ICSM LiDAR Acquisition Specifications and Tender Template

VERSION 1.0, NOVEMBER 2010

Preface

Digital elevation data which describes Australia's landforms and seabed is crucial for addressing issues relating to the impacts of climate change, disaster management, water security, environmental management, urban planning and infrastructure design. In recent years dramatic developments in LiDAR technology and industry capabilities have revolutionised our ability to address these issues at the local level. However, inconsistent and diverse product specifications, and variable data quality are often making it difficult to integrate datasets to address regional, state and national issues. In order to optimise investment and the utility of both existing and future data collections there is a need for a national base specification which defines a consistent set of minimum products which ensure compatibility across projects and States.

In late 2008, the Australian Intergovernmental Committee for Surveying and Mapping (ICSM) Elevation Working Group released Version 1.0 of the Guidelines for Digital Elevation Data acquisition. The intent of this specification and tender template is to further improve on the quality, consistency, utility and compatibility of data being captured by government and commercial off-the-shelf (COTS) products increasingly being offered by the private sector. Moreover, the specifications and tender template provide opportunities for greater collaborative investment across all levels of government, and capacity to reduce tender and compliance costs for investors and providers.

Use of these specifications will also ensure that primary LiDAR point cloud data and derived products can be easily integrated and ingested into the National Elevation Framework Data Portal (NEDF-Portal), providing increased discoverability and access to the broader user community.

The specifications have drawn on recent experience across all levels of Australian government, consultation with LiDAR data providers, and the U.S. Center for LiDAR Information, Coordination and Knowledge (CLICK). They provide a minimum base specification and are not intended to limit development of more specialised products. Nor are they intended to inhibit industry development and innovation. We therefore encourage interested users, investors, researchers and suppliers to contribute to ongoing development. If you wish to make a submission aimed at improving this document or require technical support, please email elevation@ga.gov.au. For further related information please visit the following sites:

http://www.anzlic.org.au/nedf.html

http://www.icsm.gov.au/icsm/elevation/index.html

http://www.ga.gov.au/topographic-mapping/elevation/index.jsp

http://nedf.ga.gov.au

Logo	Project Title

Contents

1 Project Brief

Provide an overview of the background to the project and the project objectives.

2 General Project Requirements

Provide a summary of the required project deliverables and any specific issues that must be addressed in the project.

3 Project Timeframe

Provide a summary of the overall project timeframes and specific milestone dates. This should include dates relating to the Tender process, data acquisition, product delivery and reporting. Any requirements for any staged delivery of services and products should also be specified.

4 Project Area

Provide an overview map of the project area and any detailed maps or diagrams as an attachment. Describe the overall landscape characteristics (biophysical, cultural, climatic, etc) which may affect data acquisition, processing or validation. For example, the nature of the terrain, dense vegetation that may impact on ground responses, land access for validation. Provide a digital file in shapefile format depicting the extent of the project and other relevant features.

5 General LiDAR Specifications

	Description	Specifications
1	Coverage	*Description of the survey area with reference to detailed diagram(s) provided as Attachment A and available in digital (shape file) format. The defined survey area should be buffered by a minimum of 100m.*
2	Date of Capture	1. LiDAR: *specific capture window requirements.* 2. Field Data: *specific requirements relative to LiDAR acquisition*.
3	Delivery Dates	*Tender process, data acquisition, product delivery and reporting. Any requirements for any staged delivery of services and products should also be specified.*
4	Fundamental Spatial Accuracy Requirements	Fundamental spatial accuracy of the survey must conform to the following ICSM Category 1 standard: a. Fundamental Vertical Accuracy (FVA) i. <= +/- 30cm. 95% confidence interval (1.96 x RMSE) b. Fundamental Horizontal Accuracy (FHA) i. <= +/- 80cm. 95% confidence interval (1.73 x RMSE) *Refer to ICSM Guidelines for Digital Elevation Data. Previous reporting of vertical accuracy has generally referred to FVA of <= +/- 15cm at the 68% confidence interval and FHA of <= +/- 45cm at the 68% confidence interval.*
5	Horizontal Datum	The Geocentric Datum of Australia 1994 (GDA94).
6	Map Projection	The coordinate system for all deliverables is the Map Grid of Australia (MGA).
7	Vertical Datum	1. Orthometric: All deliverables specified below as *orthometric* will be referenced to the Australian Height Datum (AHD) – as determined by the published heights of local survey control marks within or adjacent to the project extent. 2. Ellipsoid: All deliverables specified below as *ellipsoidal* will be in terms of the GDA94 reference frame. The source of the ellipsoidal height control shall be explained in the 'Post-Survey Spatial Accuracy Report'.
8	Geoid Model	AUSGeoid98 shall be used to derive orthometric heights from ellipsoidal data. *The most recent ICSM-approved Geoid model shall be used. The current (as at October, 2010) Geoid model is AUSGeoid98. This will be revised to AUSGeoid09 in the near future, and should be used upon formal adoption or on instruction from the Contract Authority. Refer to the following for the most recent approved Geoid model*: *http://www.ga.gov.au/geodesy/ausgeoid/*
9	Adjustment to local AHD	1. Adjustment to "local" AHD as defined above is required under the following circumstances: a. Where the FVA described above is exceeded when the Geoid derived orthometric heights are validated against local AHD, or b. Where a bias in the vertical validation resulting from anomalies in the Geoid model or other sources is identified across the whole project area. 2. Details of this adjustment are required as part of the 'Post-Survey Spatial Accuracy Report'.

10	Survey Control	1. All survey control data used or derived from this contract must be supplied to ensure independent Quality Assurance (QA) of the survey operations, and for possible inclusion in the State's survey control infrastructure. It is therefore essential that all primary ground stations are permanently marked in accordance with the appropriate State system. 2. The primary ground control and check point surveys must be referenced to the local datum specified above comprising State survey control marks with "established" GDA94 coordinates and/or "accurate AHD" heights as defined in the relevant State Surveying regulation. 3. Survey to establish new primary control shall use techniques to achieve a minimum standard of: a. Horizontal: Class B b. Vertical: Class B or LD. As described in the ICSM Standards and Practices for Control Surveys (SP1) Version 1.7. *Elevation data must be validated and corrected for systematic errors to ensure accuracy specifications are met. Documentation must describe how this has been achieved. Refer to the Quality Assurance Section for specific deliverables in relation to this topic.*
11	Sensor Requirements	The sensor must be capable of: a. detecting multiple discrete returns, with a minimum of 4 potential returns for each outbound laser pulse. b. recording the intensity of each return. *Full waveform collection is both acceptable and welcomed; however, waveform data is regarded as supplemental information. The requirement for deriving and delivering multiple discrete returns remains in force in all cases. These requirements may be varied according to specific user requirements.*

