Priorities for Investment in Remote Sensing Satellite Technology for Australia

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by

Prof. Clive Fraser, Science Program Director
Cooperative Research Centre for Spatial Information

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Executive Summary

There is a growing national consensus, reinforced by recent studies and the recently prepared *Australian Strategic Plan for Earth Observation from Space*, as well as the federal government's new *Principles for a National Space Industry Policy*, that Australia has a strong dependency and reliance on foreign Earth Observation (EO) satellites, in particular for environmental and disaster monitoring, and that it wishes to grow its regional prominence and international participation in global remote sensing programs.

This gives rise to questions regarding investment priorities for the nation in EO satellite infrastructure and technologies. This paper initially looks at the background to Australia's present complete dependence upon overseas owned and operated EO satellites, and then briefly summarizes relevant strategic objectives in EO. Three priority areas of investment, namely a hosted EO payload on a geostationary satellite, gaining membership in a satellite constellation consortium, and upgrading Australia's ground segment infrastructure, are considered. These investment priorities are viewed on the one hand as potentially achievable, given anticipated resources, and on the other as enhancing the prospects for continuity of supply of EO imagery to the 100 or more known government programs, long-term research projects and commercial endeavours that rely on provision of medium- and high-resolution satellite imagery.

Background

Given Australia's stated intention to play a more active role internationally in the data acquisition components of Earth Observation (EO) satellite systems, the question arises as to what should be the priorities for investment in the space-borne or ground segments of EO infrastructure.

The context for this prioritisation is conveniently provided within the Australian Strategic Plan for Earth Observations from Space, prepared in 2010. The following is drawn from the foreword by the Presidents of the Australian Academy of Sciences and the Academy of Technological Sciences and Engineering:

The Working Group has concluded that Australia ……. must immediately commit to a much stronger national role in earth observations from space. It recommends a strategy for ensuring that Australia plays its part in the international Earth observation effort in ways that will optimally meet our national needs over the next 10 to 15 years and beyond.

The Plan identifies a number of strategic objectives for EO satellite systems, which can be summarized as follows:

- Monitor, understand and predict climate change and variability
- Monitor, understand and predict the water balance across Australian catchments
- Monitor natural disasters and develop strategies to manage and mitigate their impacts

- Monitor and predict weather and other environmental factors to ensure the safety and security of Australian transport systems
- Assess sites for renewable energy sources and predict conditions relevant to overall load management
- Monitor, manage and plan agriculture, forestry and natural ecosystems
- Monitor, manage and predict the environment of coasts and oceans
- Monitor Australian borders and assure national security

There are presently some 70 EO satellites either deployed or scheduled to be deployed within the next few years. These span the spectrum both in terms of the sensor (optical, thermal IR, microwave, etc) and the 'business' model under which they operate (national or international focus, commercial, public good, open or restricted data access, etc.). In looking at how current Australia's requirements, as spelt out above, might be accommodated by existing EO systems and arrangements, it becomes apparent that the majority of the nation's needs can be met so long as existing access arrangements for EO image data are maintained.

Assumptions regarding the continuation of existing arrangements centre upon:

- The willingness of the international EO data providers to maintain and guarantee supply.
- The international EO community continuing to be content with a situation where Australia reaps the rewards of access to important EO data, but does not share in the risks associated with deployment and operation of assets in space, but rather provides support through established and maintained ground EO infrastructure.
- Longer-term continuity of international medium-resolution optical EO satellite programs, as exemplified by Landsat and MODIS, in the prevailing financial environment where funding support for such programs run by NASA and ESA is diminishing.
- The Defence Department continues with the status quo.

It is encouraging to note that there is quite a deal of redundancy in the provision of panchromatic, multispectral, radar (SAR) and even shortwave and thermal infrared image data. Risks to long term programs are certainly present, as exemplified by the recent loss of the ALOS EO satellite and the vulnerability of the present Landsat program. Some 90 Australian government operational programs and several R&D programs rely to varying degrees on Landsat and MODIS imagery, and whereas Australia, through Geoscience Australia, CSIRO and BoM, has favourable existing arrangements with satellite operators such as NASA, NOAA, USGS, JAXA and ESA for access to EO imagery, these arrangements have limited value if there is an interruption to satellite operations.

However, by and large, much of Australia's need for EO data can be met satisfactorily at present by current and soon-to-be-deployed polar orbiting satellite systems. Notwithstanding these reassuring words, there are gaps in terms of what is required in EO coverage and technology, and what is on offer from the various providers. For example, there is a well-recognised gap in temporal coverage (that is less than one day revisit capabilities) of medium- and high-resolution imagery, as indicated by Figure 1 below, which plots spatial resolution (<300m) of current EO satellites against revisit times. As can be seen from the figure, minimum revisit times exceed 1 day, a limitation which can only be overcome by either multi-satellite polar orbiting constellations or geostationary satellites with higher resolution imaging capability than is currently available. Landsat has at best a revisit time of 16 days, assuming no cloud cover.

