Geoscience Australia Submission

To the National Research Infrastructure Capability Issues Paper - August 2016

Geoscience Australia welcomes the opportunity to comment on the Issues Paper.

Geoscience Australia is the Australian Government's technical advisor on geological, geophysical and geospatial issues. As an agency that applies geoscience to Australia's most important challenges, Geoscience Australia relies on an Australian research sector that is innovative, responsive and internationally engaged through access to worldclass infrastructure. Geoscience research infrastructure has contributed to:

- Building Australia's resource wealth by discovering new mineral and energy resources
- Making Australia's communities safer by improving the understanding of natural hazards, including earthquakes, and our exposure and vulnerability to them
- Providing the foundation geospatial capability which underpins satellite positioning (through the National Positioning Infrastructure Capability) and imaging of Australia (through the Australian Government Data Cube and associated satellite Imaging capabilities)
- Securing Australia's water resources, and
- Sustainably developing and managing Australia's maritime jurisdiction.

In its first phases, NCRIS has invested in key capability areas that have contributed to these goals, and started to shift the way geoscientific data is used in Australia for research and innovation. These capability areas include:

- eResearch (NCI, ANDS, Nectar, RDSI): High Performance Computing and Data Infrastructure
- AuScope: A world-class infrastructure system for earth sciences including Geospatial capabilities
- IMOS: A national system for observing the ocean
- TERN: An observing network for ecosystem science

NCRIS investments in the National Computational Infrastructure (NCI), our Marine National Facility (the RV Investigator) and infrastructure funded through the Auscope mechanism, have, in combination, laid the groundwork for a national environmental and natural resources change detection and decision support capability.

Structured collections of continent-spanning but fine scale satellite Earth observation data collected over the last 40 years and housed at the NCI have made it possible for Geoscience Australia to develop the initial Australian Geoscience Data Cube (AGDC). This tool makes it possible for all users (including researchers) to interact with deep continent-scale archives of satellite data in a way that has never been possible before. This has already supported development of new applications to support agricultural productivity, water management, land management, carbon accounting and disaster risk reduction. Operationalisation and expansion of the AGDC will offer unprecedented opportunities for researchers to measure ecological change, detect landscape scale processes, observe ecosystem interactions as well as providing operational tools to assist farmers, land managers, governments and the general public in understanding how Australia is changing in near real time and in unprecedented detail.

Investment in infrastructure through AuScope has significantly enhanced our understanding of continental Australia, including the sub-surface, and has for the first time integrated geology, geophysics and geodesy into a single Earth Observing system, creating new insights into the structure and evolution of the Australian continent and helped to discover new mineral and energy resources.

Through AuScope NCRIS has also invested in Geospatial capability, in particular establishing the national Continuously Operating Reference Station network, allowing researchers to model Australia's deformation and to investigate the origins of intraplate earthquakes. This work opens opportunities to grow our ability to forecast earthquakes. The infrastructure also enables the accurate georeferencing of thematic data types allowing them to become interoperable geographically. Importantly the same investment has bought Australian society one step closer to developing a national positioning Infrastructure capability which will enable Australians to accurately locate themselves in real time, and therefore interface with the full diversity of "big data" that currently exists. This will drive the next wave of innovation through automation, artificial intelligence and augmented reality.

The $120M investment in Australia's marine national facility, RV Investigator, has established a world class facility to support research across Australia's vast maritime jurisdiction. Importantly, the RV Investigator is a flexible state-of-the-art marine research platform that enables Australia to benefit from its Blue Economy, which is valued at $42B annually. The capability to seamlessly collect of earth and environmental data across the terrestrial and marine environments by incorporating the RV Investigator enables Australia to provide regional contributions to large international research programs that address globally significant research questions. These research questions include understanding the origins and evolution of the Australian continent and how this relates to our mineral and territorial sea claims, and the crucial role that the regional oceans play in driving oceanographic, biological and atmospheric processes, including the causes and effects of global climate change. As the flagship of Australia's marine research infrastructure, the RV Investigator will drive future research efforts for the sustainable development and management of Australia's maritime jurisdiction, including the management of Australia's marine reserve network.