12	Collection Requirements	1. The survey design must plan on: a. recording a minimum Nominal Post Spacing (NPS) of two (2) outbound pulses per square metre b. a scan angle not exceeding 40^{o} Total FOV (+/- 20^{o} from nadir) c. an across/along track point spacing ratio not exceeding 2/3. *Note: This requirement is primarily applicable to oscillating mirror LiDAR systems. Other instrument technologies may be exempt from this requirement. A minimum NPS of one (1) outbound pulse per square metre may be approved in less complex terrain.* 2. Flight line overlap must be 10% or greater, as required to ensure there are no data gaps between the usable portions of the swaths. Collections in high relief terrain are expected to require greater overlap. Any data with gaps between the geometrically usable portions of the swaths will be rejected. 3. Data Voids (areas => $4xNPS^2$), measured using 1st-returns only within a single swath are not acceptable, except: a. where caused by water bodies b. where caused by areas of low near infra-red (NIR) reflectivity such asphalt or composition roofing c. where appropriately filled-in by another swath 4. The spatial distribution of geometrically usable points is expected to be uniform and free from clustering. In order to ensure consistent data densities throughout the project area: *Note: This requirement may be relaxed in areas of significant relief where it is impractical to maintain a consistent NPS.* 5. Environmental conditions for data capture. a. Cloud and fog free between the aircraft and the ground. b. Floodplain/wetland data must be captured during times of base-flow and outside of significant surface inundation due to natural events and /or regulated environmental flows. c. Coastal surveys (areas under tidal influence) should be flown within 2 hours either side of low tide to minimise the effect of standing water or wave action. d. Flights should not be undertaken during periods of heavy smoke haze. *With prior approval, collections for specific scientific research projects may be exempt from these requirements.*

6 LiDAR Point Cloud Specifications

	Deliverables	Specifications
1	Unclassified Point Cloud	1. All returns, all collected points, fully calibrated and adjusted to specified vertical datum, by swath. 1 file per swath, 1 swath per file, (file size not to exceed 2GB). 2. Fully compliant LAS v1.2 (or v1.3), point record format with all standard attributes including: a. Intensity values (native radiometric resolution). b. Return number. c. Georeferencing information in all LAS file headers. d. GPS times recorded as adjusted GPS time, at a precision sufficient to allow unique timestamps for each pulse. 3. LAS v1.3 deliverables with waveform data are to use external "auxiliary" files with the extension ".wdp" for the storage of waveform packet data. See the LAS v1.3 specification for additional information). 4. Data is to be provided in the following Vertical Datums: a. Ellipsoidal (GDA94). 5. File naming as per Attachment B.
2	Classified Point Cloud	1. All returns, all collected points, fully calibrated and adjusted to specified vertical datum, and classified as specified below. 2. Fully compliant LAS v1.2 (or v1.3), point record format with all standard attributes including: a. Intensity values (native radiometric resolution). b. Return number. c. Georeferencing information in all LAS file headers. d. GPS times recorded as adjusted GPS time, at a precision sufficient to allow unique timestamps for each pulse. e. ASPRS/LAS "Overlap" classification (Class=12) shall not be used. ALL points not identified as "Withheld" are to be classified. 3. LAS v1.3 deliverables with waveform data are to use external "auxiliary" files with the extension ".wdp" for the storage of waveform packet data. See the LAS v1.3 specification for additional information) 4. Data is to be provided in the following Vertical Datums: a. Orthometric (AHD) b. Ellipsoidal (GDA94). 4. Tiled delivery, as per Data Supply Specifications below. 5. File naming as per Attachment B.

<table>
<tr>
<td>3</td>
<td>LiDAR Point Cloud Classification Scheme</td>
<td>
1. All classified point cloud data must adhere to the following modified ASPRS classification scheme.
2. The minimum number of point classes to be delivered according to this scheme is defined by the Classification Level specified below.
<table>
<tr><th>Number</th><th>Point class</th><th>Description</th></tr>
<tr><td>0</td><td>Unclassified</td><td>Created, never classified</td></tr>
<tr><td>1</td><td>Default</td><td>Unclassified</td></tr>
<tr><td>2</td><td>Ground</td><td>Bare ground</td></tr>
<tr><td>3</td><td>Low vegetation</td><td>0 – 0.3m (essentially sensor ‘noise’)</td></tr>
<tr><td>4</td><td>Medium vegetation</td><td>0.3 – 2m</td></tr>
<tr><td>5</td><td>High vegetation</td><td>2m ></td></tr>
<tr><td>6</td><td>Buildings, structures</td><td>Buildings, houses, sheds, silos etc.</td></tr>
<tr><td>7</td><td>Low / high points</td><td>Spurious high/low point returns (unusable)</td></tr>
<tr><td>8</td><td>Model key points</td><td>Reserved for ‘model key points’ only</td></tr>
<tr><td>9</td><td>Water</td><td>Any point in water</td></tr>
<tr><td>10</td><td>Bridge</td><td>Any bridge or overpass</td></tr>
<tr><td>11</td><td>not used</td><td>Reserved for future definition</td></tr>
<tr><td>12</td><td>Overlap points</td><td>Flight line overlap points</td></tr>
<tr><td>13-31</td><td>not used</td><td>Reserved for future definition</td></tr>
</table>
3. Class 1 (default) are points which have been subjected to a classification process but emerged in an undefined state. Class 0 have never been subjected to a classification process. This definition is necessary to maintain compatibility with common LiDAR processing suites.
4. When a simple ground/non-ground classification has been applied, all non-ground points will be allocated to Class 1.
5. Class 8 “model key points” is actually a subset of class 2 and so is created as a separate product.
</td>
</tr>
</table>

4	LiDAR Point Cloud Classification Levels	*Once the Fundamental Spatial Accuracy requirements have been achieved, significant errors in the vertical accuracy of the classified point cloud are likely to be caused by incorrect classification. For example, dense understory vegetation classified as ground points will significantly reduce the vertical accuracy of any bare earth DEM. LiDAR Point Cloud Classification Levels have been introduced to provide greater transparency in the overall quality of the LiDAR products, particularly within non-bare-ground land cover types, to ensure products are "fit-for-purpose".* *It is expected that classification of the point cloud data will be carried out to achieve known minimum accuracy levels for ground data, and additional land cover categories depending on client requirements. The onus for reaching the required accuracy lies with the data supplier. Independent assessments may also be carried out by the Contracting Authority. Classification accuracy requirements may be relaxed to accommodate collections in areas where the Contract Authority agrees classification to be particularly difficult.* **Level 0 - Undefined** All points allocated classes 0 (unclassified) or 1 (default) by LiDAR processing software with no classification algorithms applied. Classification Accuracy Required: unspecified. **Level 1. Automated and Semi-Automated Classification.** Fully or semi-automated, batch processing of the point cloud data into the following classes: 2 (ground), 3-5 (vegetation), 6 (buildings/structures), 7 (low/high points and noise), 9 (water). At Level 1, some of these classes such as water (9) might be derived with the assistance of masking or other semi-automated techniques Classification Accuracy Required: 95% for *Ground points* (minimum), and other classes as specified. **Level 2. Ground surface improvement.** Level 1 classified data is further enhanced, using automated and manual methods, by the removal of significant anomalies which remain in the ground class (2). Typically, this editing will re-classify points into class 3-5 (vegetation) and class 9 (water). Classification Accuracy Required: 98% for *Ground points* (minimum), and other classes as specified. ***Level 2 is the minimum standard for new acquisitions carried out under the National Elevation Data Framework (NEDF). Level 3 and 4 may often require reference imagery to achieve the required specifications.*** *Continued over page*

