Submission
2016 National Research Infrastructure Roadmap
Capability Issues Paper

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Introduction

The Australian Earth Observation Community Coordination Group (AEOCCG) is a forum for all people who collect and use earth observation (EO) data in Australia including industry, academia, and government. More details about the AEOCCG are available at: www.aeoccg.org.au

Our submission has been prepared based on consultation with our community (through an anonymous survey), as well as preparatory material for the "Australian Earth Observation Community Plan" due for release in November 2016. Thus the submission represents reasonable requirements for the Australian research, government, industry and private sectors that collect, use and produce data and information products from EO systems, which include airborne and satellite sensors. Given the nature of EO, most of our comments relate to the Environment and Natural Resource Management capability, with additional comments of relevance to National Security and Underpinning Infrastructure.

Through this submission we highlight the key requirements for the EO community, which include:

- Effective coordination of the nation's earth observation activities. Existing investment through NCRIS (mainly via TERN and IMOS) has enhanced coordination and collaboration, but more must be done in future to ensure we make full potential of EO to deliver benefits for research, industry, and society;
- Improving Australia's access to numerous international EO data streams by committing long-term to the infrastructure that underpins our reciprocal obligations and ensures this data can be made useful for Australian contexts (notably calibration and validation activities), and also expanding investment to ensure Australia has ongoing access to and influence on international EO activities; and
- Ensuring appropriate data infrastructure is accessible to the whole EO community to manage, analyse, and interpret EO data (which is often TB or PB in size).

Australia has significant world leading expertise in developing and applying earth-observation and analytics to a wide range of fundamental environmental sciences, state and national government monitoring activities, and emerging private industries. However, these areas have lacked a consistent and effective coordination to develop effective public-private partnerships to serve

Australia's critical infrastructure dependencies on earth-observation analytics[1]. Government activities at all levels from local to state and national, as well as large numbers of private industry activities, are at significant risk as they are completely dependent on multiple data streams from foreign satellite data providers. Addressing this risk requires multiple actions, which cannot just be building one satellite alone. Our ability to initiate and maintain SME's that can work effectively with government and research infrastructure to build a robust and sustainable supply of EO data is compromised and not progressing at the rate of other similar and less developed countries.

Australia requires a more effectively coordinated national earth observation and analytics capability that works across all sectors of the environment - atmospheric, terrestrial, coastal, marine - and includes urban and production landscapes (agriculture, horticulture, and pastoral). It is not possible for one agency (e.g. Geoscience Australia or the Bureau of Meteorology) to do this alone due to the multiple levels of activity across government, industry and research, and the multiple kinds of data needed - rather it needs a program that spans all of these. This is also not a call for a single satellite for Australia, but for a longer term strategic view that enables us to co-invest with other space-agencies, possibly develop an EO satellite for Australian-specific critical needs (geostationary, high spatial and spectral resolution), and also enable more agile industry-lead solutions such as Cubesats. National infrastructure investment can support this by providing critical infrastructure for R&D across industry and academia such as 'sandpits' and incubator programs, access to data (through international agreements), access to ground station capacity, and sustained calibration and validation infrastructure suitable to support a diverse range of application areas.

A national earth-observation and analytics capability, when coupled with the relevant EO strategic plans currently in development (2026 AEOCP – to be launched in Nov 2016, 2026 Spatial Industry Transformation and Growth Agenda – to be launched January 2017, https://2026agenda.com/) will build on the country's significant past investments in research infrastructure, and enable development of significant private-public partnerships flowing from use of the coordinated research infrastructure capabilities.

This proposed approach builds on the work of TERN, the NCI, IMOS, key Commonwealth and State agencies and others, which has established the basis for a bright future for EO in Australia, particularly through receiving-facilities, data-streams, base-data and networks of trained personnel. Further development, coordination, and application of these activities can provide essential ecosystem, monitoring and forecasting capabilities for Australia (see also the Ecosystem Science Council of Australia (Prof. G.Wardle) submission to this consultation).