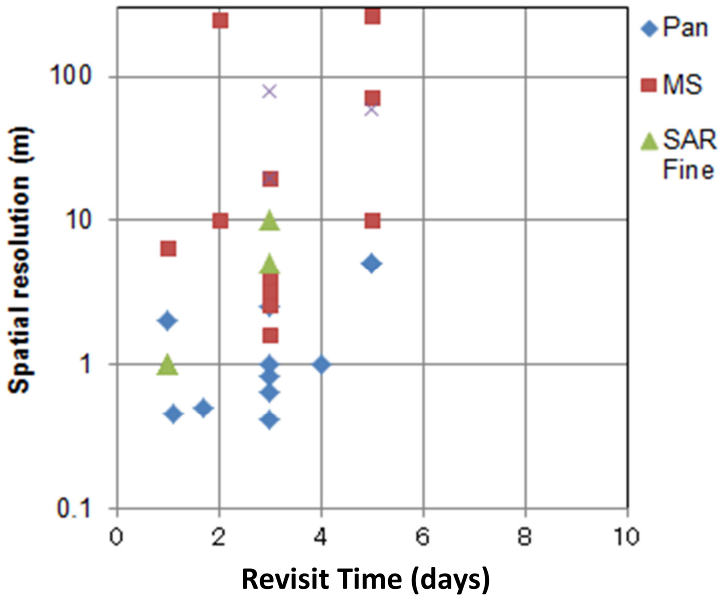

Figure 1: Revisit times versus spatial resolution for current EO satellites (Pan indicates panchromatic imagery, MS multispectral and SAR indicates synthetic aperture radar).

Australia needs to focus upon those particular strategic objectives above that constitute pressing national concerns and that are not well served by existing EO systems. Prime candidates for these include the ability to monitor natural disasters, the monitoring and prediction of weather and other environmental factors to ensure the safety and security of Australian transport systems, and the monitoring of Australia's borders for national security purposes.

In late September 2011, Senator Kim Carr, Minister for Innovation, Industry, Science and Research, released the *Principles for a National Space Industry Policy.* EO from space is recognised as one of the space applications of national significance, upon which the Australian Government will focus in its endeavours to promote growth in the development of public and private services associated with space technologies. The three priority needs highlighted in the following paragraphs align well with the principles related to EO technology and applications. Similar strategic R&D infrastructure investment priorities for space-derived data and services have been included in the recently released DIISR *2011 Strategic Roadmap for Australian Research Infrastructure*.

Priority Needs

1) Hosted Payload on a Geostationary Satellite

The vast majority of the 70 EO satellites and their 150 different imaging sensors operate in sun synchronous polar orbits that restrict their image acquisition to around 10 - 10:30am local time each day, and their revisit time to several days, depending upon whether their imaging sensors are steerable or not. An immediate priority implied in the strategic objectives not well served by existing EO polar orbiting satellites is enhanced temporal coverage, which can be partially achieved through multi-satellite constellations. Rapid Eye, with its 6-hourly repeats, and the DMC mini-satellite constellation, with its daily coverage, are two examples. The requirement for near-real time coverage (eg at a frequency of an hour or better) can only be satisfied in the context of rapidly evolving natural disasters, such as bushfires, through persistent imaging from geostationary satellites. There are a number of foreign-operated geostationary EO satellites providing vital data covering parts of or all of Australia's continental landmass. These weather satellites generally provide near real-time imagery within the visible and infrared regions of the spectrum, but only at low resolution, generally at 1km for the visible and 3-5km for the infrared bands. Such spatial resolution falls short of requirements for other than very broad scale monitoring.

As exemplified by the GOCI imaging payload on the Korean COMS-1 satellite, spatial resolution of 500m is achievable within the visible spectrum from a geostationary EO satellite. Moreover, enhancing this resolution to 300m is seen as quite feasible with today's technology. For resolutions higher than around 300m, large aperture optics are required, as is high dynamic stability to support the longer integration times. These factors rapidly drive up design complexity, size and cost.

Two of the compelling drivers for a geostationary EO satellite with persistent imaging are near real-time bushfire and weather monitoring, both applications requiring imagery in the thermal infrared spectrum. However, not only is the feasible spatial resolution of thermal imagery an order of magnitude less than that achievable with GEO visible and NIR sensors, but the associated hardware requirements of cryogenic cooling renders imaging in the thermal infrared spectrum (wavelength of around 11-14μm) infeasible for hosted payloads. Instead, a dedicated GEO imaging platform would be required, with costs also being an order of magnitude more than those associated with a circa $50 million, 100-odd kg hosted imaging payload.