4	LiDAR Point Cloud Classification Levels *continued*	**Level 3. Ground Correction.** Significant and highly supervised (often manual or semi-automated) effort is generally required for this level to ensure that only actual ground points are assigned to class 2. Typically, this editing will both remove and add points to the ground, vegetation and water classes derived using the automated algorithms. Full manual line scan editing of batch output may be required in highly complex environments. *Typically this level of classification (in additional to Level 4 below) would only be undertaken to meet highly specific project requirements (such as hydrological modelling) over localised areas which typically make up a small proportion of the total survey area such as vegetation along water courses.* Features which may require special attention include water and areas where the ground surface may be obscured including: densely vegetated water courses, rainforest, dense coastal vegetation or grass, rocky outcrops/boulders, contour/levee banks, wood/rubbish piles and islands. Classification Accuracy Required: 99% for ***ground points*** (minimum), and other classes as specified. **Level 4. Detailed Classification and Correction** Detailed classification and correction of all specified classes. This may include all or a subset of classes listed in section 3. When specified, each class must achieve the required classification accuracy. Development of a hydrologically conditioned DEM will generally require a higher level of editing to remove man-made structures such as buildings, bridges and culverts. *Typically this level of classification would only be undertaken to meet highly specific project requirements.* Classification Accuracy Required: 99% for all specified classes.

5	Required Point Cloud Classification Level	***Use the following checklist to specify the classes and level of classification required, noting the minimum requirements for new NEDF acquisitions.*** 1. The following point cloud classification levels are required as a minimum standard for new acquisitions under the NEDF:

Number	Point class	Required Classes	Classification Level Required			
			L1	L2	L3	L4
0	Unclassified	☒	☒	☐	☐	☐
1	Default	☒	☒	☐	☐	☐
2	Ground	☒	☐	☒	☐	☐
3	Low vegetation	☒	☒	☐	☐	☐
4	Medium vegetation	☒	☒	☐	☐	☐
5	High vegetation	☒	☒	☐	☐	☐
6	Buildings, structures	☒	☒	☐	☐	☐
7	Low / high points	☒	☒	☐	☐	☐
8	Model key points	☒	☐	☒	☐	☐
9	Water	☒	☒	☐	☐	☐
10	Bridge	☐	☐	☐	☐	☐
11	not used	☐	☐	☐	☐	☐
12	Overlap points	☐	☐	☐	☐	☐
13-31	Other As specified	☐	☐	☐	☐	☐

7 LiDAR Derivative Data Specifications

Deliverables		Specifications
1	Intensity Image	1. 1m grid intensity image 2. Mosaic generated using average laser intensity values from “first return” LiDAR points. 3. ECW format using 5:1 compression. 4. Tiled delivery, as per Data Supply Specifications below. 5. File naming as per Attachment B.
2	Digital Surface Model (DSM) (orthometric)	1. 1m grid Digital Surface Model (DSM) 2. The DSM should be generated from the “first return” LiDAR mass point data. This will include ground and non-ground points such as vegetation and buildings. 3. The DSM generation should employ a Point to TIN and TIN to Raster process with Natural Nearest Neighbour interpolation. 4. Void areas (i.e., areas outside the project boundary but within any tiling scheme) shall be coded using a unique “NODATA” value. 5. ESRI floating point GRID format. 6. Tiled delivery, as per Data Supply Specifications below. 7. File naming as per Attachment B.

3	Digital Elevation Model (DEM) (orthometric)	1. 1m grid bare earth Digital Elevation Model (DEM) 2. The DEM should be generated from the LiDAR mass point data classified as "Ground" only, so that it defines the "bare earth" ground surface. 3. The DEM generation should employ a Point to TIN and TIN to Raster process with Natural Nearest Neighbour interpolation. 4. Hydro-flattening will be undertaken for natural and man-made water bodies and water courses as defined below: a. Non-tidal water bodies with a surface area greater (>) than 625m^2 b. Non-tidal water courses greater than 30m nominal width. This should not unnecessarily break a stream or river into multiple segments. At times it may squeeze slightly below 30m for short segments. Data producers should use their best professional judgment. c. Flat and level bank-to-bank with a gradient following the immediate terrain. d. Water courses should break at road crossings and bridges. e. Sinks must not be filled. f. The entire water surface edge must be at or immediately below the surrounding terrain. g. Tidal variations over the course of the collection or between different collections may result in discontinuities along shorelines. The provider must confirm with the Contract Authority if and how these shorelines and water bodies will be processed. h. Any additional data layers created for the purposes of hydro-flattening such a masks or breaklines must be provided as shapefiles. The Contract Authority must be provided with all necessary data to re-produce the DEM from the mass point data. i. The methodology used for hydro-flattening is at the discretion of the data producer. *Note: The "hydro-flattening" specifications defined above are not intended to satisfy detailed hydrological or hydraulic modelling. Detailed hydrological enforcement and conditioning specifications are under development for these purposes. For more information contact* elevation@ga.gov.au. 5. Void areas (i.e., areas outside the project boundary but within any tiling scheme) shall be coded using a unique "NODATA" value 6. ESRI floating point GRID format. 7. Tiled delivery, as per Data Supply Specifications below. 8. File naming as per Attachment B.
4	Canopy Height Model (CHM)	1. 2m grid 2. Height of all LiDAR mass point returns above the ground by subtracting the ground elevation from the maximum first return for each 2m bin. 3. Void areas (i.e., areas outside the project boundary but within any tiling scheme) shall be coded using a unique "NODATA" value 4. ESRI floating point GRID format. 5. Tiled delivery, as per Data Supply Specifications below. 6. File naming as per Attachment B.

5	Foliage Cover Model (FCM)	1. 10m grid 2. One minus the gap fraction probability as defined by the proportion of counts from all vegetation returns at least 2m above the ground for each 2m bin expressed as a percentage (%). 3. Non-thinned data must be used. 4. Void areas (i.e., areas outside the project boundary but within any tiling scheme) shall be coded using a unique "NODATA" value 5. ESRI floating point GRID format 6. Tiled delivery, as per Data Supply Specifications below. 7. File naming as per Attachment B.

