Australian Government

Geoscience Australia

Development of Guidelines and Standards for the Acquisition, Processing and Quality Assurance of Elevation Data

Phil Tickle

Chair

ICSM Special Interest Group on Elevation Data (ESIG)

ESIG Terms of Reference

1. Develop technical guidelines and standards for the acquisition, processing and quality assurance of elevation data.

2. Develop generic best practice ‘Statements of Work’ that may be used by agencies in developing project deliverables.

3. Liaise with ICSM committees and other appropriate bodies to optimise alignment of activities.

4. Facilitate national awareness of guidelines, best practice and standards

- Membership from State and Commonwealth jurisdictions, industry and academia

Why do we need a Guidelines and Standards

- Current investment in high-accuracy elevation data is largely project-based
  - High purchaser transaction costs

- Wide variety of specifications and processing often makes it difficult to integrate project data into larger programs
  - Issues of interoperability
  - High provider transaction costs

- In-appropriate specifications for intended purposes
  - Paying too much or too little
- Evolving requirements, technical capabilities and "best practice"
  - standards need to evolve
- Purchasers are not always aware of latest "best practice"

ESIG Review of Best Practice

- Australian and International guidelines and standards
- Recent Requests for Tender
- Industry providers and consumers

- Identification of common elements for inclusion in a set of “best practice” guidelines
- Focusing initially on acquisition, rather than specifications relating to the “nested DEM”

Scope of the Review

- Framed within the concept of the Multi-Resolution Nested DEM
  - 3 tiers of vertical resolution
    - 10-30cm
    - 50cm – 2m
    - 5-15m
- Initial guidelines focus on first tier photogrammetry and LIDAR (largest current investment)
  - Recognising the need to include IFSAR and other capabilities in the future
  - Recognising that it is not feasible set guidelines that are not consistent with commercial system capabilities
- Aiming to build on USA Guidelines for Digital Elevation Data and ASPRS Lidar Guidelines

Scope of the Review

- Definitions
- Data types
- Data model types (mass points, TINS, Breaklines, Etc)
- Horizontal and Vertical Accuracy
- Data Formats
- Horizontal and vertical datums and geoid models
- Testing and reporting of accuracy including modelling of surface errors
- Quality assurance methods and reporting
- Coordinate systems and units
- Metadata standards which describe the source data and the models used to produce derivative products.
- Surface classification, processing and editing
- Classification and extraction of surface and non-surface features such as vegetation and buildings for deriving bare earth DEMs
- Methods of interpolation and extraction
- Hydrological enforcement

Information Sources Used

- ~40 documents relating to:
  - Requests for Tender
  - Technical specifications
  - Quality Assurance Procedures
  - International guidelines
    - USA, Canada, UK, NZ
- Discussions with users and vendors
- Applications included:
  - Wetland and floodplain management; coastal inundation, flood modeling; erosion monitoring; forestry and vegetation management; topographic mapping; engineering, and nautical charting

Horizontal and Vertical Data Standards

- Recommending 3 “Orders of Accuracy”
- Directly related to price

Order	Special	1	2	3
Typical Use	Surveys required for engineering and infrastructure design	Modelling of inundation from floods or storm surges in areas of high value assets	Modelling of inundation from floods or storm surges in areas with minimal infrastructure.	Modelling of large areas for preliminary route assessment.
Vertical Accuracy (RMSE, 1 sigma or 68%)	<0.1m	+/-0.15m	+/-0.3m	+/-0.5m
Horizontal Accuracy (RMSE, 1 sigma or 68%)	<0.3m (typically 2 or 3 times the vertical accuracy)	+/-0.45m	+/-0.9m	+/-1.5m
Recommended contour interval	<0.3m	0.5m	1m	2m
Minimum grid cell size (DEM)	<1m	1m	2m	5m
Maximum tile size	1km x 1km	2km x 2km	2km x 2km	4km x 4km