Our ability to exploit observations to understand the planet upon which we live, and how it is changing through time, is becoming more critical. We must help our researchers engage with this data. We also note that while the initial investment in these capabilities has established world class infrastructure, uncertainty about medium term operational funding has negatively impacted the development of skills and human capability that is normally associated with this class of infrastructure.

It is imperative that Australia establish the right research infrastructure to enable our research community to work together, and with government and industry to apply this data for national benefit, and for international opportunity. The appropriate funding of existing infrastructure, along with targeted investment in new capabilities, will ensure Australian researchers have every opportunity to excel and deliver real benefit to our society.

Specific answers to the questions posed are provided below.

Geoscience Australia welcomes the opportunity to comment on the Issues Paper.

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

Geoscience Australia does not believe additional capability areas are required. We would however prefer to see a stronger emphasis on the Solid Earth in the Environment and Natural resource Management capability area. We would also prefer to see satellite based remote sensing data, including the requisite ground infrastructure, data, HPC systems and interpretive capability included within "Underpinning Research Infrastructure"

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

Geoscience Australia suggests that the governance characteristic "Strategic approach to whole of life costs" should acknowledge the role that government agencies have in operating, sustaining and supporting critical infrastructure that supports national research. In many cases, this infrastructure can be leveraged to support a broader base of research uses, when appropriately managed, than alternative institutionally based infrastructure management. Such approaches also streamline the translation of research into products that can be used by decision makers. By carefully structuring future investments there is, therefore, potential to deliver a better return on investment for taxpayers by better utilising facilities.

Specific examples include satellite ground stations, observatory networks, authoritative national data repositories and products, and reference/fiduciary calibration/validation sites/facilities. Such facilities are often already maintained in some form within government to meet other mandates. Facilities run by government agencies typically have high degrees of trust in their robustness and quality, confidence in their independence, and greater clarity on long-term support and sustainment arrangements.

Geoscience Australia suggests that, where relevant, future NCRIS governance ensure that investments in new infrastructure complement existing/planned infrastructure investment by government agencies.

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

Geoscience Australia agrees that investment in access to international facilities is fundamentally important for Australian Researchers

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

We identify three scenarios for consideration where investment in international facilities is preferential to investment in similar Australian facilities:

- Where use demand from Australian researchers does not warrant investment in exclusively Australian facilities, but Australian researchers still need access to the capability (i.e Access is critical but not at 100% usage)
- Where the infrastructure investment is beyond the means of Australia's infrastructure investment program, but co-funding or partnering can gain access to the capability for Australia. Satellite Earth Observation systems are an example here.
- Where geographical distribution of infrastructure is a key consideration. Here we refer to globally distributed observing networks, or specific infrastructure that functions best in a location outside of Australia.

When considering these scenarios it is important to recognise that National investment may still be required to permit access to these international facilities, or to provide an Australian contribution to the globally distributed infrastructure.

Satellite Earth observation is one case where the need for national investment in access to international facilities is clear. The satellite observatories that collect critical Earth observation data only exist overseas. Australia is therefore committed to cooperate internationally in this area as through cooperation 'more countries will get more data'. At the moment access to data from international Earth Observing programmes is based on a combination of how much 'good will' space agencies offer, and what individual Australian agencies have to 'trade' in terms of in-kind contributions (e.g. participation on a project team, operation of data hubs, or data calibration infrastructure) from existing budgets/programmes. This is often tactical and makes it difficult to assure access to the data Australian researchers most want from high-priority cutting-edge missions (such as hyperspectral sensors) that have huge potential for key application areas in Australia (such as agriculture). In practice, this means that a small group of researchers may get access to a subset of observations of relevance to their specific project, whereas a strategic approach may have enabled the nation to negotiate access to a set of observations that are aligned to our strategic needs across scientific domains, with the result that a wide range of different projects can be supported. In future, the establishment of formal, funded, long-term strategic partnerships with international space agency partners would make access to data more predictable for researchers, and would benefit other NCRIS facilities, such as those focussed on products that support particular domains. The cost of such partnerships, relative to the cost of constructing the observatories locally, is very small.

