National Elevation Data Framework

The Shared Digital Representation of Australia's Landform and Seabed

Business Plan

Version 3

26 October 2007

Contents

EXECUTIVE SUMMARY

The purpose of the proposal is to develop a collaborative framework that can be used to increase the quality of elevation data and derived products such as digital elevation models describing Australia's landform and seabed. The aim is to optimise investment in existing and future data collections and provide access to a wide range of digital elevation data and derived products to those who need them.

The strategic imperative is how to optimise Australia's investment in elevation data and ensure this investment is directed at policy and operational needs at both national and local levels. It is about putting the "third dimension" on the national agenda.

Impetus for a national approach to collection of digital elevation data is coming from a range of sources. Most recently, the Council of Australian Governments (COAG) identified as a priority:

> Develop a national digital elevation model (DEM) for the whole of Australia, with vulnerable regions being mapped using very high-resolution images. This would involve linked topographic and bathymetric information at a resolution relevant to decision-making.[1]

A national workshop on the requirements for elevation data for coastal vulnerability to climate change identified the need for a new collaborative approach to how elevation data could be collected and managed in Australia. The workshop concluded that the development of a national elevation data framework was a priority to support the COAG agenda in areas such as coastal inundation and flood mitigation.

A key challenge is how to prepare for future high-resolution elevation data derived from an increasing range of aerial, satellite and ship borne sensors. While broad coverage of elevation data at high resolution is becoming a reality at lower unit cost, there are still significant investments to be made in capturing, processing, managing and providing access to elevation data.

Workshops to address user requirements and implementation details were held around Australia in July-August 2007. Over 300 participants and fifty written responses were then used to develop a comprehensive user needs analysis setting out requirements for the framework and identifying detailed data needs for around 100 important functions and application areas found in all levels of government and industry. Immediate needs are in key areas such as climate change, water management, disaster mitigation, infrastructure planning and management, industries such as insurance and mining and in local planning.

There was widespread support for the development of a National Elevation Data Framework (NEDF) that addressed national governance needs, shared investment in the next generation of high-resolution elevation data collection and improved access to data. The workshops also identified implementation issues, including development of national standards and an improved integrated land-sea vertical datum. High priority was given to provision of a coordinated virtual data repository and one-stop online portal to improve access to elevation data. There is a need to address how the

[1] COAG: *National Climate Change Adaptation Framework*, 2006.

portal will operate, including functions of registration of data sets, data publishing, access, metadata and linking of data sets from diverse sources.

Although there were different elevation data requirements based on a wide range of different applications requiring various accuracies and coverage, there is still a use (as a default) for a nationally consistent “freely available” elevation data product. There is general support for the concept of a seamless multi-resolution extensible national digital elevation product incorporating both topography (land) and bathymetry (sea). The outer boundary of the bathymetry should be the edge of the continental shelf and may be extended to cover external territories and the Australian Antarctic Territory. Within the product there will need to be a nesting of elevation data of variable resolutions and accuracies collected from various sources and platforms, which reflected the fit-for-purpose needs at any particular time. The product should be developed within the national elevation data framework and where possible meet the needs of national programs.

Particular mention was made of the private sector providers’ willingness to participate, if there was an appropriate level of return on investment. Private sector concerns focused on intellectual property (IP) being addressed up front and carefully, as this will affect private sector investment. The private sector has shown it is willing to invest if both needs and risks (funding, IP) are known.

The top five needs voted by workshop participants (in order of importance) were:

- Develop and apply national standards for elevation data and access.
- Better ability to find and access elevation datasets, using a virtual data repository and a one-stop portal.
- Close the data gap along the coast between existing land and sea data sets.
- A common vertical datum for both land and sea elevation data, with an updated Australian Height Datum (AHD) specification fit for higher resolution data.
- Leadership to develop a coordinated national elevation data acquisition program that is funded and involves all stakeholders and sectors.

There is a need to continue to engage with users with many interests in such a national capacity. The private sector has strong interests and should be broadly engaged. Issues to be addressed include:

- Governance arrangements that foster collaboration amongst stakeholders across organisational, jurisdictional and sector boundaries.
- A standards-based approach that facilitates integration of data from a variety of sources to meet a wider range of purposes and indicate fitness for purpose to potential users.
- Access arrangements that facilitate sharing and reuse of data and address issues such as licensing, security and liability.
- Consistent access mechanisms, such as web services that facilitate easy searching and access to data.
- Research to address and resolve remaining issues.

Key implementation initiatives are:

1. Business model and governance structures
2. Stakeholder engagement through facilitated communication networks and forums
3. Implementation task leaders and groups
4. National standards and common vertical datum
5. Virtual data repository and online portal
6. Shared investment model, national elevation data acquisition program and gap filling priorities
7. Nationally consistent elevation data set(s)
8. Research and development imperatives

The business plan sets out how such initiatives can be developed and carried out. More detail about specific technologies, national elevation data products, datum and other technical issues can be found in the NEDF Science Case. Detailed consideration and timeframes for next steps will be developed in the NEDF Implementation Plan after the national workshop planned to be held in Canberra in December 2007.

1 INTENT OF A NATIONAL ELEVATION DATA FRAMEWORK

"My dear Watson, I think I am beginning to see the first dark contours of this affair, the lines from which a complete and beautiful map will ultimately emerge."

Attributed to Sherlock Holmes[2]

The use of digital models depicting the earth's surface is not new. A large number of individual projects have developed these models for specific scientific research and operational needs over the past three decades. Initially, data used to create these models was digitised off existing topographic maps (over land) and hydrological charts (over the seabed). More recently, remote sensing and digital depth-sounding technologies have been harnessed to collect more precise data with wider coverage, leading to improved modelling of the earth's surface and seabed.

Adding all known, and potential, needs for elevation data together indicates that a full picture of the earth's surface covering the full extent of Australia's sovereignty will result[3]. Of course, differing requirements mean that the accuracy, resolution and attributes of parts of the picture may vary. However, the strategic intent of advocating coverage of Australia's landform and seabed is to explore the economies of scale, reduction of duplication, sharing of expertise and wider access to data amongst the many stakeholders developing and using digital elevation models (DEM)[4].

A recent comprehensive user needs analysis identified the need for a conceptual framework that addressed national governance needs, shared investment in the next generation of high-resolution elevation data collection and improved access to data. This framework should be implemented as a federated virtual elevation data repository and one-stop online portal to improve access to elevation data.

There is also general support for the concept of a seamless multi-resolution extensible national digital elevation product incorporating both topography (land) and bathymetry (sea). The outer boundary of the bathymetry should be the edge of the continental shelf and may be extended to cover external territories and the Australian Antarctic Territory. Within the product there will need to be a nesting of elevation data of variable resolutions and accuracies collected from various sources and platforms, which reflected the fit-for-purpose needs at any particular time. The product should be developed within the national elevation data framework and where possible meet the needs of national programs.

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[2] Larry Miller, *Sherlock Holmes and the Ice Palace Murders*, Penguin Books, 1999.

[3] Territory and/or submerged land subject to Australian sovereignty or shared sovereignty, taken in this paper to mean out to the edge of the continental shelf. The legal continental shelf includes areas of seabed beyond the 200 nautical mile Exclusive Economic Zone. For practical purposes, some areas of depth (say beyond 200m) may be excluded from the national DEM and it is probable that various resolution elevation data will be required for different zones based on depth or geography.

[4] The term "digital elevation data" is used to describe all data types depicting elevation. Specific terms are used to describe the products derived from these data. Therefore, the term "digital elevation model" is used generically throughout this report to mean a collection of data depicting "bare earth" terrestrial landform and the seabed. The term "digital surface model" has a broader meaning, including digital depiction of a surface that may or may not be of the "bare earth" but may include tops of artefacts such as building or trees. Another widely used term is "digital terrain model"; a general term applied to any digital representation of a topographic surface, including models of elevation, slope, aspect or other terrain attributes and usually related to land as opposed to water.