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

We have observed that the current governance for many infrastructure capabilities is too siloed and runs counter to the collaborative intent of NCRIS. One of the main reasons NCRIS has had success is because it formed effective collaborations and enabled coordination from state to national levels across Australia. NCRIS environmental facilities enable groups to work across jurisdictional,

[1] See publications available at: http://www.aeoccg.org.au/assessments-studies-plans/
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institutional and disciplinary boundaries to produce new science, approaches and capability across Australia. Within EO, this is particularly obvious through the TERN AusCover initiative (www.auscover.org.au). This collaborative model is recognised internationally as a unique and effective approach. No other country has achieved this linkage across research capabilities to government and industry. In this context we support an ongoing commitment to collaboration as a key component of national research infrastructure investment, and also support calls for greater independence, accountability, and transparency in the governance of national infrastructure (see also relevant comments in the Ecosystem Science Council of Australia's submission).

In earth observation and analytics there has been a long standing need for national coordination and development, as identified in a Senate Standing Committee on Economics report[2], joint Academies' Decadal Plan on Earth Observation from Space[3], and several reviews of the spatial and earth observation government and industry sectors and their critical needs[4]. The most recent national survey by the AEOCCG (August 2016) revealed a consistent call across research, government and industry sectors for an effectively resourced national earth observation program, with provision of appropriate research infrastructure. This is considered the essential element to enable maintenance and growth of this sector[5].

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

Yes – this is absolutely essential if Australia wishes to maintain its current access and critical dependency on the billions of dollars worth of foreign tax-payer and privately owned earth observation satellites and data streams. To support this, we repeat our statement above which highlights the need for co-investment in international research infrastructure: "This is also not a call for a single satellite for Australia, but for a longer term strategic view that enables us to co-invest with other space-agencies, possibly develop an EO satellite for Australian-specific critical needs (geostationary, high spatial and spectral resolution), and also enable more agile industry-lead solutions such as Cubesats."

We have a plethora of national reviews, private industry and government surveys, and most recently an assessment in 2015 by the Department of the Attorney General, all demonstrating that reliable and ongoing access to EO data is an essential piece of infrastructure for governments and private industry in Australia6

[2] Australian-Government (2008). Lost in Space? Setting a new direction for Australia's space science and industry sector. Senate Standing Committee on Economics Report. Canberra. http://www.asri.org.au/system/files/private/report.pdf

[3] AAS and AATSE (2009). An Australian Plan for Earth Observation from Space. Canberra. https://www.science.org.au/supporting-science/science-sector-analysis/reports-and-publications/australian-strategic-plan-earth

[4] See list at: http://www.aeoccg.org.au/assessments-studies-plans/

[5] Australian Government (2010) Critical Infrastructure Resilience Strategy. Canberra. http://www.emergency.qld.gov.au/publications/pdf/Critical_Infrastructure_Resilience_Strategy.pdf Contact Attorney General's Department for Access to 2015 CIR Strategy.

[6] See list at: http://www.aeoccg.org.au/assessments-studies-plans/, also:

As part of our reciprocal arrangements with international partners, our EO research infrastructure provides essential calibration and validation (data, techniques and highly skilled personnel) to foreign space agencies and private companies around the world. We need to maintain and build on this. In addition, we need to establish a strategic approach to making these contributions, which could include the following:

(1) Provide higher level contributions to our critical EO partners in Europe, North America and Asia, including financial contributions to their EO programs as a joint investor, where for a small investment we can assist with and access billions of dollars of EO infrastructure for use in research, government and private industry. For example, Australia has been invited several times to become a member of the European Space Agency (ESA), a cost-effective move which would give us greater security of access to data from the ESA as well as giving us a seat at the table to influence and direct future EO missions so they are more suitable to Australia's needs; and

(2) Development of our own EO satellite capability for our highest priority Australia-specific data needs, and to provide data to our neighbours, e.g. high-spatial and spectral resolution geostationary satellite.

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

In the context of EO, if international facilities can provide what is needed (in this case data streams) for a reasonable cost and at a high quality, it seems sensible to use this. For the case identified in our response to Question 4: Australian government, industry and research depends on multiple types of EO data, which is delivered through facilities in multiple foreign countries. Australia could not efficiently gather these multiple types of EO data on its own through a satellite program focussed on just one satellite. It is more effective to have a coordinated approach to maintain these essential data streams, which includes direct and high level engagement and financial contribution to foreign space agencies. Alongside this, it may be appropriate to develop an EO satellite to address our own critical needs; and to partner with private industry in satellite, airborne and drone development.