Data Types

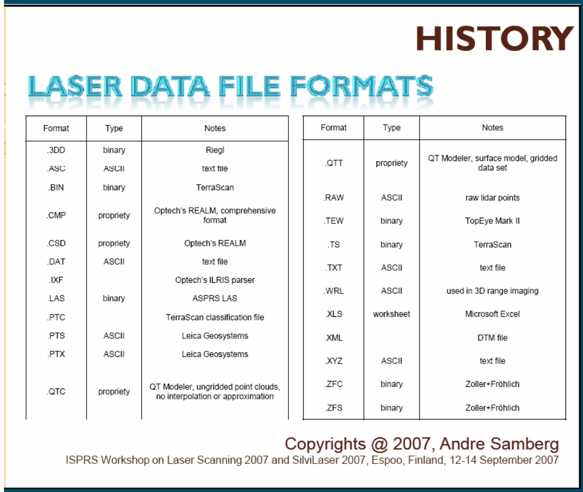
- System Data
  - System specific data produced at the time of acquisition
- Primary Data
  - Elevation data corrected using INU/GPS and ground control
  - LAS or ASCII
  - Random spot heights
  - Breaklines, ground, non-ground, etc
- Derived Data
  - Data interpolated from the primary data

- Important to focus on the Primary Data elements

- Significant benefits for adopting the ASPRS LAS data exchange format for primary data

- Combination of ASCII and proprietary GIS formats (industry stds) for derived data

LAS – Lidar Data Exchange Format Standard



HISTORY

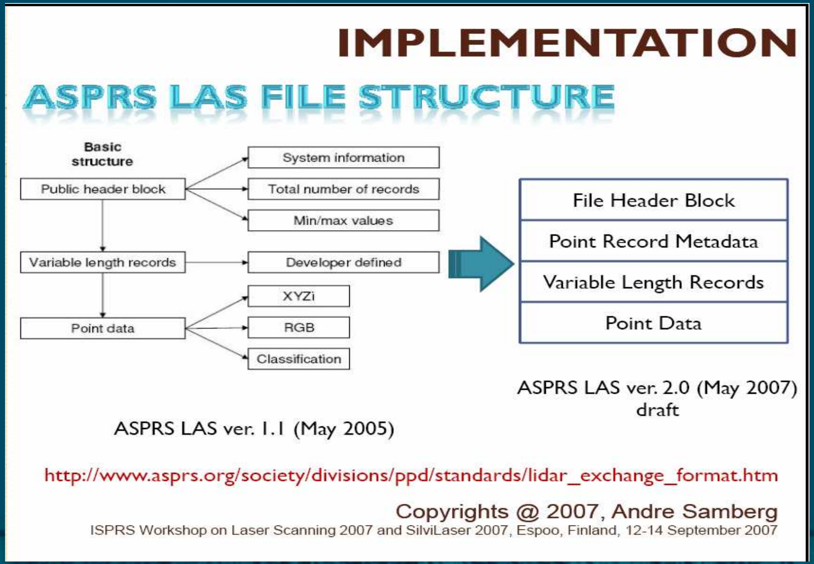
LASER DATA FILE FORMATS

Format	Type	Notes
.3DD	binary	Riegl
.ASC	ASCII	text file
.BIN	binary	TerraScan
.CMP	propriety	Optech's REALM, comprehensive format
.CSD	propriety	Optech's REALM
.DAT	ASCII	text file
.IXF		Optech's ILRIS parser
.LAS	binary	ASPRS LAS
.PTC		TerraScan classification file
.PTS	ASCII	Leica Geosystems
.PTX	ASCII	Leica Geosystems
.QTC	propriety	QT Modeler, ungridded point clouds, no interpolation or approximation

Format	Type	Notes
.QTT	propriety	QT Modeler, surface model, gridded data set
.RAW	ASCII	raw lidar points
.TEW	binary	TopEye Mark II
.TS	binary	TerraScan
.TXT	ASCII	text file
.WRL	ASCII	used in 3D range imaging
.XLS	worksheet	Microsoft Excel
.XML		DTM file
.XYZ	ASCII	text file
.ZFC	binary	Zoller+Fröhlich
.ZFS	binary	Zoller+Fröhlich