It is proposed that a National Elevation Data Framework (NEDF) be created to coordinate activity and optimise the potentially large investment in new elevation data collection and use by all levels of government and the private sector. The Framework should have characteristics such as:

- **Strategic:** Take a broad view of the national interest, reflect current policy priorities, meet known and emerging operational needs across Australia and seek to develop Australia's capability in digital elevation data collection, modelling and application technologies.
- **Comprehensive:** Provide access to elevation data set for both landform and seabed covering the full extent of Australia's sovereignty.
- **Dynamic:** Maintained over a long timeframe that allows for incremental improvement of data accuracy and coverage over time as more data becomes available.
- **Flexible:** Meet local as well as national needs by providing access to data from many sources that may use various data collection technologies and allow for differing product specifications of data type, accuracy, resolution and attributes that reflect availability of data at any point in time.
- **Inclusive:** Encompass the efforts of many data collectors and the needs of many data users across the public, private and academic sectors.
- **Accessible:** Improve access to digital elevation data sources by publishing availability and using consistent data licensing and access arrangements.
- **Authoritative:** Report key characteristics of existing data to users, allowing them to find sources of digital elevation data that are the "latest and best available" to fit defined needs and built to agreed standards.
- **Efficient:** Add value (and where possible reduce cost) to those sourcing and using data by implementing pragmatic administrative and technical arrangements that make best use of existing organisational arrangements, market mechanisms and technologies.

In summary, a national framework will need to be a strategic vehicle that is driven by both data users and providers and builds on existing efforts. It should promote effective investment in elevation data and provide consistent standards and arrangements that give an outcome that is greater than just the sum of the individual efforts of many sources and users. It should form the basis for developing of the next generation of elevation data sets and derived digital elevation models.

The actual operational structure, form and contents of a national framework set out in this business plan grows out of an assessment of current situation, user needs analysis and views from stakeholders in all sectors.

2 CURRENT SITUATION

"But these contours are as yet shadowy, no more than dark wisps of possibility".[5]

2.1 Data Sources

Digital elevation data can be derived from a number of sources. These sources include:

- Ground surveys – based on technologies such as leveling or real-time kinematic Global Positioning System (GPS) survey data that may be input directly into computer systems. Elevation data generated from survey is very accurate but can be an expensive and time-consuming process.
- Cartographic data sources - deriving elevation data from cartographic documents such as existing topographic maps and engineering plans showing contours and spot heights. This was the traditional method for obtaining first coverage over an area but is limited to resolution and accuracies of the source documents used.
- Remote sensing data capture - based on the stereoscopic interpretation of aerial photographs (photogrammetry), airborne scanning or profiling or a wide range of available satellite imagery. Resolution and accuracy is dependent on the source used. These sources are now the most widely used to collect new elevation data.

An apparent trend is to obtain broad coverage with ever-increasing resolution and accuracy as data from new remote sensing platforms come onto the market. These include instruments carried in aircraft and satellites. It can be said that acquisition of elevation data is moving into a high-resolution future. More information about these matters is contained in the NEDF Science Case.

2.2 Data Coverage

A national coverage land DEM was achieved in the early 1980's by the Bureau of Mineral Resources using digitised spot heights off 1:250,000 mapping. This initial coverage of the Australian continent was at the relatively coarse resolution of six minutes and its primary purpose was to assist geomorphology studies. This model was subsequently improved upon by digitising spot points from other map series, notably 1:100,000 maps. The project, began in earnest around 1984 was called the Digital Terrain Model of Australia and collected significant low, high and change of grade points with a published accuracy of 20 metres in height. The initial driver for this project was line-of-sight analysis for allocation of electromagnetic spectrum by the then Department of Communications, mainly in the eastern states but eventually achieving national coverage. The national coverage at 1.5 minutes - error corrected and drainage enforced - was done and released for general use by CRES/ANU by Hutchinson and Dowling in 1989. Incremental improvements have been made over the years to meet the needs of other users. An ongoing collaborative project between CRES/ANU and Geoscience Australia (GA) has been adding new data mainly derived from topographic feature data and then using a filtering, drainage enforcement and

[5] Larry Miller, op cit.

smoothing algorithm called ANUDEM. It has led to products such as the GEODATA Nine Second DEM available from GA. The first version of this product was released in 1996. Version 3 is about to be released.

The GEODATA Nine Second DEM (DEM-9S) Version 3: 2007

The GEODATA 9 Second DEM Version 3 will be, like earlier versions, a gridded digital elevation model with grid spacing of 9 seconds in longitude and latitude (approximately 250 metres). It is computed from topographic information including point elevation data, elevation contours, streamlines, lake edges, sink points, cliff lines and coastline. 9 Second DEM is a cooperative effort of Geoscience Australia and Centre for Resource and Environmental Studies (CRES) at the Australian National University. The DEM was derived primarily from Geoscience Australia GEODATA TOPO-250K and 1:100,000 map data. Theoretical estimates indicate that root mean square elevation errors range between 7.5 and twenty metres across most of the continent.

Most State and Territory mapping agencies achieved DEM coverage over their jurisdictions during the 1990's and early 2000's at a range of resolutions. In the case of NT and WA, it was derived from the GEODATA data set. In others, such as, Victoria and NSW, it was digitised contour and height data from existing large-scale State map series. Queensland developed a new data set from Shuttle Radar Topography Mission (SRTM) data sourced from NASA in the United States, in addition to catchment-based DEMs derived from topographic map data. In other cases, such as Tasmania, a mixture of sources was used. All these jurisdictional data sets are of varying resolution and accuracy is not always quoted. Details of these data sets can be found in the Australian Spatial Data Directory (ASDD) accessible from the Geoscience Australia or jurisdictional websites.

QLD Catchment Digital Elevation Models

Queensland Department of Natural Resources and Water have derived 25 metre Digital Elevation Models (DEMs) over the majority of eastern and southern flowing drainage basins in Queensland. The ANUDEM modelling software was used to produce 25 metre floating-point grids. Source digital data were contours and drainage from GA 1:100000 map sheets with a 20 metre contour interval for most areas and some 40 metre contours. Drainage lines were pointed in the direction of flow to ensure the output DEMs were as hydrologically correct as possible. The average accuracy of the source data is +/-25 metres in the horizontal position and +/- 10 metres in elevation. The derived DEMs are being used for a broad range of modelling ranging from catchment runoff to prediction of bushfire risk.

In this same period, individual projects developed DEM coverage over limited areas to meet specific needs. State, Territory, a few local governments and firms in areas such as land and project development carried out these projects, often outsourced to commercial survey companies. It is at this level that the DEMs with highest resolution

were captured. These projects were focussed on terrestrial studies, with some limited coverage of the seabed in ports and territorial waters.

2007 Port Phillip and Western Port LiDAR Project

The 2007 Port Phillip and Western Port LiDAR Project is currently underway collecting high accuracy LiDAR data including both on and off shore areas. The project is being implemented through the Victorian Department of Sustainability and Environment's Coordinated Imagery Program (CIP) and is a good example of the benefits of collaboration.

Initially the project started with a number of local government councils and a water utility approaching looking to purchase LiDAR data over a common area. Through CIP's efforts further purchase partners committed sufficient funds to significantly increase the size and accuracy of the project. This project has since developed into a large acquisition project with purchase partners including Local Government, Water Utilities and DSE, and as a result has increased the captured area to five times the original area.

The project is using LiDAR to capture both terrestrial and bathymetric data for a wide range of purposes including urban planning, coastal erosion and climate change. Contours of 0.5 metre intervals are being derived from terrestrial LiDAR. Ground and last return surface models are also being created. This data will be used for a variety of projects including the assessment of coastal erosion over consecutive years, flood modelling in urban areas and the differentiation of tree and building heights.

Bathymetric LiDAR or Laser Airborne Depth Sounding (LADS) is a technology that enables the collection of the sea bed information to a depth of about 50 metres. The detail on the sea bed is expected to be used by purchase partners to assist with modelling of coastal erosion, and coastal storm surges to inland areas and may even help better define Victoria's Coastline.

Significant local projects are funded from various national programs.

$1.37m for Digital Elevation Modelling to produce accurate, high-resolution orthophotography data for the Victorian NAP regions.