8 Data Supply Specifications

Deliverables		Specifications
1	File naming	See Attachment B for NEDF file naming conventions.
2	Coordinate Origins for Gridded Data.	The origin of all gridded data must be placed on a whole metre coordinate value that will align with the zero (0) origin of the MGA Zone.
3	Data Tiling	1. All standard data sets should be supplied as single files where possible and tiled to manageable file sizes if necessary as below: a. 1km x 1km tiles based on MGA coordinates with origins that align with the zero (0) origin of the MGA Zone. b. Larger tile sizes which maximise workflow efficiency will be considered. c. The origin of the tile must be placed on a whole metre coordinate value of the south west corner of each tile. e.g. 426000mE_7243000mN 2. A Tile Index is to be provided by the contractor in ESRI shape file format. The tile name as specified above must be included as an attribute in the Tile Index file. 3. File naming as per Attachment B.
4	GPS data for occupations of base-stations	1. GPS data for all base station occupations in excess of 6 hours is to be provided in RINEX V1.2 format (Receiver Independent Exchange Format). 2. GPS observation log sheets which include the following details: a. Survey mark id b. Occupation time & date c. Antenna height measurements d. Instrument /antenna types & serial numbers The GPS observation log sheets should be provided in pdf format or Excel spreadsheet if data is captured digitally. *Where appropriate, some jurisdictions may find it useful to also request GPS data for any static primary control surveys.*
6	Data Delivery Reports	1. A delivery report describing the contents of the data supplied with every data delivery (interim, staged, final). The delivery report must also contain reference to the metadata supplied within the delivery.

7	Metadata	1. For each supplied data product a complete metadata statement consistent with the ANZLIC Metadata Profile (Version 1.1) must be provided in XML format. The ANZMET Lite metadata tool will be used to validate all XML records. http://www.osdm.gov.au/Metadata/ANZLIC+Metadata+Profile/default.aspx 2. In addition, the NEDF Metadata Profile and Tool will be used to provide additional LiDAR specific metadata. The NEDF Metadata tool reads an XML metadata record created by ANZMET Lite. The tool will be made available by the Contract Authority. 3. The list of additional NEDF metadata required is provided in Attachment C. 4. Metadata must be provided with every delivery including interim, partial and final deliveries. 5. The job will not be signed off by Contract Authority until the metadata is satisfactorily supplied.
8	Delivery Media	1. Data should be delivered on DVD or External Hard Drive (USB or FireWire). External hard drives will be retained by the Contract Authority. 2. Data deliveries should be clearly labelled with name of Service Provider, date of supply and list of contents.
9	Report Formats	All reports are to be provided in Word (.doc) format, Excel spreadsheet (.xls) or appropriate digital format approved by the Contract Authority.

9 Project Planning and Reporting Specifications

Deliverables		Specifications
1	Project Plan	Project plan detailing work breakdown structure, agreed data capture plans, project milestones and delivery schedules, progress reporting schedules etc within 10 days of the acceptance of the Contractors quote.
2	Pre-Survey Quality Assurance Plan	The Contractor shall prepare and submit to the Contracting Authority a Quality Assurance Plan that conforms to an identified management system and generally complies with ISO 9001. The plan must address the organisation and management of the project, work procedures, environmental considerations, safety and risk control and test procedures. The Plan must also detail the procedures to be used in verifying that the deliverables meet the required specification including: • The procedures and methodologies to be used to verify that the deliverables meet the required specifications. • Details of proposed calibration checks and methodology to be used to establish both reference stations and ground test sites. The Project Plan must be submitted and accepted prior to commencement of the survey.
3	Post-Survey Spatial Accuracy Report	Acceptance of the Post-Survey Spatial Accuracy Report and related information is required ***before*** point classification and other product derivation is to proceed. The absolute and relative accuracy of the data, both horizontal and vertical, and relative to known control, shall be verified prior to classification and subsequent product development. This validation is limited to the Fundamental Spatial Accuracy (defined below), measured in clear, open areas. A detailed report of this validation is a required deliverable. The report will include the following: • Flight trajectories as specified below. • Details of system calibration checks. • Results of relative (flight run) matching and details of any adjustments made. • Source of primary ellipsoidal height control. • Details of ellipsoid to orthometric corrections applied including any final adjustment to local AHD supplemental to the standard Geoid correction. • Results of vertical and horizontal accuracy validation. • All survey control coordinates, site id and check point comparisons in both Excel spreadsheet and ESRI shape file formats. • Digital photographs of all survey and check sites, with the site id included in the filename. The bearing of the photo direction should also be included. • Other related information.
4	Flight Trajectories	All flight trajectories used for the capture of the delivered LiDAR data will be supplied in ESRI Shape files. The shape file table's must include the date of capture, local start time, local end time and which reference station was used for each trajectory.

5	Progress Reports	The contractor, as a minimum will report by email each two week period. The report should contain a summary of progress, delivery and implementation, and details of any problems encountered and remedial action taken. The report should also address the planned activities for the two weeks ahead, regardless of whether successful capture has been achieved.
6	Project Report	The Project Report should comprise a technical discussion addressing how each of the contract specifications has been met, a statement of consistency with any specified standards, results of independent accuracy and validation tests, metadata statements and extra-ordinary issues that may have affected the nature or delivery of the project. All aspects of the project operations must be adequately reported.

10 Quality Assurance Specifications

Description		Specifications
1	Fundamental Spatial Accuracy Validation (FSA)	<u>Vertical Accuracy Validation</u> 1. The fundamental vertical accuracy of the point cloud dataset must be determined with check points located only in open, relatively flat terrain, where there is a very high probability that the sensor will have detected the ground surface. 2. The vertical accuracy of the point cloud dataset is to be tested using a TIN surface constructed from bare-earth LiDAR points compared against ground survey check points. 3. Check points are to be surveyed independently of any LiDAR GPS operations. 4. The number of check points (locations) is dependent on the extent of the survey. The following strategy should be used as a guide: a. Check points must be established to adequately cover the full extent of the survey area, and be representative of the project area landscape. b. A minimum of 20 check points (locations), then 1 per 50km² where LiDAR coverage exceeds 400km². When 20 points are tested, the 95 percent confidence interval would generally allow 1 point to fail the threshold given in product specifications 5. The proposed check point survey design must be submitted with the quotation, and approved by the Contract Authority prior to implementation. Acceptance of the post-survey spatial accuracy report discussed above is dependent on the quality, number and distribution of these check points. 6. If additional independent validation is required, data should be assessed in accordance with ASPRS Accuracy Reporting Guidelines. <u>Horizontal Accuracy Validation</u> 7. The onus for reaching the required accuracy lies with the data supplier. Independent accuracy assessments may also be carried out by the Contracting Authority. 8. Independent testing of horizontal accuracy for LiDAR products is not required as part of this base specification. Instead data producers are required to report on the expected horizontal accuracy of elevation products as determined from system and sensor calibration studies. 9. In the above circumstances a “compiled to meet” statement of horizontal accuracy at 95 percent confidence should be reported. 10. As an alternative, the producer may demonstrate compliance through analysis of distinct features which are identifiable in the elevation data (e.g fences) or intensity images with other data sources such as high resolution imagery with known horizontal accuracy. 11. If additional independent validation is required, data should be assessed in accordance with ASPRS Accuracy Reporting Guidelines.