A formal relationship would also enable Australia's research community to have a greater say in what new satellite missions are developed, influence that has potential to get Australia what it needs at a much lower cost than trying to develop missions domestically. It would also provide opportunities for Australian researchers to access the advanced facilities (e.g. engineering facilities) of the space agencies to pursue their own research in areas of the value chain where Australia may carve out an important niche role (e.g. advanced sensor design), as well as enabling Australia to get greater use out of its own facilities (such as the AITC) by leveraging them to support collaborations with the space agencies and their partners.

On a related note, in many cases access to data from 'research' satellites requires Australia to have access to sophisticated satellite ground stations that can be used to communicate with the satellite and acquire the data. This is an area where investment in national infrastructure would benefit both

Australian researchers (who would have access to more comprehensive data) as well as being seen as a material contribution 'back' to international satellite operators.

On the second point around an Australian contribution to globally distributed networks, numerous examples exist including IMOS and AuScope Geospatial. Both these observing systems function by virtue of being part of a global system. The global nature of the infrastructure has the added benefit of facilitating global engagement by the Australian research community, and the resultant transferral of capability to Australia.

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

Geoscience Australia suggests that workforce skills should be considered a research infrastructure issue. Investment in physical infrastructure without having strategies in place for its utilisation (including targeted investment in capacity building where relevant) is illogical. We also note the importance of investment program policies and funding mechanisms on the workforce. As previously identified in our covering letter, medium term security of tenure would significantly enhance the attractiveness of Australia as a skilled workforce destination. It is well understood that attracting the requisite skills from elsewhere in the short term, has a positive capacity development outcome in the medium to long term.

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

Geoscience Australia notes that even for resource-constrained facilities, time can be allocated to support training and skills development programmes. Geoscience Australia has found the professional development and training support provided by NCI, for example, to be invaluable in upskilling its researchers on issues relating to exploitation of high performance data.

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

Geoscience Australia is of the view that access to world class research infrastructure will allow research institutions to better develop their academic and technical staff, and students, to take full advantage of all of the tools that can help them to deliver the best research consistent with their institutional priorities. This includes national research infrastructure.

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

Geoscience Australia is of the view that the principles discussed (merit-based public-sector Australian research; merit-based or partial cost recovery based public-sector international research; and the private sector at partial or full cost recovery) are valid.

However, Geoscience Australia notes that ‘pathways’ are a key issue for the private sector: even if they develop a new product/service on a ‘full cost recovery’ model using research infrastructure, there is a limit to how far they can go to ‘commercialising’ that product/service on that infrastructure if it is successful.

National supercomputing facilities for research, for example, should not ultimately be ‘taken over’ by fee-paying industry for operational/production purposes or they will not be performing their core function of supporting innovation and research. It is critical, therefore, to ensure there are pathways for industry to ‘transition off’ research infrastructure to infrastructure where the new innovation/product/service can be scaled up on a fully commercial basis. This is a key aspect of the government’s efforts to improve linkages between research and commercialisation; we do not want innovations spun up on research infrastructure to have a difficult time finding ‘somewhere to go’ right at the point where a viable business model is just emerging.

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

Geoscience Australia is of the view that the funding of any piece of national research infrastructure should reflect ‘full lifecycle cost’ which includes making provision for decommissioning. Decisions on whether to continue beyond the planned ‘end of life’ should be made early, so that any funding allocated for decommissioning can instead be invested into future work.

Geoscience Australia notes that co-investment in research infrastructure facilities (such as ground stations) can ameliorate this issue somewhat by allowing the possibility of NCRIS defunding as research impact lowers and operational implementation proceeds.

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

No comment.

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

Geoscience Australia notes that scientific research is becoming an increasingly important tool in resolving contentious policy questions. This makes it increasingly important that the results of such research are fully open and defensible.

It is critical that the core observational data that is being used to drive research (in particular the fundamental observational data) is fully traceable (with quantified errors at each stage) back to fiducial reference standards, and that it is actively stewarded by experts in the data in compliance with archival standards.

