AAS (Australian Academy of Science)
National Committee for Space & Radio Sciences Decadal Space Plan: Earth Observation

Australia in Space: a strategic plan for Australian space science
Working Group Report

Working Group Topic: Earth Observation

Chair: Jointly run by Earth Observation Australia Inc., from initial work by Prof. Simon Jones

Contributors: Simon Jones, Stuart Phinn, Megan Lewis, Renee Bartolo, Sylvia Michael

Disclosures of interest: Not applicable

Vision statement:

By 2030, Australia will generate Earth observation (EO) products and services from Australian and global space and ground assets. Our sovereign EO collection, processing, analysis, and distribution infrastructure, industries and skilled workforce are world class, underpinning and stimulating the growth of the broader economy. Our science, industry, government and defence sectors driving EO development and applications are connected, coordinated, and scalable, allowing world class education to enable effective research to operational development of EO in all these areas. Our EO capability will support essential Australian industry, government, and community needs.

The statement above supports vision statements from:

- "Australian Earth Observation Community Plan 2016-2026"
  By 2026, the Australian Earth Observation sector will develop and deliver high-quality EO information, infrastructure, and services that are used widely by government, industry, research and the community in Australia and internationally.
- Australian Space Agency – National Civil Space Priority Roadmap "Earth Observation" to be released in December 2020
  Text with-held until public release

Background on topic area:

Earth Observation (EO) encompasses a broad suite of activities that use remote sensing to gather observations and produce measurements and spatial data to monitor and examine our planet, its environments, human activities and infrastructure [1]. EO data are collected at a range of scales from centimetres to kilometres, throughout all our environments — built, natural, and managed. Some EO data have been collected regularly for decades through ongoing satellite programmes, while other data may be collected at specific times and places in response to particular needs such as natural disasters or emergency situations.

The EO supply chain starts with the collection of observations using a variety of platforms including satellites, aircraft, remotely operated vehicles (airborne or waterborne), and in situ sensors (Figure 1).

These platforms may be fitted with any number of sensors capable of collecting different kinds of image data from the full electromagnetic spectrum, including visible, thermal, and micro-wavelengths as used by imaging radar. As a result, EO sensors can ‘see’ and measure more than the human observer can, over larger areas, on a repeated basis, and over any environment including harsh, dangerous, or difficult to access areas. These observations are collected at different spatial resolutions (pixel size and total area observed), different revisit periods from minutes to days to months, on specific dates, and in urgent response to emergency situations. The collected raw data are then processed with ground- or water-based calibration and validation data to deliver data products, information and services about our land, oceans, atmosphere, and built environments. This information can be used for a wide range of applications, including weather and oceanographic forecasting, preparedness and response to natural disasters like floods and bushfires, mineral exploration, precision agriculture, water resource management, urban planning, and environmental monitoring (Figure 2). Furthermore, EO information assists in decision-making across industry, government and defence, and informs development, implementation and assessment of government legislation at local, state-territory and national levels.

EO data are used for measuring and mapping:

(1) Categories of features, such as land use and cover, mineral deposits, infrastructure, roof types, weeds, etc.

(2) Biological or physical properties, such as vegetation heights, fuel loads, crop yields, soil exposure, water depth and velocity, building heights, cloud height and thickness, temperature, geomorphology, etc.

(3) Changes in (1) and (2) over time, such as the detection of crop growth over time, or vegetation clearing, wind direction and strength, wave directions and strength, etc.

The diversity of spatial information products and services currently obtained from EO is very broad and continually expanding, with multiple Australian and overseas reports consistently demonstrating:

(1) The significant and growing economic value of spatial information produced from EO data for our economy and governments, and

(2) The essential nature of these data for supporting critical government and industry activities that ensure our food, water and energy supplies and security contribute to public health outcomes, and improve preparedness for and response to natural disasters.

The potential growth in, and return from, EO-related applications derived from satellite and unoccupied aircraft systems (UAS) information products and services are immense [2].