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

Yes. Conducting science and transitioning science through research to operational applications in industry and government requires a long-term and coordinated investment in the highly skilled and trained personnel who develop, run and improve our research infrastructure capabilities. In turn this will provide more jobs and enable development of more industry around the science and research capabilities.

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

National research infrastructure facilities must include training and skills development as part of their programs of work. Some already do, but this should be built up.

Australian Government (2010) Critical Infrastructure Resilience Strategy. Canberra. http://www.emergency.qld.gov.au/publications/pdf/Critical_Infrastructure_Resilience_Strategy.pdf Contact Attorney General's Department for Access to 2015 CIR Strategy.

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

Research institutions should take a significant amount of responsibility in this space. Developing a nationally coordinated earth observation and analytics capability would allow these requirements to be established and then implemented across relevant contributing organisations.

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

Current models could move towards inclusion of set levels of state and industry co-investment, where possible. This may not apply across all capabilities, and should be done on an assessment of the specific end-users of the infrastructure, its capability and products. In the case of earth observation and analytics, levels of state and industry co-investment would be possible.

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

This is a critical issue for development of products from airborne and satellite image data, e.g. base data sets (surface reflectance) which are used to derive information products that research, government and private sectors use. NCRIS facilities such as TERN and IMOS provide internationally unique ground/ocean/atmospheric calibration and validation datasets, which are used in a number of international EO programs by foreign space agencies to ensure correct operation and use of their data. NCRIS facilities thus play an essential role in providing data and expertise to deliver standard datasets, along with quality-assurance and –checking protocols. This capacity needs to be maintained and built where possible to enable continuing national consistency in this area.

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

We cannot recommend international models in the context of EO, but point out that some Australian approaches are leading globally in this context, especially those within TERN.

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

In principle, we believe that national research infrastructure is a matter primarily of Commonwealth responsibility. Refer also to the answer given to Question 12.

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?

It is clear that EO has a continuing role to play in both of the emerging directions identified in the Issues Paper – Integration, and Climate and water resources. In particular, we support the call on p21 that '*Big data should include the dissemination of integrated timely and harmonised data for and from both research and non-research purposes to maximise the sustainable management of our continent's 7.741 million km^2.*' Through the existing NCRIS infrastructure, we have seen significant advances in this space, particularly by improving access to existing national data (such as operational data from agencies including the Bureau and Geoscience Australia), developing value-added data products from these data, and collecting new and complementary national data streams not covered by existing national agencies. The gains so far have been tangible and beneficial, but more is needed. In particular, focus should be given to remove any barriers to access of national EO data, and developing 'ready-to-use' data products or tools for non-EO specialists (including researchers from other science domains, industry, and environmental management bodies).

Effectively using big data and 'smart data' methods as mentioned in the paper also requires appropriate and accessible data infrastructure, which we discuss more in our response to Questions 30-32.

With regards to the Current capabilities and emerging capability needs identified in the Issues Paper, we simply note that EO is inextricably linked to each of these, and with appropriate infrastructure investment we know EO will continue contributing across each of these areas – atmospheric observations, marine environment, terrestrial systems, and solid earth – in the future.

The Desirable New Capabilities section of the Issues Paper raises a number of ideas specific to EO.

Page 23 of the Issues Paper states '*Priority areas yet to be addressed include: access to international satellite based remote sensing data; the operationalisation of the sites that provide the calibration and validation data that underpins remote sensing products; and skilled personnel to develop algorithms and tools to fully exploit the data for the global satellite community*.'

We are pleased to see these issues raised here. As noted in our responses to Questions 3 and 4, access to international satellite based remote sensing data is a non-negotiable requirement for Australia. We believe that Australia's long-term access to these data-streams can be achieved by committing long-term to the infrastructure that underpins our reciprocal obligations and ensures this data can be made useful for Australian contexts (notably calibration and validation activities), and also expanding investment to ensure Australia has ongoing access to and influence on international EO activities. Please refer to Questions 3 and 4.