This will contribute significantly to regional planning activities, particularly in modelling and the identification of aspects of the landscape such as land use, wetlands, discharge sites, salinity-affected land, soil erosion and farm dams.
(Joint Media Release by the Federal Minister for the Environment and Heritage, Federal Minister for Agriculture, Victorian Minister for Agriculture and Victorian Minister for Environment, 9 July 2003)

Digital elevation data and aerial photography, provides ground height information and enables the analysis of features such as land profile, drainage, flood plains and vegetation cover. This information is also proving of immense value to local government. (Wimmera CMA 2007)

There is significant coverage of bathymetric depths out to the continental shelf, with digital data mainly collected for navigational and mineral exploration purposes.

Australia's Digital Chart: Australian Bathymetry and Topography Grid (1963-2002)

The topography is from Geoscience Australia (GA) 2nd edition digital elevation model for Australia. The bathymetry is from digitised charts obtained from the Australian Hydrographic Service (AHS), swath bathymetry surveys, and other ship-track data of various vintages and navigational accuracy sourced from Geoscience Australia databases. The grid was generated from over 200 million data points gathered from numerous data sources as part of the Continental Margins Program. It includes data collected since 1963 from surveys by GA, AHS, industry and foreign agencies and from over 200 days of modern deep-water seafloor swath-mapping surveys. In some areas not covered by marine surveys, it incorporates bathymetry data derived from predicted bathymetry from satellite measurements. Data has been resampled to a 9 second grid to align with the GEODATA terrestrial product.

Most recently, there has been growing interest in using ubiquitous and increasingly accurate satellite remote sensing to develop a wider coverage DEM for specific purposes. The latest large-scale need is driven by the need to model coastal vulnerability to storm surges, tsunamis and potential rise in sea levels.

Coastal DEM Project

A high quality DEM is needed to be able to model inundation, and therefore both inform future decisions and assess current vulnerability. It was noted that damage from inundation is very costly. A contiguous national framework DEM was seen as the basis for vulnerability assessment, although users will often derive regional information at resolutions and accuracies specific to their purpose. An initial purchase of SPOT HRS data sourced as a DEM and stereo pairs has been made covering the entire coastline by the Australian Greenhouse Office. It is understood that the licence for the data allows usage by a wide range of users. Resolution of the data is quoted as around 15m horizontal and 10m vertical.

The most problematic area for DEM coverage is in the littoral (near shore) seabed. Tradition collection techniques tend to be relatively slow and costly in comparison with high volume and wide coverage collection by new remote sensing technologies such as LADS. At present, these new technologies are not particularly suitable for intertidal areas with turbid waters. The collection of digital elevation data near shore is seen as an impediment in developing models of seawater movement in the near shore and onto land. It may be one of the most significant challenges in achieving future high resolution DEM coverage.

More detailed information about existing digital elevation data sets can be obtained from a recent audit of digital elevation data (currently over 900 records covering all jurisdictions) carried out by Geoscience Australia for ICSM. Geoscience Australia also maintains a catalogue of bathymetric data sources (reporting over 9 billion

soundings). The following table provides a summary of some existing digital elevation data sets. Information is derived from Australian Spatial Data Directory (ASDD) records or other published data. It shows the large number of digital elevation data sets collected over the past three decades from a wide range of sources. Generally, resolution and accuracy increases down the table, reflecting Australia-wide, jurisdictional, then project-based coverage.

Data set	Collection Dates	Source	Horizontal Resolution	Height Accuracy
GEODATA 9S national coverage	1980s to present	1:250,000 and 1:100,000 topographic maps	9 second (about 250m) grid	RMS 7.5m to 20m
Australian Bathymetry and Topography Grid	1963-2002	AHS Charts, various bathymetric surveys	9 second grid	Variable depending on source
NSW DTDB	1998-1999	Large scale maps, including 1:4000 orthophotos	5m grid	Variable depending on source
Queensland 3 second DEM	2000	SRTM Radar	3 second (about 90m) grid, estimate 20m accuracy	16m
Vicmap DEM	1974-present	1:25,000 maps	Estimate 10m accuracy	Not stated
Australian Coastal DEM (planned)	2007-	SPOT 5 Satellite HRS	Less than 15m	10m optimal
Many		Aerial photography	Depends on photographic scale – 0.5 to 2m	Depends on photographic scale
Various	1990s to present	Airborne scanning and profiling, eg LIDAR	Depends on instrument and flying height, down to 5m grid	Depends on instrument and flying height, estimate 15cm
Many	1980s to present	Field survey using levelling techniques	Average 20m grid	Down to millimetres
Emerging	2000s	Field survey using GPS heighting	Depends on sampling interval	Sub-metre using kinematic techniques

2.3 Access to Data

The *Australian Natural Resources Information 2002* report by the National Land and Water Resources Audit (NLWRA) concluded that:

"When undertaking the Audit assessments, the best quality and most accessible Australia-wide data included climate, geology, agricultural statistics, and topography (roads, rivers and elevation) data. These sets of data had been developed through long-term Commonwealth and State/Territory programs, applying agreed standards to develop products that were consistent across Australia."

However, the report recommended greater coordination of effort and standardisation to make these data more accessible.

At present, digital elevation data and derived products are available from individual agencies or commercial suppliers holding the data. Geoscience Australia does make available the principal national DEM data sets and those jurisdictional data sets derived from the national data. In the case of Queensland, a private company is the custodian of the State-wide SRTM data set. Data from Geoscience Australia and other Australian Government agencies such the Department of Environment and Water Resources (DEW) make data available under the ubiquitous Australian Government *Spatial Data Access and Pricing Policy*. The States and Territories make their data available under jurisdictional access and pricing policies or each agency sets its own access conditions. Generally, all public agencies now require acceptance of a licence agreement setting out restrictions to use. These quasi-commercial access and pricing arrangements reflect practice in accessing and using data provided by commercial sector.

Development of coordinating concepts, such as national spatial data infrastructure is already available for use across a wide range of data types. Digital elevation data, representing the "third dimension", is generally viewed as a fundamental data set within these infrastructures. However, it can be concluded from the history of these infrastructures that two-dimensional data has been the focus for coordination efforts and that elevation data has not had a high profile. This history reflects the high investment in converting planimetric data such as cadastral, natural resource and economic infrastructure to meet key user needs.

3 KEY STAKEHOLDERS

3.1 Users

There are many actual and potential users of digital elevation data and derived products. There are also multiple sources/providers of these data. The full "marketplace" for elevation data and products has been explored through workshops held around Australia during July-August 2007. These workshops attracted over 300 people representing public sector agencies, industry users, private sector providers and academic institutions. There were also around 50 written responses to a questionnaire circulated in association with the workshops.

Key uses of elevation data are found in defence, hazard management, climate studies, natural resource management, environmental planning and monitoring, land development, utility services, telecommunications, navigation, insurance, mining and agriculture.

For example, the land surface is a fundamental control on earth surface, and near earth surface atmospheric, processes. So strong is this linkage that an understanding of the nature of terrain can directly confer an understanding of the nature of these processes, in both subjective and analytical terms. Thus digital elevation models have been used widely over the last twenty years to support assessment and analysis of climate, hydrology, agriculture, forestry and biodiversity.[6]

Provision of economic infrastructure, including road, rail, pipeline, sea lanes and utility services requires specific height and terrain detail along transport and network corridors. High resolutions suitable for engineering design and construction are usually required. In fact, this more detailed data can be used to increase the accuracy of lower resolution data in surrounding areas collected for wider purposes.

Local government usage of digital elevation data tends to focus on land development and engineering projects. Most local governments have purchased image coverage of their operational area, usually in the form of aerial photography or satellite imagery, used for a variety of operational purposes. This is sourced from other government agencies or direct from commercial providers. Many have also flown airborne LIDAR using funds from State or Australian Government programs.

The full list of needs identified in the workshops can be found in the detailed user needs analysis.

3.2 Providers of Elevation Data and Products

The division between users and providers is somewhat arbitrary. Some providers supply raw digital elevation data, but often use the data to fabricate derived data products, such as DEM, that are then supplied to particular users. In nearly every case, the main providers of elevation data also provide other forms of spatial data. For example, public agencies provide products such as topographic and orthophoto maps

[6] From *ANUDEM guide*, ANU/CRES.

and digital data sets that combine height and feature data. Private sector providers often provide elevation information in the form of derived products such as site plans with contours and as-built features, or photographic images with added terrain detail. Therefore, some providers may also be classed as users of raw elevation data.