This requires investment in the development and operation of calibration/validation facilities, and also requires accreditation, management and support of data preparation/quality assurance pipelines, data storage and analysis facilities, and data archives. There may be efficiencies in coordinating this nationally through a single 'institution' (e.g. the relevant government agency identified as steward for that data).

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

No comment.

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?

No comment.

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?

Geoscience Australia supports the content in this section, including the need for integrated and sustained 'ecosystem observatories' which should enable Australian researchers (and through their research decision makers) to monitor, detect and project environmental and subsurface changes from local to global scale. Australia makes the following suggestions:

- Emphasise that 'data infrastructure' in this context is about more than data storage, compute and generic metadata standards and IT toolsets, but is about 'data ***as*** infrastructure'. The next phase of investment in this area must ensure deep understanding of the specific datasets (not just of 'data' in general) is fully harnessed to ensure users have confidence in quality and comparability (e.g. ensuring data from different sensors is comparable in space and time) of the data. This is in addition to advances in the analytics/informatics frameworks that make that data usable. Approaches to data have often been 'generic', which has been helpful in creating theoretical linkages between data across different domains, but an evolution will be required in the next phase. Suggest replacing 'Enhancement of eResearch facilities' with something slightly more specific and related to the above priorities.

- That the roadmap should support the UNCOVER Research Initiative http://www.uncoverminerals.org.au/documents/amira-uncover-roadmap and the AuScope Australian Earth Observing System http://www.auscope.org.au/future-directions/ as two areas that have highlighted the need to expand the solid earth imaging area. The dynamic evolution of the earth, from core to the crust is essential to understand our groundwater, energy and mineral resource systems.
- Explicitly include 'access to satellite remote sensing data from international partners' in the 'Examples of potential new infrastructure' to align with the content above.
-

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

In the solid earth area three projects should be considered for international engagement:

- UsArray for Geophysical and Earth Observation Infrastructure http://www.usarray.org/
- EarthCube for data and data delivery infrastructure http://www.earthcube.org/
- The International Ocean and International Continental Scientific Drilling Programs https://www.iodp.org/ and http://www.icdp-online.org/home/

In the surficial earth observation space, Geoscience Australia suggests that Australia's involvement in the intergovernmental Group on Earth Observations (GEO) warrants further attention from NCRIS in the future. An 'Australian Group on Earth Observations' facility, modelled after the United States Group on Earth Observations, would enable Australia to:

- Reap the benefits of GEO's "convening model" at a local scale. Through this model players along the value chain, from data providers to researchers to end users are connected to drive initiatives that tackle real world problems. Such an approach would help give Australia greater confidence that research investments are 'directed'.

- Collaborate more effectively in regional and global initiatives driven through GEO, as it would be easier for a 'Team Australia' approach to be incubated and then plugged in to global frameworks.

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?

Geoscience Australia suggests the development of an integrated distributed network of geophysical and remote sensors to image the solid earth, much like a telescope but looking into the earth not outwards, as infrastructure needed for fundamental research into understanding how the earth works. This infrastructure will provide the missing links between solid earth geophysics, geodesy and geospatial analysis of the earth's response to natural and human activity, providing fundamental data to understand our groundwater, energy and mineral resource systems.

National Security

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

Geoscience Australia suggests that references be added to the need for effective monitoring and surveillance systems to support:

- Detecting and tracking biosecurity issues.
- Monitoring water levels/usage/quality to support water management.
- Better projections of renewable energies, onshore and offshore, as they become even more embedded into the energy market.
- Rapid detection and tracking of natural disasters, and prediction of their impacts, noting the great potential for both immediate consequences (including business continuity risks) as well as longer-term consequences (supply chain disruptions, reconstruction costs, etc).

With the right research infrastructure in place, Earth observation data can provide the required spatial resolution as well as frequency and quality of data to enable Australia to be a world-leader in the development of monitoring and surveillance systems that operate at continent-scale. Such infrastructure would provide a platform to apply new research to 'detect' emerging threats, 'monitor' their progress on a regular basis, and 'project' their likely spread and the impacts of particular mitigation strategies.