<table>
<tr><td>2</td><td>Supplemental Vertical Accuracy Validation (SVA)</td><td>If information is required on the vertical accuracy achieved within land cover categories outside of bare open ground, either to meet the same specification as the fundamental vertical accuracy or a more relaxed specification, then supplemental vertical accuracies (SVA) shall be specified by the Contract Authority, and tested and reported for each land cover class of interest by the data supplier. The following should be used as a guide where SVA testing is required, and agreed with the contracting authority:
1. Each landcover type representing 10% or more of the total project area, and additional landcover categories specified by the Contract Authority must be tested and reported as an SVA
2. For supplemental and consolidated accuracy tests, the 95th percentile method shall be employed to determine accuracy
3. The methodology for establishing check points, testing and reporting must be consistent with the Fundamental Spatial Accuracy Validation and approved by the Contract Authority.</td></tr>
<tr><td>3</td><td>Classification Accuracy Validation</td><td>1. It is expected that due diligence in the classification process will produce datasets that meet the required classification accuracies according to the specified LiDAR Point Cloud Classification Levels and specified classes. It is expected that the data will meet the following tests within any 1km x 1km area:

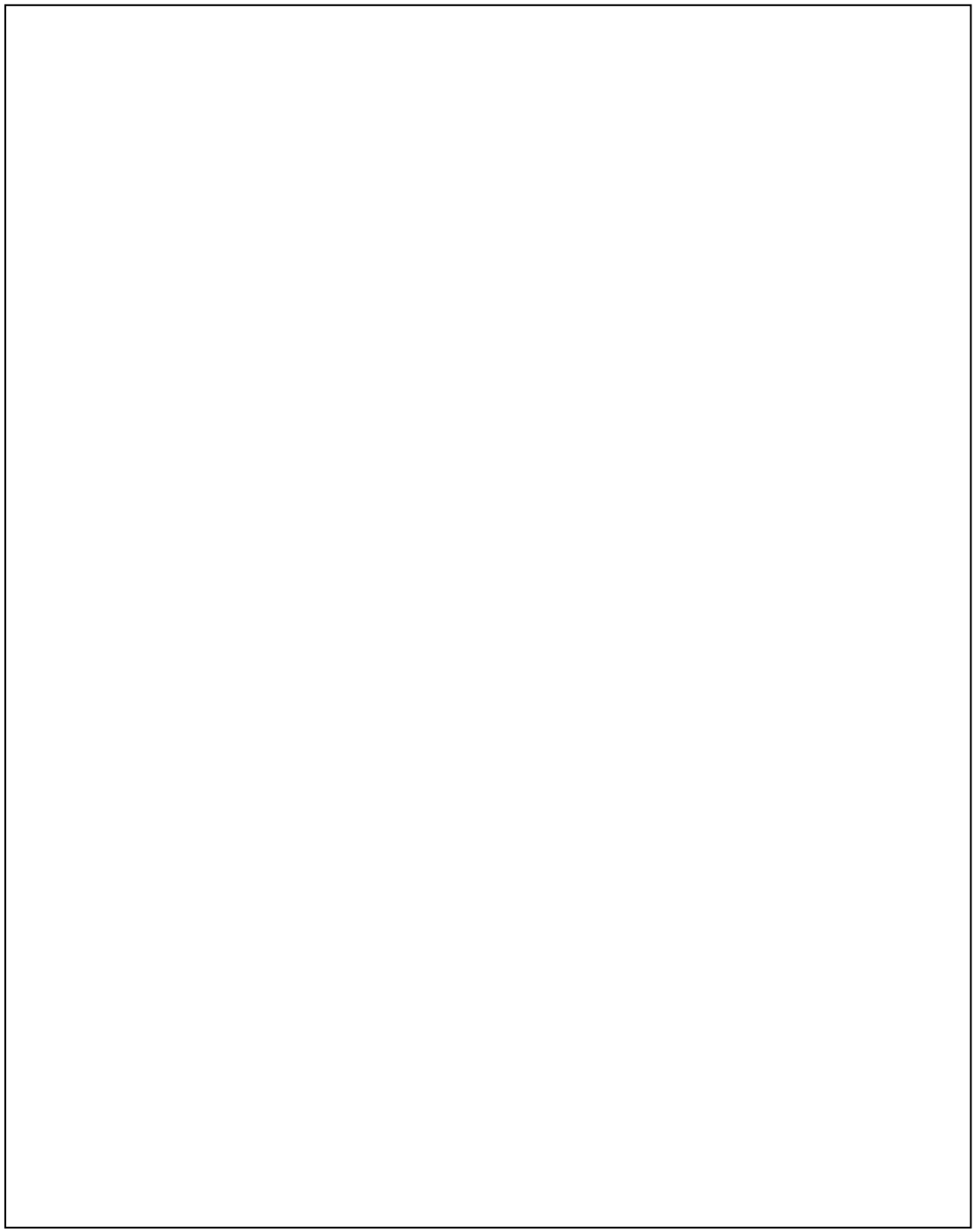
Classification Level — Demonstrated erroneous classification values for specified classes
Level 0 - Unclassified — Unspecified
Level 1. Automated Classification — <=5%
Level 2. Ground surface improvement — <=2%
Level 3. Ground Correction — <=1%
Level 4. Detailed Classification and correction — <=1% for all specified classes

These requirements may be relaxed to accommodate collections in areas where the Contract Authority agrees classification to be particularly difficult.
2. In most circumstances detailed visual inspections of individual classified scan line profiles and use of high quality reference imagery will be sufficient to independently demonstrate if classification standards have been achieved for the specified classes.
3. Classification accuracy tests should be presented in the form of an error matrix for each specified class reporting errors of omission and commission generated from randomly selected points.</td></tr>
<tr><td>4</td><td>Classification Consistency Validation</td><td>1. Point classification is to be consistent across the entire project.
2. Noticeable variations in the character, texture, or quality of the classification between tiles, swaths, lifts, or other non-natural divisions will be cause for rejection of the entire deliverable.</td></tr>
</table>

5	Spatial Distribution of Points Validation	1. In order to ensure uniform densities throughout the data set: a. A regular grid, with cell size equal to the design NPS*2 will be laid over the data. b. At least 90% of the cells in the grid shall contain at least 1 LiDAR point. c. Assessment to be made against single swath, first return data located within the geometrically usable centre portion (typically ~90%) of each swath. d. Acceptable data voids identified previously in this specification are excluded.
6	Interpolation Consistency Validation	All products derived from the LiDAR mass point data as tiles will show no edge artefacts or mismatch. A quilted appearance in the overall project surfaces, whether caused by differences in processing quality or character between tiles, swaths, lifts, or other non-natural divisions, will be cause for rejection of the entire deliverable.

Attachment A – Project Area Map

Insert Map of Project area



Attachment B - File Naming Conventions

The following naming conventions have been developed to provide easy ingestion into the NEDF-Portal. The NEDF-Portal utilises the following file naming conventions for spatial and attribute searching, with the "_" used to separate each component of the file name. It is therefore a critical element of the process. There are a number software tools available for renaming existing data files. One used regularly in is the Bulk Rename Utility which can be downloaded from http://www.bulkrenameutility.co.uk/Main_Intro.php. Importantly, ESRI GRIDS cannot be renamed using this tool. Geoscience Australia can make an ESRI GRID renaming tool available by contacting elevation@ga.gov.au.