Generally, government agencies have been the providers of medium resolution (say greater than 5 metres) products, with commercial operators providing the higher resolution data and derived products.

Some key providers are shown in the table below.

Sector	Key Providers	Key Data and Products
Australian Government Agencies	Geoscience Australia DIGO AHS	Topo mapping and DEM Topo mapping and DEM Hydrographical data and charts
State and Territory	Mapping agencies Spatial data managers within State, regional and local bodies	Topo mapping and DEM Project mapping and DEM
Commercial Sector	Remote sensing (photography, LIDAR, satellite imagery) service providers Land surveyors	Aerial and satellite imagery and derived elevation products; Project DEMs derived from field survey
Research and Development	CRCSI CSIRO ANU/CRES Universities	Fundamental research on standards, platforms and data capture Interpolation and analysis algorithms

Note that some elevation data may not be made widely accessible. In some instances, there are real constraints imposed for particular data by national security concerns, especially high-resolution imagery over sensitive national infrastructure. Other sensitive areas may include seamounts, where risk of poaching of endangered marine species is high.

Another class of constraint are licence conditions imposed by commercial data sources. Such conditions may limit usage of data to the original purchaser. These conditions are usually subject to negotiation and it is often possible to arrange sharing of data if such an aim is foreseen and encompassed in procurement contracts.

3.3 National Facilitators

There are several stakeholders who have a role in fostering a nationally coordinated approach to digital elevation data. These stakeholders include:

- Ministers whose legislative responsibilities or policy directions give them an obligation to pursue sharing and coordination to fulfill their separate mandates and whose portfolio agencies rely on current data for policy setting and decision making, covering areas such as disaster management, environment, natural resources and defence.
- Various Ministerial Councils under the aegis of COAG, such as the Online and Communications Ministerial Council and the Natural Resource Management Ministerial Council that represent key government enablers and users of digital elevation data.
- Inter-departmental Committees (IDC) comprising Australian Government agencies with an interest in technologies or uses of digital elevation data, such as the IDC for Commercial Satellites.
- ANZLIC – the Spatial Information Council that brings together the interests of the major public sector agencies with a role in providing relevant data infrastructure and digital elevation data in their respective jurisdictions.
- Intergovernmental Committee on Surveying and Mapping (ICSM), an ANZLIC Standing Committee comprising technical specialists in all governments.
- Other inter-governmental coordination bodies representing specific user communities (such as the National Committee for Soil and Terrain).
- CRCSI as the pre-eminent research body in the DEM space and its links with the broader research community with specific application of digital elevation data.
- PSMA Australia as a provider of national data sets sourced from all jurisdictions.
- GA as sponsor of the national mapping program, working with all jurisdictions to capture and maintain topographical information at largest possible scale.
- ASIBA as representative of commercial providers and links through to a wide range of users of remote sensing, photogrammetric and mapping services.

A key coordinating group is ANZLIC. This council comprises senior representatives of the Australian, New Zealand and State/Territory governments with responsibility for providing the fundamental spatial data sets across Australia and New Zealand. It sponsors initiatives such as the Australian Spatial Data Infrastructure (ASDI), has strong links with other peak bodies in areas such as disaster management, national security, local government, natural resource management and the marine environment. The ASDI is an overarching concept, incorporating the view of a cohesive data infrastructure over both land and sea to cover the full area of Australia's sovereignty.

An alignment of some coordination groups has already been achieved to help facilitate a national approach. ANZLIC, AGO and GA have entered into a collaborative arrangement and have engaged key Australian Government, State and Territory agencies, ICSM and the CRCSI to develop appropriate governance and technical arrangements.

4 NEED FOR A NATIONAL ELEVATION DATA FRAMEWORK

Government agencies at all levels, the community and industry are driving significant increase in the demand for high quality spatial data. Issues such as climate change, coastal vulnerability, water and natural resource management, emergency management, health and safety issues all require fundamental spatial data at a range of scales to meet specific requirements. Fortunately in some instances a few key datasets, such as digital elevation data and derived products, can help meet a range of needs.

A number of past reports have highlighted the need for national coordination of spatial data to meet a broad (and growing) range of user needs. In Australia, the coordinated effort to make spatial data more accessible is encompassed in Australian Spatial Data Infrastructure concept sponsored by all jurisdictions through ANZLIC. It identifies key requirements in national governance, accessibility, data standards, systems interoperability and integratability of data sets across jurisdictional borders.

Efforts to create national frameworks for specific data types include the work of PSMA to integrate jurisdictional data to create nationally consistent data sets in cadastre, road centreline, street address and others. National frameworks are being created for property transactions (National Electronic Conveyancing System), street and postal address (National Address Management Framework) and natural resource information (Australian Natural Resource Information Infrastructure). Over the sea, GA and AHS already have considerable sounding data from a wide variety of sources. Drivers include economic efficiency, reduction of duplication, meeting the needs of emerging applications requiring multi-source data, improving Australia's international competitiveness, focussing research effort and supporting decision-making in national security, disaster management, navigation, climate change and other areas that cross jurisdictional borders.

Case Study: Counter-terrorism and Emergency Management
Situational Awareness and modelled Impact Assessment for Counter Terrorism (CT), Critical Infrastructure Protection (CIP) and Emergency Management (EM) activities under the NCTC, NCCIP and AEMC endorsed National Spatial and Information Management (NSIM) Spatial Strategic Plan 2007-2010.
The ability to collaboratively share information and identify the gaps under a national framework means:

1. Raising awareness of what the framework can provide to new and existing user communities.
2. Establishing an agency/department or authority "champion" that actively promotes and drives forward the use of the underlying data.
3. Ensuring that the framework uses national standards that are commonly used by existing capabilities to avoid the push-back when changes are demanded from those existing capabilities.
4. Building a framework based on actual user requirements so you develop a framework that achieves what the user wants, not what you think they want.
5. Confront licensing, information sharing and technical limitations issues and provide viable resolution options.

The *Status of Natural Resource Information 2005* Report by NLWRA recognised the importance of a range of national data sets, including a DEM for natural resource management, including:

"A national DEM of Australia's rivers and streams, including flow directional data, river reaches, water bodies, coastline, and other associated information".

This report recommended the need to:

"Encourage the use and, if necessary, the development of nationally agreed, publicly accessible data layers for drainage divisions, river basins, catchments, river reaches and geomorphic zones and a consistent digital elevation model."

In specific relation to elevation data, there is no nationally coordinated framework that enjoins all stakeholders.

The Council of Australian Governments requested the development of a National Adaptation Framework in February 2006 as part of its *Plan of Collaborative Action on Climate Change*. This Framework outlines the future agenda of collaboration between governments to address key demands from business and the community for targeted information on climate change impacts and to fill critical knowledge gaps that currently inhibit effective adaptation. A key focus of the Framework is to support decision-makers understand and incorporate climate change into policy and operational decisions at all scales and across all vulnerable sectors. A priority identified in the Framework is:

"Develop a national digital elevation model (DEM) for the whole of Australia, with vulnerable regions being mapped using very high resolution images. This would involve linked topographic and bathymetric information at a resolution relevant to decision-making."

Case Study: Flood Mapping

Notwithstanding the prospect that residential flood insurance may become more widely available in the future for certain types of inundation, the Insurance Council estimates that there are approximately 170,000 homes in the community where a high flooding risk may lead to high localised premiums or a simple lack of availability where insurers can not accept the risk level.

The key for consumers today, is to ensure that they are informed of the current flood risks to their home and to take feasible and available mitigation steps.

The Insurance Council and Government have engaged on the flood issue through the newly formed National Flood Risk Advisory Group (NFRAG) operating under COAG. The key 'ask' from Industry to government(s) on this issue is the provision of all available flood mapping data currently held at Local, State & Federal agencies, for incorporation in the national flood map. Closely associated with this necessity is that the industry be given access to existing and planned Local, State & Federal digital elevation mapping initiatives.