We note that in a terrestrial ecosystems context, existing NCRIS investment through TERN has delivered a large body of valuable calibration and validation data both through direct collection of such data through field programs, and through the establishment of collaborative working relationships and trust across a wide body of organisations meaning historical and other datasets have been shared for use by the whole EO community (e.g. the new National Biomass Library:

http://www.auscover.org.au/xwiki/bin/view/Product+pages/Biomass+Plot+Library). This work so far, achieved in a relatively short timeframe (~5 years) provides a sound basis for future expansion of this work as identified in the Issues Paper.

We also strongly endorse the call for skilled personnel as a critical component of the nation's EO infrastructure. Australia has world-leading expertise in developing and applying EO and analytics to a wide range of fundamental environmental sciences, state and national government monitoring activities, and emerging private industries. This expertise is recognised internationally, and must be sustained. Importantly, it must be noted that Australia's skilled personnel reside across a range of organisations nationwide, including research institutions, different levels of government, and private business. To support these people, a coordinated national effort is required – both in terms of infrastructure, and in terms of coordinating efforts to maximise collaboration potential. We have seen a good example through TERN's EO work so far, in which a national collaborative network has enabled numerous experts from different locations and institutions to provide services for the EO community. This approach has also enabled rapid sharing of knowledge across the network, collaborative problem-solving, and reduced duplication of effort.

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

As noted in our responses to questions 3 and 4 in particular, Australia must continue engagement with a number of international programs and organisations to ensure we retain access to the EO data that is vital for the nation. This includes: NASA, USGS, NOAA, the ESA, JAXA, CEOS, and GEOSS.

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?

Australia has significant world leading expertise in developing and applying EO and analytics to a wide range of fundamental environmental sciences, state and national government monitoring activities, and emerging private industries. However, these areas have lacked a consistent and effective coordination to develop effective public-private partnerships to serve Australia's critical infrastructure dependencies on earth-observation analytics[7]. Our government activities are completely dependent on foreign satellite data providers. Our ability to initiate and maintain SME's that can work effectively with government and research infrastructure to build a robust and sustainable supply of EO data is compromised and not progressing at the rate of other similar and less developed countries.

Australia requires a more effectively coordinated national earth observation and analytics capability that works across all sectors of the environment - atmospheric, terrestrial, coastal, marine - and includes urban and production landscapes. It is not possible for one agency (e.g. Geoscience Australia or the Bureau of Meteorology) to do this alone due to the multiple levels of activity across government, industry and research, and the multiple kinds of data needed - rather it needs a program that spans all of these. This is also not a call for a single satellite for Australia, but for a

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longer term strategic view that enables us to co-invest with other space-agencies, possibly develop an EO satellite for Australian-specific critical needs (geostationary, high spatial and spectral resolution), and also enable more agile industry-lead solutions such as Cubesats. National infrastructure investment can support this by providing critical infrastructure for R&D across industry and academia such as 'sandpits' and incubator program, access to data (through international agreements), access to ground station capacity, and sustained cal/val infrastructure suitable to support a diverse range of application areas.

There is a great potential to capitalise on the use of Unmanned Aircraft Systems (UAS) for EO in Australia because of our low population density, progressive UAS regulations, and world-leading UAS research. UAS have a demonstrated capacity for calibration and validation of satellite products, and have the ability to generate new datasets at unprecedented detail required by a range of application domains, including ecosystem science and agriculture. Due to the 'drone hype' many operators are currently testing this technology for EO. TERN has developed and is operating a capability to evaluate these systems and operating protocols for delivering accurate and reliable data for supporting science and research. Investment in UAS EO infrastructure is required to coordinate this effort, and to identify optimal equipment, data collection protocols, and processing workflows to produce accurate and robust data products for end-users. TERN can play an important role in coordinating these activities nationally.

A national earth-observation and analytics capability, when coupled with the relevant EO strategic plans currently in development (2026 AEOCCP – to be launched in Nov 2016, 2026 Spatial Industry Transformation and Growth Agenda – to be launched January 2017, see: https://2026agenda.com/) will build on the country's significant past investments in research infrastructure, and enable development of significant private-public partnerships flowing from use of the coordinated research infrastructure capabilities.