ISPRS Workshop on Laser Scanning 2007 and SilviLaser 2007, Espoo, Finland, 12-14 September 2007

- Industry standard binary format "developed" by ASPRS
- Common binary format encourages interoperability
  - All major COTS can read LAS



- Significant benefits for providers, purchasers and down-stream users
  - Now seeing use in photogrammetry
- Most of the things needed to re-process as reference frames improve

Horizontal and Vertical Datums and Geoid Models

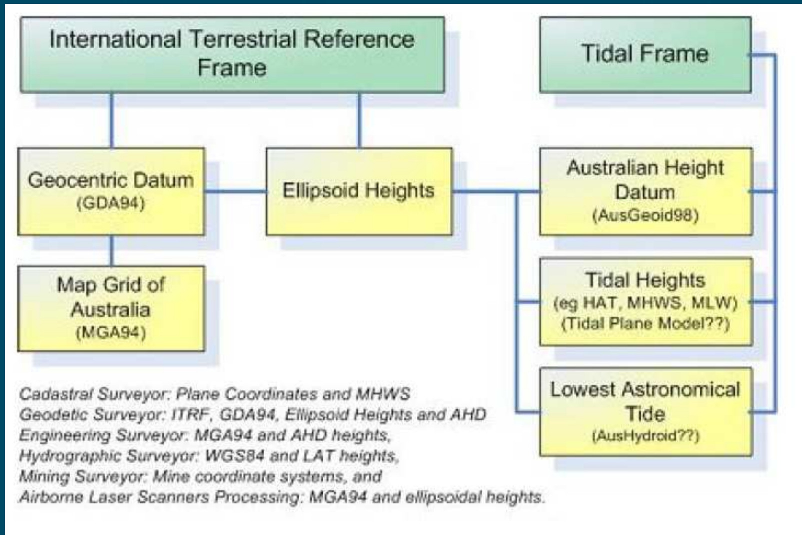


Figure 1: Realisation of ITRF and Tidal Reference Frame, (from Todd 2005)

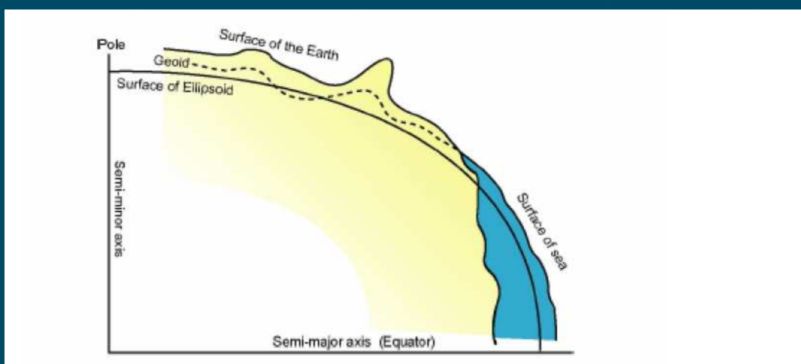


Figure 6: Relationship Between Geoid, Earth Surface and Sea Surface, from TALOS Manual (2006)

- Pragmatic approach to data integration is through rigorous knowledge of ellipsoidal heights and tidal frames
- Connect data through ellipsoidal heights
- For land surveys metadata relating to control is crucial (future-proofing)
- Aim of the guidelines will be to ensure users can move back and forwards through reference frames (MGA94, GDA94, AHD, WGS84), through time (re-processing)

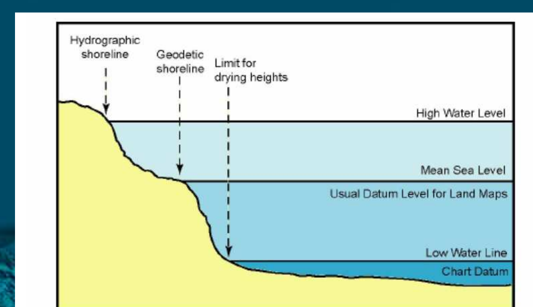


Figure 9: Vertical Datum and Horizontal Position, From TALOS Manual (2006) Chapter 2 p19