Insurance Council of Australia website – call for nationally consistent flood mapping

Recently, a national workshop on the requirements for elevation data for coastal vulnerability to climate change identified the need for a new collaborative approach to how elevation data could be collected and managed in Australia. Workshop attendees included senior representatives of public, private and academic bodies covering a spectrum of providers and users of elevation data for a wide range of purposes.[7]

There was a general consensus that:

- Australia needs national consistency in DEM acquisition.
- There was a need to avoid duplicate structures across boundaries and for a coordinated framework with people working together in parallel.
- ANZLIC is well placed for national coordination due to its jurisdictional position.
- National coordination supports the principle of gathering data once for many uses.
- It may take some time (maybe a couple of years) to lay down the implementation framework required as both technical issues, such as acquisition and data processing standards and administrative issues, such as access and licensing conditions, need to be resolved.
- Need to establish the principles under which the framework operates including the need to establish a 'single point of truth' and the framework under which data is to be made available to users.

Key reasons advanced for a national framework are summarised in the following table.

Issue	Risk	Benefit Sought	Solution
Meeting growing needs for three dimensional data	Lack of availability and access to relevant elevation data inhibits use in planning and decision making	Increased availability and easier access to elevation data fit for purpose and integrable with other data types	Clear understanding of broad range of user needs matched with data availability at national and local levels
Effective public investment in elevation data collection, management and use	Duplication of effort leads to increased costs for providers and users	Efficiency of scale, effective use of public funds, reduced acquisition, processing and data management costs, multiple use of data	Sharing data sources and expertise
Efficient use of investment	Lack of communication about future needs leads to inefficient	Increased collaboration in new data collection	Schedule of planned collection using public funds, collaboration to

[7] High Level Users Meeting: *Towards a Nationally Coordinated DEM for Assessing Coastal Vulnerability to Climate Change*, Australian Academy of Science, Canberra, 11 December 2006.

	investment		share resources
Main providers and users are found in all levels of government	Complex arrangements for access and use	Simplify access arrangements, encourage increased level of usage to improve decision-making at all levels	Institute consistent national governance and access arrangements
Funding of elevation data collection and ongoing data management	Under-investment in data that is needed to meet national and local needs	Investment levels sufficient to meet known and projected user needs	Raise profile of the value of elevation data through a national approach
Fitness for purpose	Use of data not suited to purpose because of variable or unknown data quality	Clear statement of data quality and fitness for purpose	Standard form of description of data sources, indication of point of truth data sets
Ability to share or integrate data across projects and jurisdictions	Wasted effort in reformatting or re-sampling data for reuse	Ability to reuse and integrate data	Use of appropriate (inter)national data standards and best practices
Industry development	Lack of capacity in local industry to meet needs for elevation data and products	Increased use of private sector leading to increased investment by local providers	Industry capability well understood by users, use of consistent procurement practices
Research and development	R&D not aligned to priorities of providers and users.	Focused R&D effort to increase quality and application of elevation data for both national and local needs	Collaborative research based on better knowledge of national priorities

Some specific operational opportunities are identified in the US Government *Guidelines for Digital Elevation Data (2004)* developed for the National Digital Elevation Program:

- Past data acquisitions have led to a wide variety of accuracy, resolution, datum, projection, product type, format, and other idiosyncrasies making these datasets difficult, if not impossible, to share among different agencies.
- The lack of guidelines and specifications, especially for high-resolution, high-accuracy elevation data, has caused some data acquisitions to cost more than necessary due to over-engineering, while other data purchases prove to be inappropriate for the intended application due to inadequate specifications.
- Because of continuous capability improvements, increasing numbers of providers, and varying system designs, new elevation technologies such as LIDAR are rapidly evolving. Sharing the lessons learned about these technologies by

developing and refining a common set of elevation guidelines will reduce the chance of repeating mistakes across agencies and will help the purchaser acquire the required data as painlessly as possible the first time.

Case Study: Data for Science

For Australian researchers, collaboration with peers both in Australia and internationally, through (global) research networks, is essential. Connecting to such networks provides a strong incentive to share data, and around these networks or communities of interest there appears to be a growing awareness of the value of data and the need to deposit and manage them. Outside of such networks there is less incentive to preserve and manage data for the future.

While there are policies – at the funding body level and at the research organisation's level – there are no strong rewards for adequate data management or penalties for poor data management. In the absence of an organised infrastructure to support the deposit of data into repositories, good governance and policy guidelines, data storage and retention will continue to be patchy and suffer from duplicated effort, lost opportunities and poor use of skill sets……Our grants system needs to combat this perception by rewarding collaborative activities which promote re-use and data sharing.

(Prime Minister's Science, Innovation and Engineering Council – Working Group on Data for Science, *Pathways to Successful Data Management for Australian Science*, 2006)

5 IMPLEMENTATION ISSUES

5.1 Form of a National Elevation Data Framework

There are a number of potential forms that a national framework could take. It could be made up of one or more of the components shown in the following table.

Component	Opportunities	Threats
Catalogue of existing elevation data and products	Build on lists of existing topographical and bathymetric data being compiled, use existing ASDD structure	Many existing sources are still not known, history of metadata records not being maintained
Schedule of planned projects collecting or using elevation data	Basis for increased collaboration and reduced costs, allow providers to plan capacity needs	Many players, unwillingness to predict future activity
Body of agreed data and interchange standards	Many existing national international standards can be adapted to reduce costs of integration and access, and increase competitiveness of Australian industry	Lead time to develop and agree standards, ongoing compliance costs
Consistent access arrangements and agreed DRM schema	Reduced ongoing costs for both providers and users	Jurisdictional differences and costs to change existing practices
Identify available point of truth data set(s) from multiple sources covering defined geographical areas at any point in time	Users aware of current best available data sources to meet specific needs	Lack of mandate to assign status of data sets, lack of quality statements and documentation for collection and interpretation practices
An intuitive, single point of access discovery service for the entire network of sources	Users are assisted to access relevant data and not requiring an intimate knowledge of individual repositories	A data management function not currently carried out in an existing organisation
National Repository of Elevation Data	Single point of access and distribution for nationally significant elevation data and derived products across all jurisdictions	Lack of standards and mandate
Maintained national DEM, DSM or DTM product using nested best available sources, with variable resolution	Simplified product set, raise profile of importance and facilitate increased usage of elevation data	Provider willing to invest in product, one size may not fit all uses

Feedback from stakeholders during the NEDF jurisdictional workshops indicated that the form of the national framework should be:

1. Leadership and engagement of stakeholders through a business model and governance structures.
2. Stakeholder engagement through facilitated communication networks and forums.
3. National standards and common vertical datum
4. Virtual data repository and online portal including functions of registration of data sets, metadata, data publishing, digital rights management, linking of data from various sources, distribution and access.
5. Shared investment model including identification of forthcoming data capture programs, national elevation data acquisition program and gap filling priorities.
6. Nationally consistent elevation data set(s) including the concept of a “default” national data product using a “nested DEM” concept using data of varying accuracies depending on availability that may meet a number of known user needs.
7. Research and development program focused on national priorities.

5.2 Collaborative Principles

The National Service Improvement Framework provides a set of Principles to Collaborate. The principles seek to guide collaboration across agencies, jurisdictions and sectors by providing the starting point for understanding and agreeing the 'rules of engagement'. They acknowledge that barriers to collaboration are unlikely to simply disappear; rather they must be actively overcome.

Principle 1:
All parties to a collaborative service delivery arrangement must share a common vision and an understanding of the scope.

In a collaborative environment, conflicting pressures and priorities may exist among participants. As a result, it is important to ensure a common vision is developed, documented and shared for all joint work.

Principle 2:
Collaborative service delivery will be customer centric, requiring the customer constituency to be consulted and their views represented in decision-making.

Collaborative service delivery efforts must recognise improvement in the customer experience as a basic driver to collaboration. Therefore, customers need to be consulted early and often in the development process to fully understand their needs and priorities. This provides the opportunity to design and deploy services centred on customer business needs and processes. Common and streamlined business processes can provide a greater consistency of customer experience and improvements in public sector efficiency through higher levels of standardisation, reuse of business processes and information, and improved quality.

Principle 3:
Participants must demonstrate, through action, a willingness to make collaboration succeed.

Parties must find reasons "why" rather that reasons "why not". Collaboration must respect jurisdictional independence and identity and be sensitive to compliance obligations placed upon each party by pre-existent policy, legislative and administrative frameworks. Where a conflict between proposed collaborative arrangements and jurisdictional policies and/or legislation becomes apparent, parties must have a willingness to be pragmatic, focus on what is possible and take action to find solutions. Action must go beyond mere whole-of-government rhetoric.