Globally, the return on investment in EO is conservatively estimated to range from $2 to $10 for every $1 spent, depending on the specific application [3].

With ongoing development of EO data acquisition and processing platforms there are countless opportunities for EO to increase its value to society in coming years. To enhance Australia's economic and social well-being, Australia should invest strategically in our EO capability now, in order to create a vibrant, innovative and highly productive EO sector that effectively links industry, government, research and the public for widespread benefit.

Australia has an active Earth Observation community distributed geographically and across research and education, government, private industry and NGOs (Figure 3). Although Australia does not operate any EO satellites, we are active across the entire EO supply chain, from the initial stages of data collection and storage through to processing, distribution and application. We are also global contributors in the research and development of new EO sensors and processing algorithms. Our EO sector transforms EO data to value-added spatial information and services for government and industry and supports the end use of EO-based spatial information products and services by public and private sectors in everyday activities.

Australian government agencies at all levels have collected EO data over Australia since the 1940s, as evidenced by our extensive state-based aerial photo and image archives. Since the late 1970s we have moved to routine acquisition of satellite data, and since 2010 we have seen dramatic advances in:

- The ability to collect EO data across multiple satellite, airborne, and other platforms such as unoccupied aircraft systems (UAS) and the types of sensors these use; from digital photography to multispectral, hyperspectral and thermal sensors, LiDAR, radar and radiometry;
- Improved access to these data over areas of a few square metres to continental and global scales on a regular basis;
- Our ability to store, process, analyse, visualise and distribute very large and long-term EO data sets online, and to deliver derived spatial information and services to a wide range of users through mobile devices and websites; and
- End-user awareness of the level of expertise and time required to produce EO data, and the products and services derived from EO data, across diverse applications.

While Australia operates no EO satellites of its own, we access a wide range of satellite imagery, at moderate to low spatial resolution (20m — 1km pixels) through long-standing partnerships and arrangements with other countries. As part of these arrangements, Australia provides important ground station capability, highly skilled personnel, data access and distribution infrastructure, local environment and scientific knowledge, along with calibration and validation data to our international partners, and development of new algorithms and processing workflows. In combination, these activities add value to the available data for both our partners and ourselves. Access to higher spatial and spectral resolution data is through a range of private industry satellite, airborne, and UAS providers. The number and types of all these data sources are increasing continually.

EO services, delivered by both the public and private sector, are recognised as essential public-private infrastructure with numerous national reviews showing that Australian governments and industry are dependent on EO to maintain our economy and societal wellbeing [4-7]. Data and information applications from EO are now commonly used across all levels of government, industry and society in a range of sectors (Figure 4). Over 140 Commonwealth, state and territory government programmes are dependent on EO from space, and the minimum economic benefit of these observations on the Australian economy is approximately $5.3 billion per annum. These services are also estimated to have created more than 9,000 jobs in 2015 and are projected to generate over 15,000 jobs by 2025. There are numerous examples of the economic and societal benefits generated from EO in Australia, across areas such as weather forecasting, onshore and offshore mining, mitigation and management of natural disasters like bushfires and floods, water resource management, design and assessment of conservation areas, insurance assessment, and land use planning (an excellent series of case studies showcasing the value of Earth Observation for different sectors is available in ACIL Allen (2015) [2]).

Barriers for Growth and Innovation:

While the existing impacts and level of dependence on EO in Australia are very significant in terms of diversity of activities and economic value, there is unrealised potential for the EO sector in Australia. Unless change occurs across the sector, this unrealised potential will grow, in effect translating to a net loss in essential capability for satellite, airborne and UAS data collection, processing and delivery. Some well-documented challenges will become significant barriers to growth if not addressed, including:

- Assuring coordination and a consistent vision within the EO community across research and education, government, and private industry, to ensure effective cooperation, collaboration, and use of resources within the sector, as well as improving advocacy by the sector at national and international levels. This vision needs to be backed by a clear strategy. When realised, this will bring together a far more effective critical mass of expertise, significantly increasing the value returned from Australia's investment in EO;
- Developing a clear, coordinated strategy to invest in and protect our international partnerships to ensure continued access to satellite data and international expertise, especially given our high dependency on foreign-owned satellite data;
- Providing clear pathways to develop, support and sustain the EO capacity required for Australia through skilled people, a growing knowledge base, and advanced data collection, storage, and analysis infrastructure;

- Effectively managing and enabling access to the very large and rapidly growing collections of EO data including historical archives and required new data streams, and taking advantage of new information systems and technologies for storage, processing, analysis, visualising and transfer, to overcome historical problems and future challenges with discoverability and access to the data, products and services; and
- Establishing connections between EO producers and users to enable the development of EO products and services suited to current and future user needs, and supporting the commercial development of EO applications to deliver productivity gains across the economy, amongst other societal benefits.

Recommendations:

The recommendations below support the priorities and actions from:

- "Australian Earth Observation Community Plan 2016-2026"
  By 2026, the Australian Earth Observation sector will develop and deliver high-quality EO information, infrastructure, and services that are used widely by government, industry, research and the community in Australia and internationally.
- Australian Space Agency – National Civil Space Priority Roadmap "Earth Observation" to be released in December 2020
  Text with-held until public release

1. Connection, Coordination and Communication within Australia's EO Communities:

Undertake action and support programs that will enable Australia's EO science communities to be connected across education, government, industry and defence, for the development of a skilled and connected workforce and set of activities that understands how to work with and support each other to deliver essential national infrastructure.

2. Connection, Coordination and Communication with International Partners: Securing Australia's Role in the International EO Community

Through relevant national coordination bodies, Australia's EO communities develop consistent national positions on priority short (1-5 year) and longer term (5-10 year) requirements to communicate to the Australian Space Agency, to inform its EO Civil Space Priority work and international engagement.

It is essential this is across education, all levels of government, industry and defence, and is NOT solely based on views of Commonwealth agencies in Canberra alone.

3. Recognise, Connect and Build Australia's Infrastructure, Skilled Peoples and Organisations (Public and Private)

Identify and link the sciences underpinning EO space sciences, from the development, build and operation of imaging satellites, to the development and delivery of products and services from satellite EO.

Link to the development of skilled workforce, public and private infrastructure and partnerships, and research to operations.

4. Establish and Maintain Resources and People to Develop, Build and Deliver EO Sensors, Satellites, Products and Services

Enable all scales of industry, from single person start-ups to multi-national companies to partner with research groups, to develop, build, and deliver new capabilities, sensors, products and services for collecting and transforming Earth observation data into information.

Improve collaboration between and integration of contributing disciplines such as physics, engineering, signal processing, and machine learning, in education and research training programmes, to take advantage of innovation that is taking place at the interface of these disciplines.

5. Link Education and Research Paths from Science to Government, Industry and Defence

Improve collaboration between and integration of contributing disciplines such as physics, engineering, signal processing, and machine learning, in education and research training programmes, to take advantage of innovation that is taking place at the interface of these disciplines.

Promote and develop EO as an integral part of education in applications that would benefit from EO, such as agriculture, environmental sciences, geoscience, and mining, etc.

Increase linkages between undergraduate, postgraduate, and research training with government, industry, and defence applications and needs.

Figures:

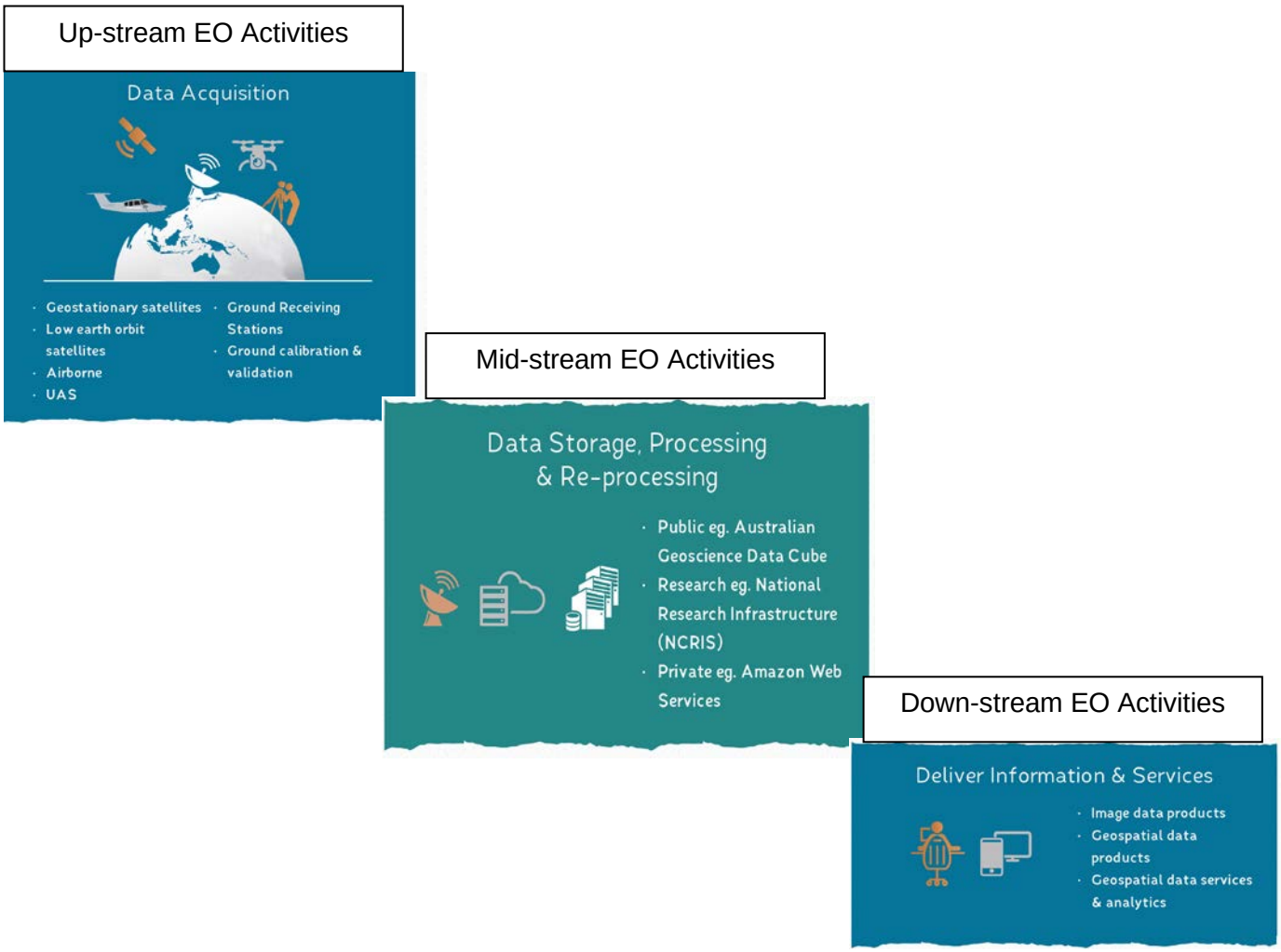

Figure 1: The EO 'supply chain' from the acquisition of observations using a variety of sensors and platforms, through to the processing and storage of data and data products, through to provision of information and services that can be used in a wide range of applications.