Increasingly the Australian government, particularly the Australian Defence Force, are assisting responses to catastrophic natural disasters. Situational awareness in natural disasters is a key need for Australia both nationally and in the region so that response and recovery agencies can assist in a timely manner. One area Australia has particular strengths in is the extraction of features from Earth observation data but this style of processing takes days or weeks. Research is required to reduce the latency of these products so that Australia can respond to the increasing number of natural disasters in Australia and our region.

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

No comment.

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

No comment.

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?

Geoscience Australia would like to clarify the meaning and applicability of capability area "Geospatial Systems". Geospatial capability provides:

1. Geospatial datasets including satellite, aerial and terrestrial imagery and mapping data that underpin almost every discipline of science.
2. The geo-referencing system and informatics capability that enables the interoperability of disparate (temporal, spatial, resolution) georeferenced datasets collected by government, industry and the research community. These data sets are typically not referred to as spatial data, but do have a spatial reference upon which interoperability can be achieved (e.g Statistical sensus data).
3. Geodetic measurements (e.g. GNSS observations) and informatics capability that directly contribute to the science of the solid earth (tectonics, crustal uplift/subsidence, sea level change, earth rotation), the atmosphere (e.g. atmospheric water vapour, ionospheric weather etc), and the hydrosphere (i.e. global water/mass movement) all of which broadly support Earth science.
4. A high accuracy positioning capability that allows researchers to interface with the above data in real time, and to collect geo-reference field data in an informed way. This National Positioning Infrastructure (NPI) will provide a national capability for research and innovation that will be transformational.

While much progress has been made during NCRIS 1 to develop geospatial capability and to make it accessible and integrated continued efforts are required to further develop this capability, and to have it utilised more intrinsically by other capability areas and researchers. Accordingly Geoscience Australia suggests the reference to 10.3.5 "for Australia to become a global leader in the global positioning industry" be altered to read "for Australia to become a global leader in Geospatial capability."

Additionally Geoscience Australia notes that investments to date in enhanced access to geospatial data (such as NCI and RDS(I)) have broken down major technical barriers by ensuring large volumes of data are available on high performance storage located next to high performance compute. This has taken us a significant step forward, and ongoing investment in new hardware and greater capacity is absolutely essential.

Through these investments it is now easier for researchers to find observation data from a sensor and interact with it. However, these investments have not made it significantly easier for users to *analyse and apply* that data, and therefore uptake to date has not been as high as would be desired from this national infrastructure investment. One of the big challenges is that although a user can locate raw data from different sensors, they are not given the 'infrastructure' required to relate those observations to each other, and integrate them into their analysis. This highlights the critical need for 'research-ready' data. The major exception to this is where users are interacting with the raw data through an analytical framework such as the Australian Geoscience Data Cube, where expertise about the specific data involved is brought to bear alongside expertise in ICT infrastructure and generic informatics.

As a result of the learnings from the Australian Geoscience Data Cube initiative, Geoscience Australia suggests that the nation is ready to take the next step forward, from 'infrastructure ***for*** data' which is mostly what is now in place, to ‘data ***as*** infrastructure’. Such systems are important because investments are not just made in hardware to store and process data, but in the ‘data expertise’ that is required to make that data usable. By scoping such ‘data *as* infrastructure’ in this way, researchers have access to something in which they can have confidence of:

- Continuity of new data.
- Provenance and long-term security of the data;
- Quality of the data including quantified uncertainty;
- Comparability of the data across time and space, and between sensors;
- Availability of the tools and resources (compute storage) to analyse that data;
- Ability to easily combine/share their work with the work of others.

With all of these conditions in place, Geoscience Australia suggests it is more likely that Australian researchers and their industry partners will start to commit to investments in major long-term research projects required to actually exploit the data to its fullest potential.

Geoscience Australia suggests that the Roadmap explicitly recognise the need for future investment in the area of ‘data as infrastructure’, with the Australian Geoscience Data Cube as a potential ‘Flagship’ project in this area, noting the critical importance of Earth observation data to Australia’s major research challenges.

