3.4. Photogrammetry

3.4.1. Title Sheet

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3.4.3. Overview

3.4.3.1. Scope

This guideline sets out the RTA's preferred methodology for the collection, organisation and electronic transfer of photogrammetric digitised data used to produce a digital terrain model for interfacing with a design model.

3.4.3.2. Objective

The objective of this Guideline is to provide photogrammetric digitised data in a format that can be used with the RTA's modelling software to produce a digital terrain model.

It defines the way in which data is to be collected, organised and how it is to be presented to the RTA.

3.4.3.3. Audience

This guideline has been prepared to assist and guide persons and/or organisations that provide photogrammetric digitised data for digital terrain modelling, with the RTA as the intended final client.

3.4.3.4. Usage

The use of these guidelines is limited to the production of digital terrain models derived using photogrammetric techniques. The data will not be used for digital mapping purposes so annotation such as names, descriptions and embedded contour heights, together with symbols (for points, lines or areas) must not be included in the data supplied.

3.4.4. Organisation of CADD Data

3.4.4.1. Photogrammetric Digitised Data

3.4.4.1.1. Schedule 'D' RTA Photogrammetric Digitising Specifications (see appendix)

Schedule 'D' sets out the processes to be followed when collecting photogrammetric digitised data including:

- Digital Terrain Modelling's Special Requirements
- Orientation Records
- Data Acquisition
- Digitising Modes
- Digitising Physical and Cultural Features
- Relief
- Edge Matching
- Feature Listing which shows:
  - the features to be digitised
  - whether a feature is to be collected as a discrete point or line feature,
  - and whether heights are required for a particular feature.

3.4.5. Preparation of CADD Drawings

3.4.5.1. Presentation

A paper plot is required in order to check the completeness of the photogrammetric digitising and that the reformatting of the data for data interchange was carried out correctly. The plot needs to be supplied at the specified photogrammetric digitising scale. The appearance of the plot (line types, line thickness, colours, symbols etc) are not critical, however a legend showing the symbols used by the software for producing the paper plot should be supplied.

3.4.6. Data Interchange

3.4.6.1. Procedure

3.4.6.1.1. Schedule 'D' RTA Photogrammetric Digitising Specifications (see appendix)

Schedule 'D' sets out the procedure to be followed when transferring photogrammetric digitised data to the RTA. It includes:

- file naming
- media types
- data format

It should be noted that the digitised data must be supplied in either

- MX GENIO format or
- 3 Dimensional Digitising (3DD) ASCII format (.MAF file). 3DD is the photogrammetric digitising software used by the RTA.

3.4.7. Appendix - Schedule 'D' RTA Photogrammetric Digitising Specifications

PROJECT

Road No/Name:

Council Area:

Project Name:

3.4.7.1. General

3.4.7.1.1.

The photogrammetric digitising to be obtained in accordance with these specifications will be used with the Authority's modelling software to produce a digital terrain model for interfacing with a design model. The data will not be used for digital mapping purposes so annotation such as names, descriptions and embedded contour heights, together with symbols (for points, lines or areas) must not be included in the supplied data.

3.4.7.1.2. Digitising Area

The area to be digitised is outlined in a full red line on the project prints.

3.4.7.1.3. Diapositives

Where the limits of the digitising area are drawn by the subcontractor onto the diapositives (for the convenience of the stereoplotter operator) the line work should be as fine as possible (using a Staedtler Mars-Omnichrom pencil) and not placed on the side containing the emulsion.

3.4.7.1.4. Instrument Settings

The supplied analogue instrument settings are approximate only and have been computed for the largest model scale for a Wild A10 stereoplotter

3.4.7.2. Digital Terrain Modelling's Special Requirements

3.4.7.2.1. Height Accuracy

The importance of the height accuracy of all contours and 3 dimensional features cannot be overstressed.

With digital mapping, this accuracy is only critical for contours and spot heights and where features such as drainage must match the re-entrants of contours.

With the required digital terrain modelling, however, the heights along many other features will also be used for the interpolation of heights for design purposes. Thus the height values recorded along roads, railways and certain physical features must be compatible in height with the contours and other 3 dimensional features, which they either intersect or join. The RTA's modelling software will be used to make these comparisons and to compute the mean difference and the standard deviation of the differences about the mean. Any datum shifts between these strings and the strings that they cross will be revealed. The subcontractor will be required to correct significant differences.

3.4.7.2.2. Field Survey Check Strings

In addition to checks on the compatibility in height of the subcontractor's digitised data, field survey check strings observed during the photo control survey will be used to obtain estimates of the absolute height accuracy at various locations.

3.4.7.2.3. Datum Shifts

The absolute height accuracy of 3 dimensional data may decrease due to a height datum shift. Frequent checks on the height datum by the stereoplotter operator are therefore required during digitising and after a prolonged break by reobserving ground and minor control points. If a datum shift is detected, observations for a new transformation onto the ground and minor control points must be performed before continuing with the digitising.

As a check for the existence of datum shifts relative to the aerial triangulation results, check points and/or breaklines have been observed by the RTA within the digitising area.