Principle 4:
Collaboration arrangements must be collegiate and sufficiently flexible to encourage participation regardless of jurisdictional affiliation or size.

Collaboration arrangements must be flexible enough to allow for different participation levels in order to maximise project exposure to all relevant parties. Where possible, inclusive cross-jurisdictional structures (for example representative mechanisms) must be used in the decision making process.

Principle 5:
A standards based approach to collaboration will be employed whereby relevant standards and guidelines will be agreed early to steer all collaboration work.

Standards will be applied at all levels of collaboration, including the technical level to support the development of a secure, interoperable information technology environment and at the governance level to ensure both confidence and credibility in decision making. Existing standards, particularly international standards will be adopted where appropriate, with preference given to standards that have the broadest application. In areas where standards do not exist, a process will be agreed to determine standards.

Principle 6:
An analysis of all costs and benefits must underpin the initial decision and sustain the ongoing case to deliver collaborative services.

In order to be worthwhile and sustainable, the development of an integrated service must be founded on a full analysis of costs and benefits, tangible and intangible, real and imputed, capital and recurrent. The costs and benefits should be supported at senior political and executive levels with consistency between jurisdictions regarding what defines and comprises costs and benefits. The accrual of costs/benefits on a whole-of-government basis must be considered as well as those for individual agencies. Funding models may be used to balance inequalities between the costs and benefits to individual agencies.

Principle 7:
Governance arrangements in a collaborative environment must be explicit, open, transparent and sustainable and include a clear definition of accountabilities.

Governance arrangements must be both sustainable and progressively refined in recognition that the collaborative service delivery is not neat or linear, rather an iterative process. They must also be robust enough to anticipate and mitigate risks associated with changes in areas such as policy, personnel, government, and senior executive leaders. Governance mechanisms must be consciously kept to the minimum needed to achieve desired business objectives.

Principle 8:
Collaborative service delivery initiatives must be delivered in a secure environment with acceptable levels of privacy and confidentiality protection.

Providers and customers must be confident that reasonable steps will be taken to assure the security, privacy and confidentiality of any stored information.

Principle 9:
An express agreement between parties must support any collaborative service delivery.

The working arrangements/ rules of engagement between collaborating parties must be documented, signed by appropriate agents, and in an appropriate form.

5.3 Data Management Principles

Management of digital elevation data should not be viewed in isolation from other data types. There are some common practices applicable to all spatial data, especially when related to existing frameworks such as the Australian Spatial Data Infrastructure advocated by ANZLIC and in the natural resource space, the concept of an Australian Natural Resource Infrastructure (ANRII) advocated by NLWRA. A set of principles adopted by both infrastructures is shown in the box below.

National principles for spatial data management

- Data must be developed and maintained to **meet agreed international or national guidelines or standards** for the management of spatial information as endorsed by ANZLIC – the Spatial Information Council or through national coordination arrangements. *This will ensure the data are comparable and consistent where required.*

- Data must be **documented** in the Australian Spatial Data Directory. Documentation must be current and provide enough information for users to determine whether they are suitable for their purpose. *This will ensure that users can easily find out whether suitable data already exist.*

- Data must be **easily accessible** to all sectors of the community in format, location, cost and under conditions that do not inhibit their use. *This will ensure that users can obtain the data*.

- Data must be **accompanied by a licence** when transferred, clearly setting out the conditions under which they may be used, the rights and responsibilities of the data provider, and the rights and responsibilities of the data receiver. Licence arrangements are required to ensure that the data are accessible, while protecting copyright, intellectual property, privacy and confidentiality. The rights of the individual and governments in relation to confidentiality, privacy, security and intellectual property must be preserved. *This will ensure that the rights of all parties are protected and understood.*

- Before funding data collection, organisations and jurisdictions should actively **identify and exploit** the many existing **opportunities for cooperation and sharing of fundamental spatial data** to avoid duplication and maximise benefits of investment in data collection.

(From NLWRA *Australian Natural Resources Information 2002*, based on the principles developed by ANZLIC in 1999)

5.4 Governance Model

The objectives of a national governance arrangement must be:

- **Promoting national interests** – putting national interests alongside the particular interests of any jurisdiction. This requires independence in the strategic direction of the initiative and its day-to-day management.
- **Achieving jurisdiction co-ordination** – accommodating the differing perspectives of individual jurisdictions. This requires inclusive management committed to obtaining and fairly considering all views.
- **Securing industry engagement** – getting and maintaining the attention of all key stakeholders. This requires an open and dedicated consultation management process that arrives at conclusions rationally.
- **Delivering stakeholder consensus** – producing outcomes acceptable to all jurisdictions and stakeholders. This requires sensitive treatment of differing perspectives in an agreed issues resolution framework.

(From National Electronic Conveyancing System *National Governance Arrangements*)

The governance model adopted must be explicit, clarifying roles, responsibilities and accountability structures. It must support a clear understanding of relationships between the collaborating parties and users, and it must distinguish between shared and individual accountabilities. This principle applies equally when collaboration involves a private sector partnership

Development of the NEDF requires that some special roles be created or adapted from existing arrangements. A potential model is shown in the following table.

Responsibility	Lead Organisation	Key Participants
Leadership and communication	ANZLIC	All jurisdictions, peak bodies for commercial sector, research and standards
Stakeholder engagement (national level)	NEDF Steering Group representing government, industry and research	Stakeholder representatives
Stakeholder engagement (jurisdictional level)	Jurisdictional coordinators	Jurisdictional agency and local government Business and professional associations
Standards development and adoption	Technical Working Group	ICSM/PCTI Geoscience Australia DIGO AHS CRCSI ASIBA

The role of the NEDF Steering Group includes:

- Engaging key stakeholder groups in developing the national framework;
- Guiding, coordinating and assigning roles for implementation of the NEDF;
- Resolving key governance issues such as protection of intellectual property, data pricing and barriers to elevation data access;
- Enunciating key data capture requirements and priorities to meet known future user needs and promoting shared investment between programs where possible;
- Periodic review and reporting of progress on NEDF implementation to key stakeholders.

The role of the Technical Working Group includes:

- Developing and adopting relevant (inter)national standards needed to implement the NEDF;
- Issuing of guidelines based on these standards to assist both suppliers and users of elevation data to work within the NEDF;
- Reporting progress to the Steering Group and providing recommendations on technical and research issues needing to be addressed.

5.5 Investment Model

Investment in the national framework needs to be made at a number of levels, including:

1. Development and adoption of governance arrangements, setting up the business model, facilitating stakeholder engagement and ongoing coordination through the NEDF Steering Group and Technical Working Group and resolution of national standards, datum and digital rights management issues.
2. Development of the virtual repository and online portal to facilitate access to existing elevation data.
3. Data capture and procurement processes that facilitate shared investment in the national interest.
4. Development and management of a national elevation data product meeting a range of known user needs.

Key components of the investment model needed to create and sustain the NEDF and optimise future investment in elevation data capture, procurement and use are shown in the following table. Leadership and funding sources are suggested.

Component	Deliverables	Leadership and funding
Funding for overall coordination and governance	Stakeholder engagement Resolution of governance issues such as IP and access Governance structures National standards	ANZLIC and industry peak bodies constituted as the NEDF Steering Group and Technical Working Group
Facilitate access to	Virtual repository and	Geoscience Australia

existing data sources	online portal	National programs requiring elevation data
Optimise investment in new data capture and procurement	Clearinghouse including register of proposed projects	Geoscience Australia Relevant Ministerial Councils Other peak bodies
Seamless national coverage "default" data set	National elevation data product	Geoscience Australia National programs Jurisdictional agencies

5.6 National Standards

A key task for Technical Working Group will be to develop standards and guidelines that will facilitate implementation of the NEDF. These guidelines and standards will need to address operational issues such as minimum data standards, vertical datum, documentation, interchange, integration and access. Ideas on content are set out in the following three sections.