Figure 2: EO information and products are routinely applied across a wide range of industries for economic and societal benefit, some of which are shown here.
A comprehensive list of 200 EO applications can be found at www.skywatch.co/get-inspired

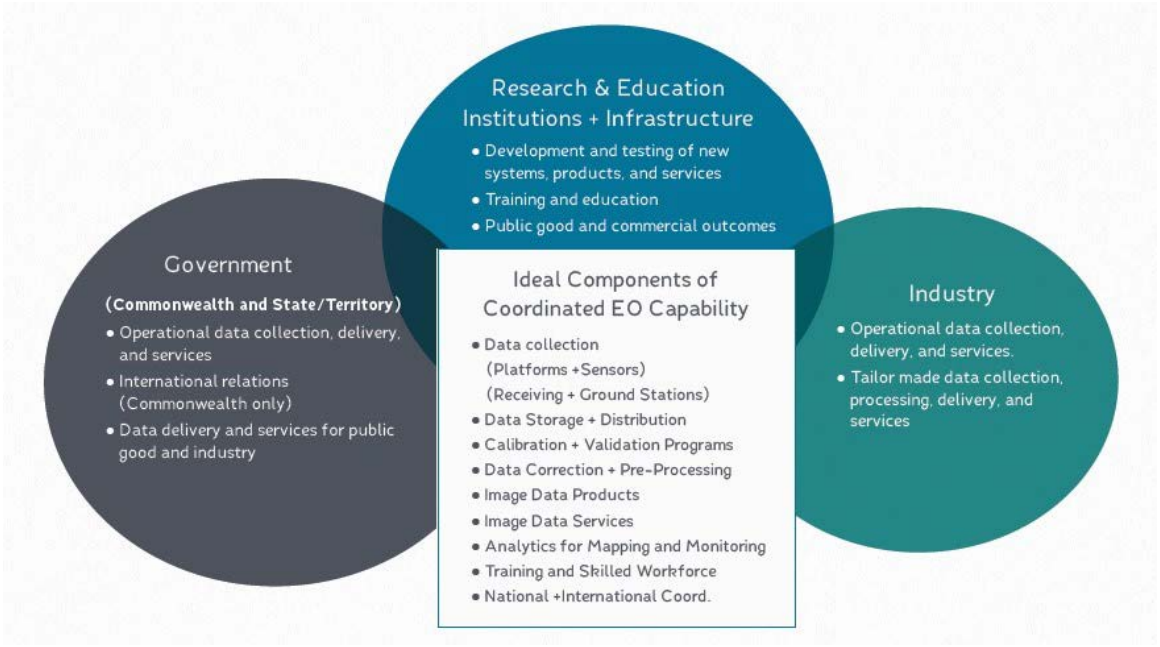

Figure 3: The ideal connected and coordinated EO capability for Australia, with all components of this sector — government, industry, and research and education — delivering complementary activities to ensure an effective and cohesive national EO capability. The central box represents the combined requirements of a national EO capability, with the individual circles representing the different contributions from government, industry, and research and education sectors. Collaborative research infrastructure provided by the Commonwealth is an essential shared resource across all groups.