This proposed approach builds on the work of TERN, the NCI, IMOS, key Commonwealth and State agencies, and others, which has established the basis for a bright future for EO in Australia, particularly through receiving-facilities, data-streams, base-data and networks of trained personnel. Further development, coordination, and application of these activities can provide essential ecosystem, monitoring and forecasting capabilities for Australia.

National Security

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

There also needs to be inclusion of essential earth observation data collection and distribution capabilities. These data are essential for food, energy and water provision, as well as the ability to conduct surveillance on our coasts and oceans.

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?

We need to develop a robust and sustainable public-private EO sector in Australia and recognise that this is an essential dual-use area with a large number of defence and security applications. Australia's critical infrastructure resilience program has recognised this, and that continuity of EO data supply is a significant moderate to high-level risk for our defence requirements. This highlights the need for a strategic approach to developing and delivering a national earth observation and analytics approach for Australia.

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?

EO observation data analytics is an underpinning and essential national capacity for Australia in government, industry, science and defence.

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

As noted above in multiple responses, it is essential, highly cost-effective and beneficial across all levels of government, research and industry for Australia to co-invest with other countries in their longer term international EO programs that design, build and operate satellite and airborne imaging systems. This will provide longer term and secure access to the multiple scales and forms of EO data that Australian research, government and industry are critically dependent on.

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

EO observation data and analytics are an underpinning and essential national capacity for Australia in research, government, and defence, hence the infrastructure that supports this is also. The Capability Issues Paper is correct in identifying the following underpinning areas, and their relevance to supporting EO research and applications development is as follows:

- High Performance Computing (HPC): for processing of very large EO image archives, such as the national and state Landsat and Sentinel archives. Geoscience Australia's Data Cube hosts a partial set of the Landsat Archive, while several state agencies host the full Landsat archive and the growing ESA Sentinel satellites archive. Processing of these data archives and very high spatial resolution data requires operational HPC.
- High capacity networks: for transfer of EO data sets. This is currently a rate limiting factor in transferring EO data and products within and external to Australia. It needs to be improved as the volumes of EO data captured and transferred increases.

- Trusted communication (access and authentication): is essential for EO research and application data streams where the processing history must be shown and must also be secure.
- Geospatial systems: are the hardware, software and people that fit around EO data, and enable its processing and transformation to geospatial data sets, which have extensive applicability as essential environmental data across all levels of government and industry.

Our recent national survey clearly showed the need for national coordination in access to the base EO data from a wide range of foreign owned satellites, i.e. access to fully corrected EO data sets that can be integrated with other geospatial data for a wide range of applications. This requires access to facilities that enable the viewing, processing and analysis of EO data archives such as Landsat, or other higher resolution data. HPC, high capacity networks, trusted communication and geospatial systems are all parts of the facility that deliver this capacity. The Australian Geoscience Data Cube and its use of the NCI for data storage and processing, is an example of this. However this is not the only solution, and government should recognise there are currently more accessible and easier to use international public-access systems (e.g. Google Earth Engine). Private geospatial agencies are also now using the same models to market and sell their image archives, with on-line HPC and large storage, linked to output analytics. We cannot afford a forced 'one processing and storage' facility for all research and operational EO data and products. Currently and into the future we will continue to have multiple large-data, HPC resources to access, and need infrastructure that recognises that, and builds a base resource for Australia. The Bureau of Meteorology and Geoscience Australia are logical places for maintaining collection and delivery of core or base EO data products, and delivery of these. Establishing an enhanced research capacity and ability to grow public-private partnerships from these core EO data sets will require significantly more effective and publicly accessible HPC, with high capacity network transfer, trusted communication, and easy to use geospatial systems. The Australian Geoscience Data Cube – NCI partnership is a start to addressing this, but it is not readily accessible to the general EO community or easy to use in its current form. That said, we recognise the DataCube is in its early days so the potential for improvement over time is great, if the user community is invited to inform and contribute to its development.

End of Submission