NEDF Data Naming Conventions

The NEDF Portal uses 2 types of spatial searching. For ESRI GRIDs it uses the dataset itself to undertake geoprocessing, and for rapid searching it uses the spatial extent of datasets by incorporating the extents into the name of the file. A single file image mosaic is named in a similar manner to a tiled dataset only with the added flexibility of defining tiles of any width and height in addition to traditional square tile. The Portal also uses "_" as a delimiter so it is crucial that you only use these where specified. Using this naming system allows files of any type to be spatially indexed and catalogued. For example, in addition to LiDAR tile and mosaic products, you can also catalogue project reports, pictures or any other reference information and retrieve them through the Portal.

The following file naming conventions have been developed to achieve national consistency, to improve dataset management, and to minimise data transfer and ingest costs for both producers and users.

Intensity imagery, or other forms of imagery provided

This image will generally cover the entire extent of the survey and uses the following filename convention in ECW or geoTIFF format as specified.

Naming Convention for LiDAR intensity or other forms of imagery: *ProjectNameYYYY-INT-GSD_xxxyyyy_zz_wwww_hhhh.ecw*		
ProjectName	*KempseyLidar*	A meaningful description of the total survey area of interest. Do not use "_" as part of the Project Name
YYYY	*2009*	Year of survey
INT/RGB	*-INT*	Intensity image file identifier. Use RGB for 3 band natural colour imagery or RGBI for 4 band infrared
GSD	*-002*	Ground sampling distance or resolution of image in metres.
xxxyyyy	*_4806558 (480,000mE) (6558,000mN)*	Easting and northing value (whole kilometre) of the south-west corner of the tile. A single "_" must be used to separate the remaining file name components.
zz	*_56*	MGA zone of the file
wwww	*_0020*	Width of the **dataset or tile** in whole kilometres
hhhh	*_0050*	Height of **dataset or tile** in whole kilometres
For example: KempseyLidar2009-INT-002_4806558_56_0020_0050.ecw		

LiDAR Unclassified Point Cloud in LAS Format
All LiDAR point cloud data are to be delivered fully compliant LAS v1.2 (or v1.3), Point Record Format

Naming Convention for LiDAR point clouds: *ProjectNameYYYY-UNC-DAT-SWT_xxxyyyy_zz_wwww_hhhh.las*		
ProjectName	*KempseyLidar*	A meaningful description of the total survey area of interest. Do not use "_" as part of the Project Name
YYYY	*2009*	Year of survey
UNC	*-UNC*	Unclassified point cloud. Fully calibrated and adjusted to specified datum
DAT	*-ELL*	Ellipsoidal heights (GDA94)
SWT	*-1..n*	Swath number (1 file per swath)
xxxyyyy	*_4806558 (480,000mE) (6558,000mN)*	Easting and northing value (whole kilometre) of the south-west corner of the tile. A single "_" must be used to separate the remaining file name components.
zz	*_56*	MGA zone of the file
wwww	*_0002*	Width of the tile in whole kilometres
hhhh	*_0002*	Height of the tile in whole kilometres
For example: KempseyLidar2009-RAW-ELL-001_4806558_56_0002_0002.las		

LiDAR Classified Point Cloud in LAS Format
All LiDAR point cloud data are to be delivered fully compliant LAS v1.2 (or v1.3), Point Record Format .

Naming Convention for LiDAR point clouds: *ProjectNameYYYY-CL-DAT_xxxyyyy_zz_wwww_hhhh.las*		
ProjectName	*KempseyLidar*	A meaningful description of the total survey area of interest. Do not use "_" as part of the Project Name
YYYY	*2009*	Year of survey
CL	*-C2*	classification level.
DAT	*-ELL or AHD*	Specified vertical datums. Ellipsoidal (ELL) or Orthometric (AHD)
xxxyyyy	*_4806558 (480,000mE) (6558,000mN)*	Easting and northing value (whole kilometre) of the south-west corner of the tile. A single "_" must be used to separate the remaining file name components.
zz	*_56*	MGA zone of the file
wwww	*_0002*	Width of the tile in whole kilometres
hhhh	*_0002*	Height of the tile in whole kilometres
For example: KempseyLidar2009-C3-AHD_4806558_56_0002_0002.las		

LiDAR Classified Point Cloud Model Key Points in LAS Format
Model Key points (MKP) are a generalised subset of the original mass points and represent the minimum number of points required to determine the shape of the ground. The filename convention is identical to that above with "-MKP" appended to the classification level:

Naming Convention: *ProjectNameYYYY-CL-MKP-DAT_xxxyyyy_zz_wwww_hhhh.las*		
ProjectName	*KempseyLidar*	A meaningful description of the total survey area of interest. Do not use "_" as part of the Project Name
YYYY	*2009*	Year of survey
CL-MKP	*-C2-MKP*	classification level and Model Key Point identifiers.
DAT	*-ELL or AHD*	Specified vertical datums. Ellipsoidal (ELL) or Orthometric (AHD)
xxxyyyy	*_4806558 (480,000mE) (6558,000mN)*	Easting and northing value (whole kilometre) of the south-west corner of the tile. A single "_" must be used to separate the remaining file name components.
zz	*_56*	MGA zone of the file
wwww	*_0002*	Width of the tile in whole kilometres
hhhh	*_0002*	Height of the tile in whole kilometres
For example: Kempsey2009-CL2-MKP-AHD_4806558_56_0002_0002.las		

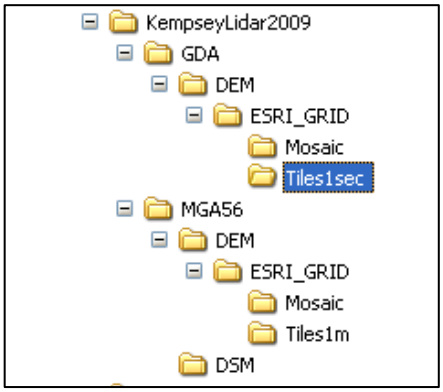
ESRI GRID Format
ESRI GRID's have the following constraints which require specific naming conventions:

a. Names cannot be more than 13 characters
b. Names must start with a letter

Due to these constraints the following folder and filenaming convention for ESRI GRIDs must be used for both projected and geographic units. It is also important to note that each individual ESRI GRID must be stored within a standardised folder structure consistent with the following convention to provide appropriate project information to easily associate the ESRI GRID's with the other files from which they may have been derived.

Separate folder structures for GDA and MGA projections are required in addition to each Product Type specified (e.g. DEM, DSM). All ESRI GRIDS must also have all necessary projection definitions populated.

The following folder structure may be used as a guide for GDA and MGA datasets. The folder structure may change slightly to suit requirements, and should be confirmed with the Contract Authority at project commencement.