Hydrological Conditioning

- Hydrological enforcement most common in moderate resolution DEMs
- Future uses of high resolution data likely to require greater investment break-lines and selective drainage structures
- Enforcing relevant drainage features
  - Streams, culverts, etc
- Ensuring water flow is continuous across the landscape
- Removing sinks

- Initial emphasis is on raising awareness and “high-level” guidelines.

Testing and Reporting on Accuracy

- Only ~1/5 of RFTs reviewed included specific QA procedures
- Well defined by the USA NDEP (2004) guidelines
  - Significant opportunity to raise awareness relating to land cover and terrain type testing guidelines
- Both absolute and relative accuracy important
  - Absolute - systematic errors
  - Relative - point to point errors (e.g slope)
  - Most testing only looks at absolute accuracy in open terrain

Impact of Land Cover on Accuracy

TABLE 3. RMSE AND MEAN ABSOLUTE ERROR BY LAND-COVER CLASS. ALL UNITS ARE METERS

Land-cover Class		Decimation Level (i) 0	1	2	3	4	5
Pavement $n = 41$	*RMSE (m)*	0.14	0.13	0.13	0.14	0.16	0.16
	MAE (m)	0.12	0.11	0.11	0.13	0.14	0.14
Grass $N = 33$	*RMSE (m)*	0.14	0.14	0.14	0.16	0.16	0.18
	MAE (m)	0.11	0.12	0.11	0.12	0.12	0.13
Shrub/Scrub $N = 60$	*RMSE (m)*	0.37	0.38	0.45	0.35	0.39	0.33
	MAE (m)	0.26	0.28	0.32	0.25	0.28	0.26
Mixed $n = 37$	*RMSE (m)*	0.26	0.35	0.37	0.35	0.37	0.36
	MAE (m)	0.20	0.23	0.28	0.28	0.32	0.28
Deciduous $n = 83$	*RMSE (m)*	0.39	0.43	0.41	0.42	0.42	0.43
	MAE (m)	0.27	0.29	0.29	0.30	0.31	0.32
All Points $n = 242$	*RMSE (m)*	0.31	0.34	0.36	0.33	0.35	0.34
	MAE (m)	0.21	0.23	0.24	0.24	0.25	0.25

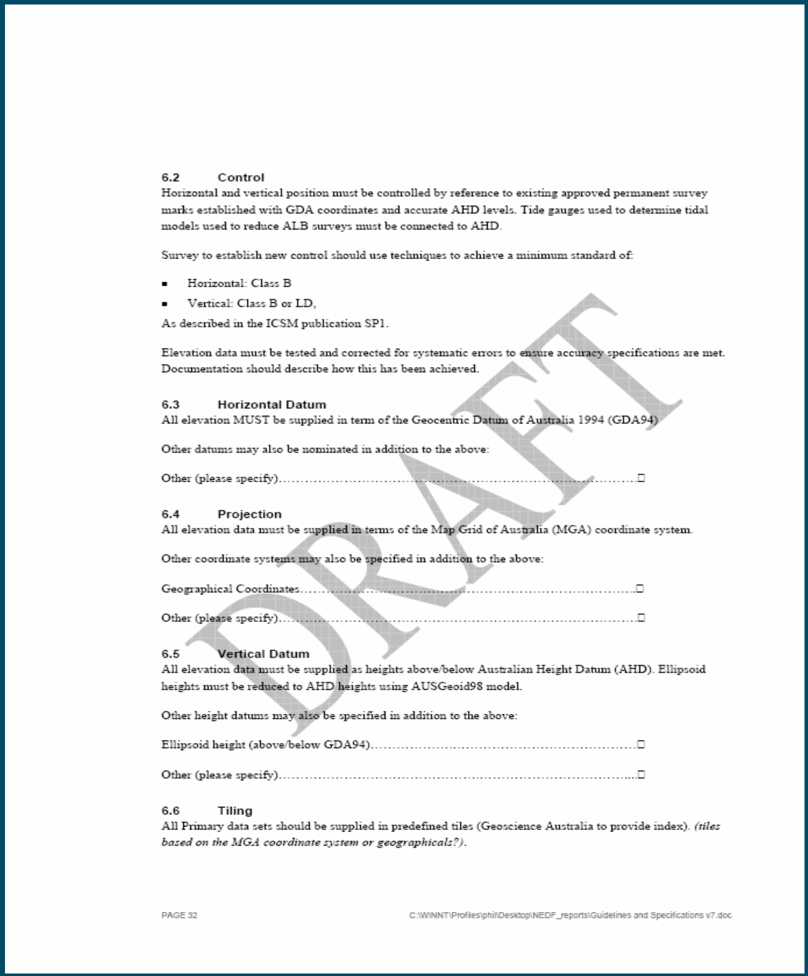
PHOTOGRAMMETRIC ENGINEERING & REMOTE SENSING