The persistent coverage characteristic offers a compelling reason for ranking a GEO EO imaging capability (hosted payload or dedicated satellite) as a top priority potential investment for Australia. The benefits to meteorological forecasting and the general remote sensing community involved in land cover classification and monitoring would be considerable. Countering enthusiasm for GEO satellites, however, is the fact that in relation to disaster monitoring, the spatial resolution is usually too low to be particularly useful, and the provision of thermal imagery needed for real-time bushfire monitoring is infeasible for all but very costly, dedicated GEO satellites. In the event that Australia was to collaborate on a GEO imaging satellite program, the logical countries involved would be China, South Korea and Japan, because of the common longitude with Australia.

2) Membership of a Satellite Constellation Consortium

A low-cost and viable option for rapidly enhancing Australia's participation in EO satellites is via a satellite constellation consortium, perhaps best exemplified by the Disaster Monitoring Constellation (DMC). This fleet of sun-synchronous satellites, which are individually owned and controlled by different countries (Algeria, China, Nigeria, Turkey, Spain and the United Kingdom), have orbital spacing such that any part of the globe can be imaged every day. The multispectral imaging satellites generally have spatial resolutions of 22m or 32m, but the recently launched Nigeriasat-2 has a 2.5m very high resolution mode as well, and Beijing-1 has a panchromatic imaging mode at 4m resolution. The merit of the DMC model is that imaging from the UK-tasked fleet of satellites can be coordinated such that major disasters can achieve daily coverage, irrespective of geographic location.

All DMC satellites are built by Surrey Satellite Technology Ltd. (SSTL) in the UK. SSTL has a unique model of up-skilling personnel from the participating countries through comprehensive training and development programs. For example, the Nigeria-X satellite was built by Nigerian engineers who received their education and training at SSTL. Such development programs would be very beneficial to the bootstrapping of any EO satellite manufacturing undertaking within Australia.

The DMC model is well established, cost-effective and 100% successful, and has been in operation for close to a decade, but it is not the only prospect for Australia. Another example, while admittedly still at concept stage, is the TerEDyn (formerly LOGICAL) mission, TerEDyn being an acronym for Terrestrial Ecosystem Dynamics. This initiative has been proposed to NASA as a cost-effective augmentation and gap-filling satellite for Landsat. The goal of the TerEDyn concept is to derive cost-effective alternative solutions that can provide imagery of sufficient quality and quantity to augment global Landsat coverage, and to serve as a back-up to Landsat. In essence, this means additional multispectral imaging satellites, which have baseline specifications consistent with those of Landsat, but which are an order of magnitude less costly than the billion dollar or so price tag of a new Landsat satellite. Once again, an aim of the constellation implied in the TerEDyn and DMC concepts is improved temporal coverage, and continuity of coverage.

Were Australia to have its own EO satellite in polar orbit, there would be the potential of participating in broader CEOS space agency collaboration and cooperation, one aim being to coordinate multiple missions to enable provision of merged data products to improve ground coverage and revisit rates.

3) Upgrading Australia’s Ground Receiving Stations

The upgrading of Australia’s satellite ground receiving stations has to assume some priority irrespective of what the country decides to do in relation to committing to ownership or part ownership of EO satellites, or to data downlink and access arrangements. With the many new EO satellites on the horizon, 20-fold increases in imagery data volumes can be expected over the next half decade or so. Also, bandwidth requirements for image data transmission in the ground segment are increasing all the time. These considerations, coupled with requirements from satellite operators that copies of downlinked data be supplied back to the operator in near real-time (eg within an hour or two), suggest that new data processing capability and upgraded high-speed communications infrastructure is required now for Australia’s ground stations.

Concluding Remark

By way of a concluding remark, the highest priority for users of EO data in Australia could be said to be continuity of supply of imagery from current and planned international EO satellite programs at the desired spectral, spatial and temporal resolution, the latter being constrained somewhat by the nature of sun-synchronous polar orbiting satellites, steerable or otherwise. Access arrangements to high spatial resolution EO imagery, of say 1m resolution and better (eg GeoEye-1, WorldView-2, Ikonos, etc), are currently commercial, with the cost of the imagery being seen as prohibitive for broad-area applications such as state-wide environmental monitoring or land cover/use mapping. In this category of imagery there is limited vulnerability to supply. In the medium-resolution imagery arena, however, where government funded or subsidised EO satellite programs prevail, there are presently threats to continuity of supply in long-term programs upon which Australia has come to rely. There are only limited options available in planning to accommodate possible interruptions to data supply from programs such as Landsat and the now defunct ALOS, but one option is more active engagement at international level within the EO data supplier and user communities. The need for increased engagement at federal government level with a wider variety of satellite suppliers/operators is implicit within the three priority needs that have been outlined here.

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