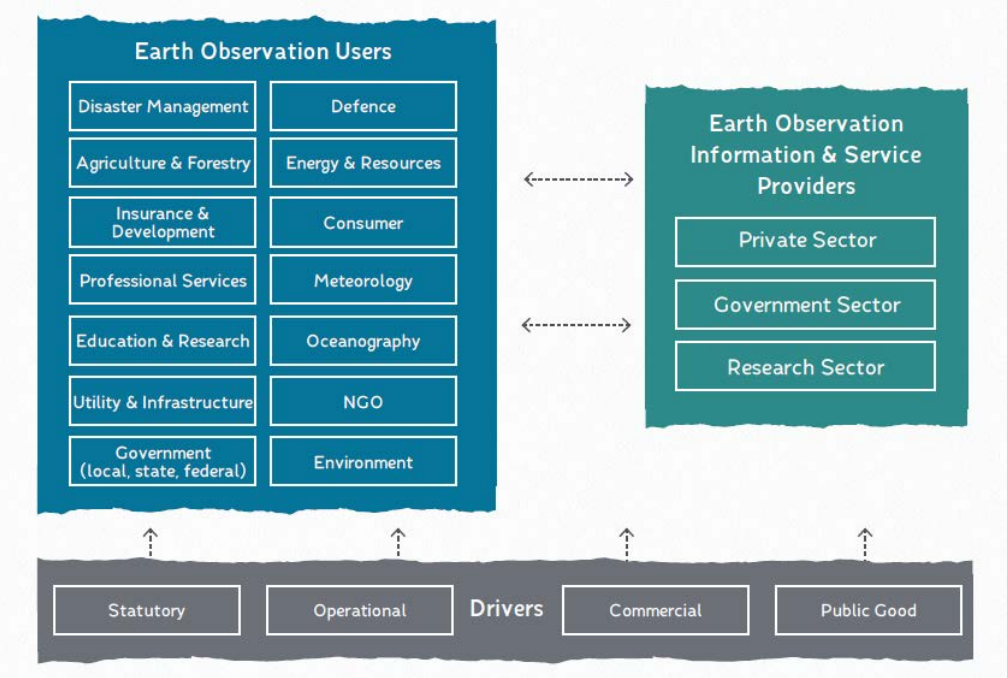

Figure 4: The users and providers of EO data products, information and services, and their drivers.

References:

(1) Coppa I, Woodgate PW, Mohamed-Ghouse ZS. (2016) 'Global Outlook 2016: Spatial Information Industry'. Published by the Australia and New Zealand Cooperative Research Centre for Spatial Information (CRCSI).

(2) ACIL Allen Consulting (2015) 'The Value of Earth Observations from Space to Australia: Report to the CRC for Spatial Information

(3) Henttu H, Izaret JM, Potere D (2012) 'Geospatial Services: A $1.6 Trillion Growth Engine for the U.S. Economy', The Boston Consulting Group

(4) Senate Standing Committee on Economics (2008) 'Lost in Space? Setting a new direction for Australia's space science and industry sector', Canberra

(5) Australian Academy of Science and Australian Academy of Technological Sciences and Engineering (2009) 'An Australian Strategic Plan for Earth Observations from Space', Canberra

(6) Commonwealth of Australia (2013) 'Australia's Satellite Utilisation Policy', Canberra

(7) Space Community of Interest (2015) 'A first pass analysis of risks associated with Australia's dependencies on space-based assets: Communications, Positioning, Navigation, Timing and Earth Observation.' Trusted Information Sharing Network for Critical Infrastructure Resilience, Attorney General's Department, Canberra, RESTRICTED ACCESS

Primary Sources:

Australian Earth Observation Community Plan 2026 (AEOCP 2026)

VISION STATEMENT: By 2026, the Australian Earth Observation sector will develop and deliver high-quality EO information, infrastructure, and services that are used widely by government, industry, research and the community in Australia and internationally.

(1) **Connection and Coordination** — establishing a consistent vision within the Australian EO community, and delivering processes for internal coordination to ensure effective collaboration, resource use, and advocacy for EO in Australia and internationally.

(2) **Securing Australia's Role in the International EO Community** — Australia must be an essential component of the international EO capability, delivering benefits to the international community and securing our access to and involvement in international EO programmes.

(3) **Infrastructure and People** — developing, supporting and sustaining a wealth of trained professionals and quality infrastructure to enable world-leading EO research, innovation and application development.

(4) **Access to EO Data and Services** — ensuring all Australian EO producers and users can easily and reliably access the data and services they need.

(5) **Generating Value** — strengthening end-user engagement to enable delivery of high quality EO products and services suited to user needs, and supporting commercial development of EO applications.

To initiate action in implementing this Plan, Earth Observation Australia Inc. (previously known as AEOCCG) commits to:

(1) Engaging widely across the EO community to seek feedback on the actions set out in this Plan, and to determine what the community sees as the important areas for action in the short- (< 5 years) and long-term (5-10 years), in order to develop an implementation plan and the required financial, personnel and other resources to address this.