Raber *et al* July 2007 799

Quality Assurance Methods and Reporting

- Generally the onus must be on the contractor
- As technology becomes more understand the need for independent testing should reduce
  - “compiled to meet standard X”
- Standard quality assurance deliverables should include:
  - Flight plans
  - Risk control, OH&S, environmental etc
  - Reports on ground control and check points
  - Connections to Permanent Survey Markers
  - The 4th dimension (time) must be considered
- Acceptance Testing Plan (purchaser)
  - Verification on conformance to contract
- Metadata
  - ANZLIC compliant

"Tick-the-box" Guidelines



6.2 Control

Horizontal and vertical position must be controlled by reference to existing approved permanent survey marks established with GDA coordinates and accurate AHD levels. Tide gauges used to determine tidal models used to reduce ALB surveys must be connected to AHD.

Survey to establish new control should use techniques to achieve a minimum standard of:

- Horizontal: Class B
- Vertical: Class B or LD,

As described in the ICSM publication SP1.

Elevation data must be tested and corrected for systematic errors to ensure accuracy specifications are met. Documentation should describe how this has been achieved.

6.3 Horizontal Datum

All elevation MUST be supplied in term of the Geocentric Datum of Australia 1994 (GDA94)

Other datums may also be nominated in addition to the above:

Other (please specify)………………□

6.4 Projection

All elevation data must be supplied in terms of the Map Grid of Australia (MGA) coordinate system.

Other coordinate systems may also be specified in addition to the above:

Geographical Coordinates………………□

Other (please specify)………………□

6.5 Vertical Datum

All elevation data must be supplied as heights above/below Australian Height Datum (AHD). Ellipsoid heights must be reduced to AHD heights using AUSGeoid98 model.

Other height datums may also be specified in addition to the above:

Ellipsoid height (above/below GDA94)………………□

Other (please specify)………………□

6.6 Tiling

All Primary data sets should be supplied in predefined tiles (Geoscience Australia to provide index). *(tiles based on the MGA coordinate system or geographicals?).*

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DRAFT

- A menu to guide purchasers through the process
- Limited number of specifications for vendors to respond to
  - Getting the simple things right
- Separate guidelines for LIDAR, ALB and photogrammetry

What's in it for me?

- By developing and refining guidelines we aim to:
  1. Reduce the chance of repeating mistakes across agencies
  2. Help the purchaser acquire "fit-for-purpose" data in a painless manner
  3. Minimise compliance costs for the provider
  4. Align multiple users needs where possible
  5. Facilitate effective expenditure and industry development through coordinated acquisition
  6. Facilitate interoperability and integration
  7. "Future-Proof" the data
  8. Facilitate improved governance and information management (IM)

Thanks for Your Time

Contact:
Phil.Tickle@ga.gov.au
02 62499 769