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

Geoscience Australia suggests that the Taskforce explore the potential value in Australia becoming a formal (funded) partner in an international space agency research and development programme, such as the European Space Agency. By the Australian Government contributing financially to ESA programmes of strategic interest (e.g. excluding human spaceflight, but including navigation and Earth observation), Australian researchers and industry would be given access to funding, projects and facilities operated by ESA and its partners that are simply not available in Australia.

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

No comment.

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?

Geoscience Australia notes the importance of clarity around the custodianship/stewardship of datasets for research. Many of the datasets that are critical for research are maintained by government agencies, within clear data governance frameworks and consistent with legislative/policy mandates. Ideally, future arrangements would clearly reflect this role and provide structures that avoid duplication/overlap (while ensuring the research community have a clear voice in data curation standards and priorities (e.g. which historical datasets get remediated and in what order).

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

Geoscience Australia refers to its answer at Question 31.

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?

Geoscience Australia understands that the Taskforce is not yet seeking specific proposals. However, to support the Taskforce's deliberations in developing the Roadmap, Geoscience Australia suggests that the Taskforce give thought to how the Roadmap might create space for Australia to establish a world class facility for dynamically measuring and monitoring changes and evolution of the Australian continent. This would involve the establishment of:

1. **World-leading Earth observation 'data as infrastructure'** to support exploitation of satellite and non-satellite Earth observations data (e.g. airborne electromagnetic data, seismic data, aircraft and ship-based bathymetry). Such a facility would focus on the development and operation of 'big data' processing, analysis and delivery methods developed through the NCI to ensure all researchers across all domains had access to a reliable, trusted, robust platform on which to develop new products and then, ultimately, to deploy them operationally. The facility would also take responsibility for:
    a. Managing data continuity, by ensuring data from new sensors that come on stream are comparable in space and time with all other observations (effort that is often duplicated or done poorly at the moment), and that users have confidence in this interoperability;
    b. Managing the calibration/validation and processing facilities and programmes required to provide assurance of the quality of data and derived products;
    c. Establishing links between satellite and non-satellite data (e.g. to provide seamless data coverage across terrestrial, coast and marine environments).

    Facilities such as NCI and Pawsey, who are experts in High Performance Computing/Data, would be key partners. Future facilities focussed on data/products to support marine and land research would be greatly assisted, with lower project star-tup costs and confidence that they have an environment in which to sustain their outputs.

2. **A national network of ground stations** to support acquisition of data from advanced satellites for research and development purposes. Such a network would need to be 'agile' and 'flexible' so that it would be a useful 'bargaining' chip in securing access to data from cutting-edge research missions for Australian researchers. To maximise cost-effectiveness,

and mitigate risks such as competition for scarce spectrum, such a network would need to leverage and complement the operational ground network run by Geoscience Australia and the Bureau of Meteorology.

3. **Flagship partnerships with key international space agencies**, upon whom Australia relies completely for access to the satellite Earth observation data that underpins research and innovation. Formal partnerships will create greater opportunities for Australian researchers to get earlier and fuller access to data from cutting-edge research missions, as well as participate in those programmes. Further, although the Australian Government has no objective of becoming a major player in developing or launching large satellites, Australian researchers and industry have much to offer as participants in niche parts of the value chain. Key opportunities include our expertise in advanced sensor design (including cross-pollination from the astronomy domain) and development of value-added products and services. Support for facilities such as the AITC are also important as they provide physical environments for Australian researchers and their space agency partners to collaborate.

Investment in the above three areas would provide a strong foundation for Australian researchers, innovators and industries to take full advantage of the deluge of 'big space data', and the associated global satellite applications marketplace, that is on the way.

In considering how this may work in practice, Geoscience Australia suggests that the Taskforce take full account of the major investments already made in the above areas by government agencies and the fact that much of the infrastructure is, pragmatically, most often managed by government agencies. Geoscience Australia suggests that future NCRIS investments support/enhance such existing government agency activity, rather than potentially duplicating them. Further comments on this topic are provided in the response to **Question 2.**