(2) Linking Earth Observation Australia Inc. (EOA) to a suitable agency or programme able to work across a range of Government agencies to implement the actions required under the five priorities of the Plan, and to develop a linked EO Capability for Australia across government, industry, and research.

(3) Establishing working groups or other groups with membership from across the EO community, who will take responsibility for progressing specific actions or priority areas of this Plan and work in close association with the coordinating programme established in (2).

(4) Build the case for and obtain government and external investment for developing and implementing the Plan, and seek sources of funding to support implementation activities in the short- and long-term.

(5) Promoting the Plan, its priority areas, and key actions to decision-makers and influencers in government and other sectors in order to build wider support for implementing the Plan.

Australian Space Agency Civil Space Strategy 2020-2030 and Earth Observation Roadmap

Not included as not complete and not in public format.

Other Sources:

- https://www.eoa.org.au/policies-reports
- Australian Space Agency (2019). Australian Civil Space Strategy.
- CSIRO (2019) Establishment of an Earth Observation Platform to Support Pacific Island Nations Environmental, Climate and Livelihood Needs - Consultation Workshop - Final Report. Authors: Andrew Steven, George Dyke, Lauren Hardiman, Alex Held, Deanna Hutchinson, Flora Kerblat, Neil Sims, Luke Smith, Jennifer Zhu.
- Australian National University (2018) Earth observation for water-related applications. Workshop summary and recommendations, 28 March, Canberra. Also see web page.
- Australian National University (2018) Environmental-economic accounts with Earth observation data. Fenner Synthesis workshop report, 10-11 May, Canberra. Also see web page.
- CRCSI (2017). Earth Observation: Data, Processing and Applications. Volume 1: Data. CRCSI, Melbourne.
- CRCSI (2014). Australian Strategic Plan for GNSS. Canberra.
- CRCSI (2013). Australia and SAR: A Road Map. Canberra.
- CRCSI and CTG Consulting (2012). Robust Imaging from Space - Satellite SAR (Synthetic Aperture Radar). Canberra.
- Australian-Government-Environmental-Information-Advisory-Group (2012). Statement of Australian Government Requirements for Environmental Information. Canberra.
- CSIRO (2012). Continuity of Earth Observation Data for Australia: Research and Development Dependencies to 2020 (2012, CEODA-R&D) G. Australia. Canberra.
- Australian-State-of-the-Environment-Committee (2011). Australia State of the Environment 2011 (SoE 2011) Canberra, Department of Sustainability, Environment, Water, Population and Communities.
- Geoscience Australia (2011). Continuity of Earth Observation Data for Australia: Operational Requirements to 2015 for Lands, Coasts and Oceans (CEODA-Ops) Canberra.
- Australian-Government (2010). Adapting to Climate Change in Australia—An Australian Government Position Paper. Canberra.
- AAS and AATSE (2009). An Australian Strategic Plan for Earth Observation from Space. Canberra.
- AAS and AATSE (2009). Decadal Plan for Australian Space Science 2010-2019. Canberra.
- 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.

Policies

- National Space Industry Policy for Earth Observation
- Australia's Satellite Utilisation Policy
- Australian Government Critical Infrastructure Resilience Strategy

Assessments

- Department of Industry, Innovation and Science (2019) 'Current and future value of earth and marine observing to the Asia-Pacific region'.
- ACIL Allen Consulting (2015). The Value of Earth Observations from Space to Australia.
- Symbios Communications (2015). Risks of Data Supply of Earth Observations from Space for Australia.
- Australian-Government (2014). The State of Space Report: Australian Government Space Coordination Committee 2014. Please provide any feedback on the content and/or the process to space@industry.gov.au.
- CSIRO (2014) An audit of satellite validation and calibration facilities and activities in Australia. Prepared for the Space Coordinaton Office, Department of Industry.
- ACIL-Tasman (2010). Economic Value of Earth Observation from Space. Canberra.
- Australian-Government (2009). Climate Change Risks to Australia's Coasts. Canberra.
- ACIL (2008). The Value of Spatial Information: The impact of modern spatial information technologies on the Australian economy. CRC Spatial Information, ANZLIC- The Spatial Information Council. Melbourne, Australia: 171.