5.6.1 Data Specification and Standards

There should be a number of minimum data standards adopted to seamlessly integrate topography and bathymetry and to improve access and usability of data derived from a number of sources. These standards include:

- Use a common reference frame comprising the Geodetic Datum of Australia (horizontal dimensions) and the Australian Height Datum (vertical dimension) or adoption of a new datum.
- Use of standard metadata records to describe elevation data sets and derived products based on international standards, such as ISO 19115.
- Specification of data quality, based on assessment of the fidelity of the source and methods used for DEM generation, manipulation, interpretation, visualisation and application.
- Data format for various representations such as surface models, TINs, Grids, etc)
- Standards applicable to particular sources:
  - Ground surveys
  - Cartographic data sources
  - Remote sensing data capture
    - Active: LIDAR, radar
    - Passive: Optical airborne and satellite

A good starting point is use of existing Australian standards and practices using exemplars such as the national mapping guidelines, ICSM guidelines and the US National Digital Elevation Program guidelines.[8] Further discussion of these matters can be found in the NEDF Science Case

[8] See www.nedp.gov: *Guidelines for Digital Elevation Data*, National Elevation Data Program, May 2004. For guidelines on source quality, *see Guidelines and Specification for Flood Hazard Mapping* Partners Mapping at http://www.fema.gov/plan/prevent/fhm/dl_cgs.shtm .

5.6.2 Interoperability

An interchange standards framework is needed to manage:

- A range of data sets and product types (DEM, DSM, GRIDs, TINs, etc)
- Integration of multi-resolution multi-temporal data from a number of providers
- Data transfer format and web access protocols

A starting point is relevant ISO standards and OGC specifications.

5.6.3 Access, Distribution and Use

Many public agencies and bodies are already acquiring very high-resolution elevation data, but most do not own the intellectual property (IP). This is beginning to change to the purchasers owning the IP, which would allow for inclusion in a national framework. In some cases, the purchasers may not need complete IP ownership of the data, as long as they have the rights to pass on products to relevant users. What is clear is that IP rights need to be negotiated before acquisition based on the intended access and use rights being contemplated for the data.

An internationally recognised scheme of Digital Rights Management (DRM), such as that being developed by OGC should form the framework setting out practices of access, distribution and use of data within the nationally coordinated DEM. DRM covers the rights and responsibilities of both provider and user in a transaction, including matters of copyright, liability, privacy and confidentiality.

Actual conditions may be based on an existing access, licensing and pricing regime, such as the *Australian Government Spatial Data Access and Pricing Policy* and/or the Digital Commons approach or at least documentation clearly setting out how the standard DRM schema is applied for each data set or product.

5.7 Actions and Timeframe

5.7.1 Development of the National Framework

It is proposed that agreement on overall user needs, research and development priorities and leadership roles will be agreed early in 2008. By that time, it is planned that:

- ANZLIC in consultation with other key stakeholders will have approved governance arrangements as set out in this business plan;
- ICSM working group will have developed the initial national standards as the basis for further work;
- Key stakeholders will have been engaged through the national workshop series and their needs documented in the NEDF User Needs Analysis;
- CRCSI will have prepared the NEDF Science Case and the Academies' Review Team will have reviewed and signed it off.

Potentially, subsequent steps to implement the NEDF are shown in the following table. Specifics will need to be worked out in preparing the detailed NEDF Implementation Plan.

Deliverable	Tasks	Key Participants	Indicative Timeframe
NEDF governance structures and implementation plan	Set up NEDF Steering Group	ANZLIC, industry peak bodies, GA, national programs	Early 2008
	Develop business rules for intellectual property, digital rights management, procurement and access issues	NEDF Steering Group, jurisdictional coordinators, local government, commercial data providers	By July 2008
	Approve and circulate NEDF implementation plan	NEDF Steering Group	By July 2008
Develop technical standards	Set up Technical Working Group	Formalise existing ICSM working group	Early 2008
	Develop data standards and interoperability specifications	Technical Working Group	By July 2008 (building on initial specifications)
	Develop access, distribution and use arrangements	NEDF Steering Group, Geoscience Australia, public and commercial data providers	By July 2008
Identify national funding and investment sources	Fund coordination and framework development, investment clearinghouse and procurement guidelines	Geoscience Australia Relevant Ministerial Councils Other peak bodies	By July 2008
	Implement data collation and collection priorities	Program sponsors	During 2008

Set up operational roles to implement NEDF components	Develop virtual repository and online portal	Geoscience Australia National programs requiring elevation data Data providers	Basic functionality by July 2008
	Develop seamless national data product based on known user needs and current data availability	Geoscience Australia National programs Jurisdictional agencies	During 2008

5.7.2 Data Capture and Procurement

This section has been developed from the NEDF User Needs Analysis to provide a starting point for discussion of national data acquisition priorities and help identify opportunities for shared investment in new data capture or procurement.

Priority Coverage	Desirable Resolution	Key Applications	Research Needs	Timing
Areas of high risk (especially urban) along coastal strip between +20m and -20m	5-10m x,y 10-30cm z	Inundation risk due to climate change and tsunamis, coastal zone management, urban growth	Sensing in shallow water, combining topographic and bathymetric data, common datum	2008
Floodplains, especially Murray Darling Basin	5-10m x,y 0.15-1m z	Flooding, risks to populated areas, water supply, catchment risks	Alignment with stream network, risk assessment and prioritisation	2008
Full national seamless coverage product	10-40m x,y 1-5m z 250m x,y deep water	National programs in water, climate change, navigation and defence	Nested DEM, data integration, drainage enforcement	2008
Cities and infrastructure projects	5-10 x,y <0.5m z	Local govt, utility, engineering and mining industries	Specification of accuracy of new technologies, fitness for purpose	Ongoing

It is useful to group elevation data requirements in order to discern broad patterns in future needs of the wide variety of uses reported in the User Needs Analysis. The following table shows a broad interpretation of these “rolled up” needs. The

information is only for indicative purposes and meant to elicit more detailed user requirements. The figures shown are for horizontal and vertical resolution and not accuracy. More detail is shown in the User Needs Analysis

Resolution Range	**Key Applications**
5-10m x,y 0.15-1m z	Specific areas for coastal zone risks and management; landscape modelling and predicting water movement through landscapes, including hydro-geological modelling, surface and groundwater modelling; whole of catchment management and sub-catchment delineation for water quality modelling, hydrological analysis and ground water analysis for catchment management and water quality monitoring, surface analysis and 3D analysis for catchment risk analysis including climate change and drought; floodplain management for insurance risk and local government; stream modelling; gully/stream bank erosion monitoring; land use and urban planning; vegetation modelling and mapping; forestry operations; infrastructure development and management; corridor mapping; aviation safety; airport and flight path management around airports; line of sight, radio and telecommunication coverage; fire modelling; landslide mapping; storm water modelling; 3D modelling in cities; precision agriculture, farm management; marine including fisheries, oil spill response, estuaries, habitat mapping and maritime environmental protection services
10-40m x,y 1-5m z	National and jurisdiction wide identification of areas of risk as above; drainage analysis; hydro-dynamic modelling out to 80m depth; international/national coastal navigation; management and planning of maritime navigation network; search and rescue; land use planning in rural areas; land suitability studies; investigations for infrastructure development; aviation safety; airport and flight path management; defence operations and flight simulation; reconnaissance and surveillance; cross-country mobility; bushfire management in prone areas, slope and fuel loads; ortho rectification of photography, production of ortho photos; geological, landform, regolith mapping and soil mapping
>40m x,y >5m z	Safeguarding communities and infrastructure; situational awareness for defence, CIP, CT and EM operations; deep water bathymetric mapping; oil and gas offshore, including pipeline design, anchoring, infrastructure planning, surface models for geological and geomorphologic interpretations; broad scale climate studies, climate change impacts, ozone modelling

