematical scientist to the capability expert group for Advanced Physics, Chemistry, Mathematics and Materials.

Under this specific capability heading we endorse the Decadal Plan's call for a national research centre in the mathematical sciences (in this context "centre" does not mean a single physical facility but rather a distributed one). There are two clear prospective NCRIS components to this, one being the need for an Australian research station with an international outlook. In this respect AMSI endorses the MATRIX initiative established by Monash and Melbourne universities which is described in Appendix G. AMSI is actively engaging with MATRIX in the delivery of its programs and it has clearly achieved proof of concept.

The second NCRIS component of this national research centre is the infrastructure facility to support mathematical engagement which proposed by AMSI in Question 1 and described in *"The capability gap and how to address it: NCRIS Mathematical Sciences Centre"* in the appendix. This facility will be a key driver of new mathematics and of the industry-research outcomes looked for in NISA.

Question 22: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

The mathematical sciences are intrinsically international and most university mathematicians have international collaborators. As a result there are many multinational programs occurring at any one time. However, the absence of significant infrastructure means that we have not been able to lead or even participate in international engagement as effectively as many of our neighbours. In particular, institute to institute engagement is limited.

Question 23: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Advanced Physics, Chemistry, Mathematics and Materials capability area?

See the response at Question 21.

**Understanding Cultures and Communities**

Question 24: Are the identified emerging directions and research infrastructure capabilities for Understanding Cultures and Communities right? Are there any missing or additional needed?

Question 25: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 26: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Understanding Cultures and Communities capability area?

While there is clearly embedded quantitative capacity in this domain the data and eResearch demands of this capability will be significantly enhanced by collaborations with statisticians and optimisers supported by the infrastructure we are proposing.

**National Security**

Question 27: Are the identified emerging directions and research infrastructure capabilities for National Security right? Are there any missing or additional needed?

Question 28: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 29: Is there anything else that needs to be included or considered in the 2016 Roadmap for the National Security capability area?

Australia's National Security capability is heavily dependent on the mathematical sciences and the installation of infrastructure designed to support collaborations with mathematicians and statisticians is of strategic importance.

**Underpinning Research Infrastructure**

Question 30: Are the identified emerging directions and research infrastructure capabilities for Underpinning Research Infrastructure right? Are there any missing or additional needed?

What is missing is a platform to support the mathematical sciences collaborations so important across almost all of the research enterprise. This is a blind spot in the issues paper. Statistics, simulation and computation are pervasive in the Roadmap but the capability to keep them current and effective is missing. For this reason we propose adding this capability to the Underpinning Research Infrastructure.

The government has made industry-research collaboration a cornerstone of NISA. What we propose is an innovative infrastructure platform which will bring these collaborations to scale in a responsive and flexible way. It will provide a mechanism for rapid adoption of mathematical innovation developing here and internationally. Without it we will continue with patchy uptake of offshore developments and not at the leading edge needed for our own national priorities.

We develop this proposal in the argued case *"The capability gap and how to address it: NCRIS Mathematical Sciences Centre"* in Appendix A.

Question 31: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 32: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Underpinning Research Infrastructure capability area?

See our response to Question 30.

**Data for Research and Discoverability**

Question 33 Are the identified emerging directions and research infrastructure capabilities for Data for Research and Discoverability right? Are there any missing or additional needed?

Question 34: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 35: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Data for Research and Discoverability capability area?

Statistical and optimisation capabilities are central to Australia's strategic data resources. It is surprising that this centrality is not more clearly identified in the Roadmap. Data acquisition, storage, management and analysis requires a collaboration of disciplines so that the very latest tools are available on every side. As we have pointed out elsewhere siloing is the enemy of progress and active engagement with the mathematical sciences must be a structural part of the infrastructure provision in this area. For this reason we urge the inclusion of infrastructure supporting mathematical sciences engagement as Underpinning Research Infrastructure.

**Other comments**

If you believe that there are issues not addressed in this Issues Paper or the associated questions, please provide your comments under this heading noting the overall 20 page limit of submissions.

See our appendices