Summary Table:

Insight	Aspiration	Actions	Impacts	Metrics
1) Connection, Coordination and Communication within Australia's EO Communities	A coordinated and consistent vision across research and education, government, industry, and defence	Undertake action and support programs that will enable Australia's EO science communities to be connected across research and education, government, industry and defence	Collaboration and engagement across the EO community A skilled and connected workforce Delivery of essential national infrastructure	Increase in efficient and effective use of our EO resources Coordinated and informed EO activities Coordinated and informed EO response to applications
2) Connection, Coordination and Communication with International Partners: Securing Australia's Role in the International EO Community	A consistent, engaged, productive, and mutually beneficial relationship with international EO organisations and agencies	Develop and communicate consistent national positions on priority short and long term requirements to the Australian Space Agency to inform its EO Civil Space Priority Coordinate and build on existing relationships within the EO community	Recognised and consistent communications with international EO organisations and agencies Continued access to data collected by international organisations and to international expertise Recognition of Australia's contribution to the international EO community	An engaged, productive, and mutually beneficial relationship with international EO organisations and agencies Recognition from and collaboration with the international EO community

Insight	Aspiration	Actions	Impacts	Metrics
3) Recognise, Connect and Build Australia's Infrastructure, Skilled Peoples and Organisations (Public and Private)	A connected and collaborative Australian EO resource network combining a skilled workforce, public and private infrastructure and partnerships, and an effective and efficient transition from research to operation	Identify and connect to the sciences underpinning EO space sciences Develop a skilled workforce Establish and develop public and private infrastructure and partnerships Establish and progress the transition of research to operation Identify and progress research to answer real world application problems	Clear pathways to develop, support and sustain Australia's EO capacity	Access to knowledgeable, efficient, and effective EO resources by all Australians and across all fields i.e. research and education, government, industry and defence

Insight	Aspiration	Actions	Impacts	Metrics
4) Establish and Maintain Resources and People to Develop, Build and Deliver EO Sensors, Satellites, Products and Services	An established, progressive, collaborative, and dynamic Australian EO capability that operates in all sections of the EO supply chain from upstream to downstream activities	Enable all scales of industry, from single person start-ups to multi-national companies to partner with research groups Develop, build, and deliver new capabilities, sensors, products and services for collecting and transforming EO data into usable and applicable information Improve collaboration between and integration of contributing disciplines in education and research training programmes Effectively manage and enable access to collections of EO Investigate and utilise new information systems and technologies for data and information storage, processing, analysis, visualisation, and transfer	Effective and efficient access to EO data, products, and services across all sectors and applications An significant increase in Australia's EO capability and skilled workforce, in line with the Australian Space Agency's Civil Space Strategy 2019 – 2028	Increased awareness, use, and application of Australia's EO data, products, and services across all sectors and applications Increased Australian EO capability to efficiently and effectively service this increase

Insight	Aspiration	Actions	Impacts	Metrics
5) Link Education and Research Paths from Science to Government, Industry and Defence	EO education programmes support a skilled and applicable workforce which contributes to both the EO community and all application sectors Research programme outcomes can be transitioned into operational EO products and services that benefit and support Australia's civil and defence needs	Improve collaboration between and integration of contributing disciplines such as physics, engineering, signal processing, and machine learning, in education and research training programmes Promote and develop EO as an integral part of education in applications that would benefit from EO, such as agriculture, environmental sciences, geoscience, and mining, etc. Increase linkages between undergraduate, postgraduate, and research training with government, industry, and defence applications and needs	The Australian EO community will have a skilled and effective workforce and research cohort which benefits and contributes to all sectors and applications Education and research programmes will be relevant to and support real-world Australian applications	Increased, efficient, and effective uptake of EO data, products, and services across all sectors and applications