Naming Convention for tiled MGA ESRI GRIDS: *txxxyyyyssppp* *(in addition to folder structure above with MGA GRIDS stored in separate folders, with all projection information defined.)*		
t = surface type.	*e*	Surface type • s – digital Surface model (DSM) • e – digital Elevation model (DEM) • f - canopy Foliage model (CFM) • c - Canopy elevation model (CHM) • h – Hydro digital elevation model (DEMH) • b – Bathymetry • m – Bathymetry and terrain elevations • t – Derived terrain variables (add as necessary)
xxxyyyy	*6458595* (645,000mE) (8,595,000mN)	• Easting and northing value (whole kilometre) of the south- west corner of the tile.
ss	*01*	Tile size (km) (square tile) • 01 – one kilometre • 02 – two kilometre • 05 - five kilometre • 10 – 10 kilometre • _5 (represents half a kilometre)
ppp	*001*	Ground sampling distance (GSD) or pixel size • 0_5 - half a metre • 001 – one metres • 002 – two metres etc
For Example: e645859501001		

Naming Convention for Mosaic (MGA) ESRI GRIDS: *txxxxxxxyyppp* *(in addition to folder structure above with MGA GRIDS stored in separate folders, will all projection information defined.)*		
t = surface type.	*e*	Surface type • s – digital Surface model (DSM) • e – digital Elevation model (DEM) • f - canopy Foliage model (CFM) • c - Canopy elevation model (CHM) • h – Hydro digital elevation model (DEMH) • b – Bathymetry • m – Bathymetry and terrain elevations • t – Derived terrain variables (add as necessary)
xxxxxxx	*hunter*	A meaningful description of the total survey area and or sensor, dataset version etc.
yy	*07*	Year of Survey
ppp	*010*	Ground sampling distance (GSD) or pixel size in metres (MGA) MGA • 0_5 - half a metre • 001 – one metres • 002 – two metres etc
For Example: ehunter07010		

Naming conventions for other files

The following naming conventions should be used for other file types and formats that may be specified as deliverables.

Naming Convention for all other MGA files: *ProjectNameYYYY-SSSS-PPPP-GSD_xxxyyyy_zz_wwww_hhhh.asc*		
ProjectName	*KempseyLidar*	A meaningful description of the total survey area of interest. Do not use "_" as part of the Project Name
YYYY	*2009*	Year of survey
SSSS-PPPP	*-DEM-GRID*	Surface type. • DSM • DEM • HDEM • CHM • CFM • Bathymetry (BAT) • Mixed (MIX). Bathymetry and terrain elevations • TTT (Other terrain variables e.g. slope (SLP). Add as necessary. Product type • Mass points (MASS) • Breaklines (BRK) • TIN (TIN) • GRID (GRID) • Contours (CON) • Cross Sections (CROSS) • Imagery (BIL, TIF, IMG, ECW etc) • Other Use additional field width and more characters if required.
GSD	*-010*	Ground sampling distance or resolution of product where appropriate. Where GSD is not required producers can extend the surface type and product description field.
xxxyyyy	*_4806558 (480,000mE) (6558,000mN)*	Easting and northing value (whole kilometre) of the south-west corner of the tile. A single "_" must be used to separate the remaining file name components.
zz	*_56*	MGA zone of the file
wwww	*_0020*	Width of the **dataset or tile** in whole kilometres
hhhh	*_0050*	Height of **dataset or tile** in whole kilometres
ext		File extension according to format conventions • LAS • xyz ascii format for easting, northing, elevation, intensity • asc – ESRI ascii GRID format • shp • dxf etc
For example: KempseyLidar2009-DEM-GRID-010_4806558_56_0020_0050.asc		

Naming Convention for all other GDA files: *ProjectNameYYYY-SSSS-PPPP-GSD_xxxxyyy_wwww_hhhh.ext*		
ProjectName	*SwanCoastLidar*	A meaningful description of the total survey area of interest. Do not use "_" as part of the Project Name
YYYY	*2009*	Year of survey
SSSS-PPPP	*-DEM-CON*	Surface type. • DSM • DEM • HDEM • CHM • CFM • Bathymetry (BAT) • Mixed (MIX). Bathymetry and terrain elevations • TTT (Other terrain variables e.g. slope (SLP). Add as necessary. Product type • Mass points (MASS) • Breaklines (BRK) • TIN (TIN) • GRID (GRID) • Contours (CON) • Cross Sections (CROSS) • Imagery (BIL, TIF, IMG, ECW etc) • Other Use additional field width and more characters if required.
GSD	*20cm*	Ground sampling distance or resolution of product where appropriate. Where GSD is not required producers can extend the surface type and product description field.
xxxxyyy	*1185324 (118.5E, 32.4S)*	Lower left ***longitude and latitude*** *(to 1 decimal place)* A single "_" must be used to separate the remaining file name components.
wwww	_0015 (1.5deg)	Width of the **dataset or tile** in whole degrees *(including 1 decimal place)*
hhhh	_0028 (2.8deg)	Height of **dataset or tile** in whole degrees *(including 1 decimal place)*
ext	*shp*	File extension according to format conventions • LAS • xyz ascii format for easting, northing, elevation, intensity • asc – ESRI ascii GRID format • shp • dxf etc
For example: SwanCoastLidar2009-DEM-CON20cm_1185324_0015_0028.shp		

Attachment C – NEDF Metadata Specifications

For each supplied data product a complete metadata statement consistent with the current ANZLIC standard (http://www.anzlic.org.au/infrastructure_metadata.html) is required. Additional metadata specific to LiDAR data is also required.

These metadata may be entered via the ANZMET Lite facility for the general description and via the NEDF Metadata entry tool for the LiDAR-specific data. The two tools are integrated to produce one comprehensive entry. The NEDF Metadata Tool is available by contacting elevation@ga.gov.au.