5.7.3 Managing Risks

Risk	Level	Mitigation Strategy
Key stakeholders not engaged	High	Use existing lead organisations and coordinating bodies to identify stakeholders, initially engage through workshops and ensure their expectations are known.
Major drivers and needs not identified	High	Develop robust user needs analysis and circulate widely for comment
Key policy makers not convinced on the need for national or whole of government approach, individual agency views prevail	High	Actively promote the concepts of "collect once, use many times" and "single points of truth". Strengthen case for shared action and investment based on identifiable triple bottom line outcomes
Inadequate funding of a nationally consistent DEM	High	Actively brief and engage potential funding sources, be prepared to strengthen business case to meet their needs. Tie specific implementation initiatives to those with a mandate to address them.
Governance arrangements are inadequate	Medium	Set up clear governance arrangements early in the project. Ensure key bodies and personnel are willing to take on leadership roles and prepared to deliver on stakeholder expectations
Private sector not engaged, critical capabilities are overlooked by government	Medium	Ensure private sector interests are represented in governance arrangements and relevant implementation activities
Agreement cannot be reached on key elements of a nationally coordinated DEM	Medium	Build on existing consensus, identify roadblocks during early stages and use governance arrangements to overcome obstacles.
Key data sets are not available due to sensitivity concerns	Medium	Identify sensitivities early in the project through interviews and workshops, take into account in implementation plan.
Technical details derail progress	Medium	Technical Working Group to set clear objectives, develop standards and adjudicate on technical detail.
Consensus on implementation priorities not reached	Low	Engage stakeholders during development of the implementation plan and obtain signoff from key bodies

Attachment: Glossary of Terms and Acronyms

National Elevation Data Framework

- *The Shared Digital Representation of Australia's Landform and Seabed*

Glossary of Terms and Acronyms

AAS

Australian Academy of Science, see www.science.org.au.

AGO

Australian Greenhouse Office, DEW.

AHS

Australian Hydrographic Service, Royal Australian Navy.

Airborne Light Detection and Ranging

See LIDAR.

ANZLIC

The Spatial Information Council of Australia and New Zealand. Comprises a senior representative of the national governments of Australia and New Zealand and the six States and two Territories of Australia. See www.anzlic.org.au.

ANUDEM

An algorithm using methods such as filtering, drainage enforcement and smoothing to improve the fidelity of an elevation model developed by the Centre for Resource and Environmental Studies (CRES), Australian National University. See http://fennerschool.anu.edu.au.

ASDD

Australian Spatial Data Directory. Comprises searchable metadata records of more than 30,000 existing spatial data sets. See http://asdd.ga.gov.au/asdd/.

ASDI

Australian Spatial Data Infrastructure, a conceptual national framework for spatial data being sponsored by ANZLIC.

ASIBA

Australian Spatial Information Business Association, national peak body for companies in the spatial information industry.

ATSE

Australian Academy of Technological Sciences and Engineering, see www.atse.org.au.

Bathymetry

Science of measuring water depths (usually in the ocean) to determine bottom topography.

BoM

Bureau of Meteorology. Responsibilities include management of a national database of water information.

COAG

Council of Australian Governments. COAG is the peak intergovernmental forum in Australia, comprising the Prime Minister, State Premiers, Territory Chief Ministers and the President of the Australian Local Government Association (ALGA). See www.coag.gov.au.

Contour

Imaginary line on ground, all points of which are at the same elevation above or below a specific datum.

CRCSI

Cooperative Research Centre for Spatial Information, the key collaborative research body in the Australian spatial information industry.

CSIRO

The Australian Government science and research body.

DAFF

Department of Agriculture Fisheries and Forests.

Data Management

Managing the storage and use of data from the time they are generated or collected, maintaining their integrity, security and useability, and ensuring that it can be discovered and reused by others for as long as it is required. The term is taken to mean all of the actions needed to maintain data over their entire lifecycle and over time for current and future users. Data management encompasses both data archiving and data preservation.

DEW

Department of Environment and Water Resources

Digital Data

Information created in, or converted to, a digital format for storage, transmission, processing and/or logical control. Such information can include text, numbers, images, audio, video, indexing metadata, telecommunications signals, instrument telemetry, control and sensor signals, biometric information, software, algorithms, equations, animations, inputs and outputs for computer analysis, modelling or simulation.

Digital Elevation Model (DEM)

DEM is a generic term for digital topographic and/or bathymetric data in all its various forms. Unless specifically referenced as Digital Surface Models (DSMs), the generic DEM normally implies elevations of the terrain (bare earth z-values) devoid of vegetation and manmade features.

DIGO

Defence Imagery and Geospatial Organisation, Department of Defence.

DoD

Department of Defence

DoTARS

Department of Transport and Regional Services

DRM

Digital rights management, means of managing rights such ownership, copyright, confidentiality, privacy and use of digital data.

EIS

Environmental impact statement

Elevation

Vertical distance of a point above or below a reference surface or datum. Usually, the distance measured upward along a plumb line between a point and the geoid. The elevation of a point is normally the same as its orthometric height, defined as “H” in the equation: $H = h – N$. This is the “official” geodesy definition of elevation, but the term elevation is also used more generally for height above a specific vertical reference, not always the geoid.

EMA

Emergency Management Australia, Attorney-General's Department.

GA

Geoscience Australia, Department of Industry, Tourism and Resources. See www.ga.gov.au.

GPS

Global Positioning System, comprising a constellation of satellites used by ground receivers to obtain position in three dimensions.

Hydrography

Science that deals with the measurement and description of the physical features of the oceans, seas, lakes, rivers, and their adjoining coastal areas, with particular reference to their use for navigation.

Hydrology

Scientific study of the waters of the Earth, especially with relation to the effects of precipitation and evaporation upon the occurrence and character of ground water.

ICSM

Intergovernmental Committee on Surveying and Mapping, a Standing Committee of ANZLIC. See www.icsm.gov.au.

ICSM/PCTI

Permanent Committee on Topographic Information, a sub-group of ICSM. See http://www.icsm.gov.au/icsm/topo/ntici_june_2005.pdf.

Interoperability

The ability of different information technology systems and software applications to communicate, to exchange and integrate data accurately, effectively and consistently, and to use the information that has been exchanged.

IP

Intellectual property.

ISO

International standards organisation. ISO Committee TC211 is responsible for developing standards for geographical/spatial information.

LADS

Laser Airborne Depth Sounding, also called Bathymetric LiDAR.

Levelling

Surveying operation in which heights of objects and points are determined relative to a specified datum.

LIDAR/LiDAR

Airborne Light Detection and Ranging. LIDAR is defined as an airborne laser system, flown aboard rotary or fixed-wing aircraft, that is used to acquire x, y, and z coordinates of terrain and terrain features that are both manmade and naturally occurring. LIDAR systems consist of an airborne Global Positioning System (GPS) with attendant GPS base station(s), Inertial Measuring Unit (IMU), and light-emitting scanning laser.

Metadata

Structured data that describe a data resource, analogous to cataloguing data held by libraries, museums and archives. Metadata aids classification, management, discovery, and use of data by people or by automated processes. Metadata may include data attributes such as type, structure, size, title, content, provenance, creation date, author or location.

NECS

National Electronic Conveyancing Service, see www.necs.gov.au.

NHT/NAP

Natural Heritage Trust/ National Action Plan on Salinity and Water Quality. See www.nht.gov.au.

NLWRA

National Land and Water Resources Audit, a program of the Natural Heritage Trust (NHT). See www.nlwra.gov.au.

NRM

Natural resource management.

OGC

Open Geospatial Consortium, international industry body developing spatial interoperability specifications.

PSMA

PSMA Ltd, a private company owned by the Australian, State and Territory governments. Its role is to integrate relevant spatial data sourced from individual jurisdictions to create national products in areas such as cadastre, street address, roads and points of interest. See www.psma.com.au

R&D

Research and Development

RMS

Root mean square, a common measure of error associated with a measurement or elements in a data set.

Shuttle SRTM

Shuttle Radar Topography Mission instrument carried on the US NASA space shuttle. Using the Space-borne Imaging Radar (SIR-C) and X-Band Synthetic Aperture Radar (X-SAR) hardware, SRTM collected data in a single shuttle flight in February 2000.

SPOT HRS

High Resolution Stereoscopy instrument carried on the SPOT 5 remote sensing satellite.

TIN

Triangulated Irregular Network, a type of digital elevation model with irregularly spaced height points, compared with a grid representation, which has regularly spaced points in a square pattern.

Topography

Configuration (relief) of the land surface; the graphic delineation or portrayal of that configuration in map form, as by contour lines; in oceanography the term is applied to a surface such as the sea bottom or surface of given characteristics within the water mass.