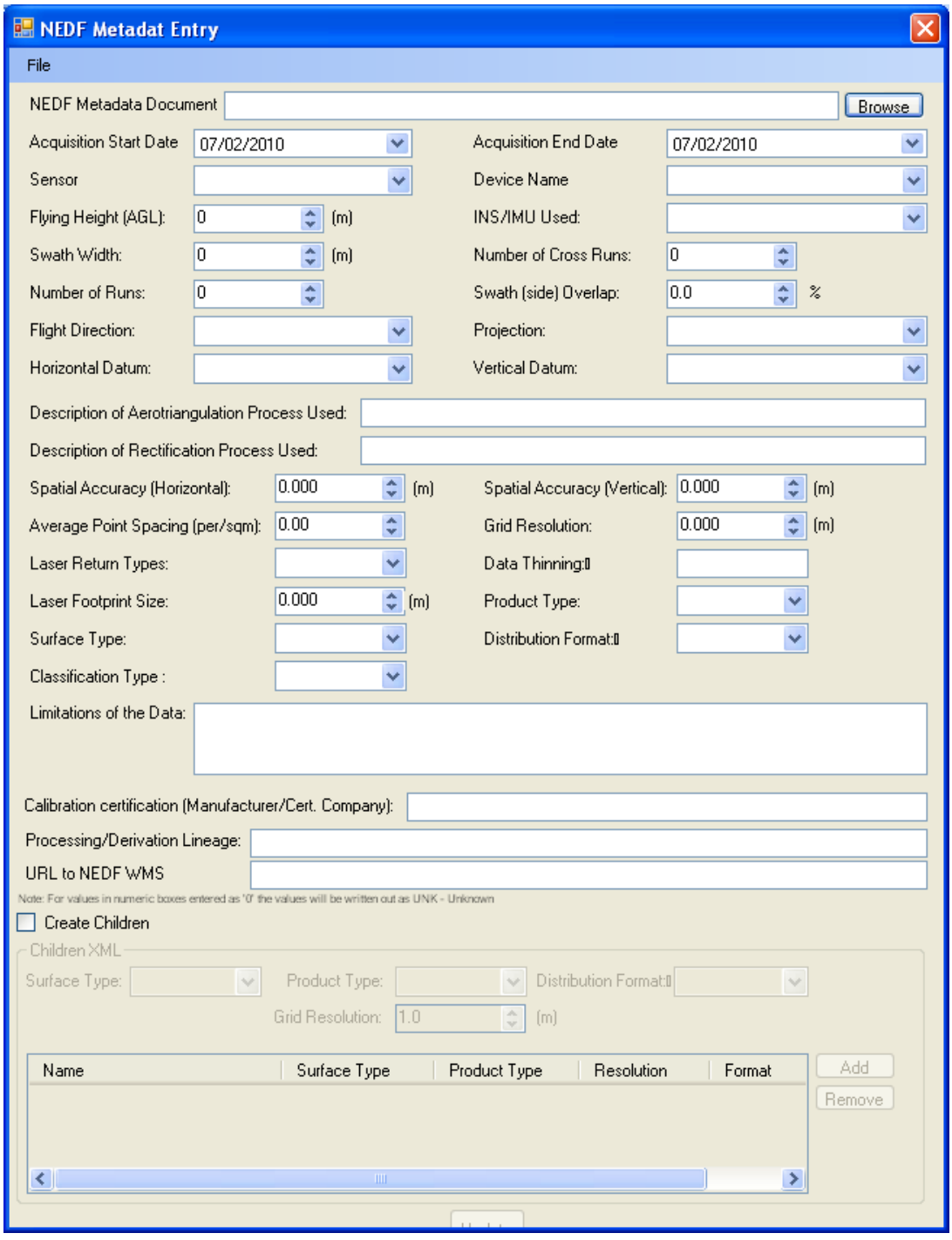


Figure 1 - NEDF Metadata Entry facility

Attachment D - Submission of Quotation

The following information must be submitted:

a) *Details on how the LiDAR work is to be undertaken, including methodology, equipment being used, system calibration, sensor parameters (e.g. pulse rate, footprint size and other relevant technical data), data processing etc;*

b) *Diagrams of the proposed survey area and flight lines for LiDAR including cross strips for each of the options proposed.*

c) *Diagrams of the proposed survey area and location of planned ground control and check points, and the origin of points (e.g. field measurement for this project or state survey control) for each of the options proposed.*

d) *Description of the processes to produce the specified data products and how the specified accuracies will be met.*

e) *Technical qualifications and relevant experience of the company, project team members and project manager in undertaking airborne LiDAR surveys. This should also include recent examples of similar projects recently completed.*

f) *Gantt chart or table describing tasks, milestones, deliverables and timeframes in weeks from the day of receipt of purchase order.*

g) *Statement of compliance against specified deliverables and specifications. Tenderers are to use the statement of compliance template provided in Attachment C.*

h) *A schedule of service charges against deliverables and submission dates for each of the options proposed.*

i) *Prices submitted need to be valid for 60 days after the date this offer closes.*

j) *In addition to the specifications requested, proponents may also wish to offer alternative solutions which could offer cost or time savings to the project.*

Attachment E - Quotation Template

One of these templates must be completed for each of the three options tendered.

……..xls

Attachment F- Queries and Delivery of Contract Material

All queries and delivery of contract material should be addressed to:

Receiving Officer

Delivery Address and Contact Details

Attachment G - Selection Criteria

The criteria for assessing quotations will be:

Category	*Weighting*
Methodology of LiDAR capture and processing.	
Price	
Time frames and contingences to maintain time frames.	
Past Performance	

Attachment H - Ownership/licensing of Foreground Intellectual Property

Ownership and licensing arrangements in relation to Foreground IP will be as follows:

Note to tenderers: The Contracting Agency placing the Official Order will indicate its required arrangement in relation to ownership or licensing of IP, using the categories below.

[Tick one]	Category	Description
	A	Ownership of Foreground IP vests in the Agency submitting the Official Order (**Agency**). No limits as to use, exploitation, reproduction, adaptation or sublicensing of Foreground IP.
	B	Ownership of Foreground IP vests in the Contractor. The Contractor grants a non-commercial, perpetual, irrevocable, royalty-free, worldwide, non-exclusive licence (including a right of sub-license) for the Foreground IP to be used, reproduced (including by displaying on a secure network at full resolution and on a public website, for viewing only), adapted and exploited by the licensee and persons and companies undertaking services for, on behalf of, or in collaboration with the licensee. The license may be granted to one or all of the following: • Australian Government Departments, agencies, authorities and companies (including the Australian Defence Force); • State and Territory government departments, agencies, authorities and companies; and • Local/municipal government departments, agencies, authorities and companies, and Natural Resource Management Regional Bodies (as defined by the Australian Government in association with State and Territory Governments)
	C	Ownership of Foreground IP vests in the Contractor. The Contractor grants a non-commercial, perpetual, irrevocable, royalty-free, worldwide, non-exclusive licence (including a right of sublicense) for the Foreground IP to be used, reproduced (including by displaying on a secure network at full resolution and on a public website, for viewing only), adapted and exploited by the licensee and persons and companies undertaking services for, on behalf of, or in collaboration with the licensee. The license may be granted to Australian Government Departments, agencies, authorities and companies (including the Australian Defence Force);

Attachment I – Statement of Compliance

Tenderers are to state the level of compliance of it's Tender Response to each Deliverable by inserting one of the following terms against each Deliverable in the appropriate space provided in the table below.

COMPLIES means the requirement or performance standard to be met by the Deliverables to be provided, that the offer shall provide the requirement or standard.

PARTIALLY COMPLIES means the requirement or performance standard can only be met subject to certain conditions. Where this is the case and the tenderer is prepared to make good on the condition, requirement or performance standard the tenderer must explain the technical and cost impact of proposed modifications.

DOES NOT COMPLY means that the requirement or performance standard of the clause is not met by the offer.

COMPLIES WITH ALTERNATIVE means that the tenderer's method, system or process either does not require the feature or the tenderer's method, system or process fully complies in a manner different to that described.

IMPORTANT

In each case where a tenderer's response is Complies, Partially Complies, Does not Comply or Complies with Alternative the Tenderer is to provide as a separate attachment to their Tender, clarification identifying how the respective response complies, partially complies, does not comply or complies with an alternative including where appropriate, identifying what if any, cost impacts such responses would have on tendered prices.

Compliance - General Specifications:

	Description or Deliverable	**Statement of Compliance (Complete response using terms indicated above)**	**Comments or Tenderer's Reference (including reference to alternatives, modifications or information supporting compliance)**
		response	*response*