3.4.7.3. Orientation Records

Orientation records of each stereomodel should be supplied and should show the following:

3.4.7.3.1.

Either the precision analogue instrument and model scale or the analytical instrument used for the digitising.

3.4.7.3.2.

The readings of all orientation elements after absolute orientation (on an analogue instrument only).

3.4.7.3.3.

The differences in easting, northing and height in metres at all minor and ground control points after absolute (or exterior) orientation.

Each difference should equal the observed value minus the value given in Schedule 'C'. If the subcontractor's software does not follow this convention, a note should be made on the orientation record accordingly.

3.4.7.3.4.

The number of instrument hours per stereomodel.

NOTE: Any problems with orientation should be recorded on the orientation record. Major differences obtained in position or height at control points should be reported immediately to the RTA.

3.4.7.4. Data Acquisition

3.4.7.4.1. Point and Line Features

All features appearing in the Feature Listing (see appendix 'A') must be digitised as either point or line strings but not a combination of both.

Appendix 'A' should be referred to when digitising features to ensure that each feature listed is correctly digitised as either a point or a line string.

3.4.7.4.2. Feature Dimensions

Digitised features are either

- Y and a null height (i.e. heights not required)
- Y and a fixed height (this refers to contours only)
- Y, height (i.e. heights measured)

Appendix 'A' should thus also be referred to when digitising features to ensure that a feature's height requirements are correctly recorded.

3.4.7.4.3. Sequential Observation of Points in Strings

To satisfy the requirements of the RTA's modelling software, all line strings must be represented by a string of points observed sequentially. Points observed out of sequence (thus temporarily reversing the direction of observation of the line string) are not permitted.

3.4.7.4.4. Digitising Rate (Vertical Modelling)

The RTA's modelling software assumes that the line between adjacent points in a string lies on the ground. Sufficient points must be observed so that this assumption is valid.

3.4.7.4.5. Digitising Rate (Horizontal Modelling)

For all smooth line strings (e.g. a pavement edge) the arc to chord distance in plan (where the chord is the line between adjacent points on the recorded string) should not be greater than 0.5 mm (at the scale specified in Schedule 'A'). This tolerance, however, does not apply to vegetation limits, which should be generalised.

3.4.7.4.6. Post-Acquisition Filtering

The subcontractor should not perform filtering.

3.4.7.4.7. Field Completion Boundary String

The terrain may be obscured in areas where dense vegetation, tall buildings and/or shadow exist requiring a field completion survey to model the terrain's surface. Except where the string *'Timber or Scrub (Dense)'* already exists, a string called a *'Field Completion Boundary'* is required to wholly or partly surround an obscured area.

3.4.7.4.8. Digitising Extent String

A string called a *'Digitising* Extent' string is to be observed along the digitising limit line shown in red on the project prints.

3.4.7.5. Digitising Modes

3.4.7.5.1. Continuous Mode

Continuous mode (based on timing or a reject cube) must only be used with fixed height strings (i.e. contours). Coarse digitising (with a large reject cube) and later interpolation/smoothing by the subcontractor's plotting software (to produce smooth contours at the specified scale) are not permitted. If the subcontractor's software selects a reject cube size based on the plotting scale, however, then half the scale number specified in Schedule 'A' should be adopted for the acquisition.

3.4.7.5.2. Point to Point Mode

3.4.7.5.2.1.

'X, Y and null height' Line Strings (i.e. height not required): Point to point mode must be used for all 'X, Y and null height' line strings, even though the feature is curved (e.g. guardrail).

The digitising rate must comply with paragraph 4.5 for these line strings (except for vegetation limits).

3.4.7.5.2.2.

'X, Y and height' Line Strings (i.e. height required): Point to point mode must be used to obtain the required height accuracy. All changes of grade must be considered.

The digitising rate must comply with paragraphs 4.4 and 4.5 for these line strings.

3.4.7.5.3. Mapping Software Routines

Mapping routines such as parallel line generation and curve fitting are not permitted for any line strings, including contours.

3.4.7.6. Digitising Physical and Cultural Features

3.4.7.6.1.

Where linear features (e.g. fence, road, creek, etc) surround and so define the boundaries of an area feature (e.g. an orchard, cemetery, etc.) then the limits of the area feature should be digitised such that the discrete points in the string are offset inside the boundary features to avoid superimposing the boundary feature strings. Thus simple line strings will define traditional 'area' features and no annotation or symbols will be inserted within the string.

3.4.7.6.2. Drainage

3.4.7.6.2.1.

The drainage pattern to be digitised should include all rivers and creeks, dry watercourses, contour and other drains, pools and swamps. Banks of streams (feature *'top of bank/embankment'* and feature *'bottom of bank/embankment'*) and eroded banks (feature *'landslide/eroded bank'*) should be digitised.

3.4.7.6.2.2.

Areas on sloping ground below springs, containing zones of high ground water content are often evidenced by marked tonal differences, changes in vegetation density or by a damp appearance due to seepage. Where such zones are apparent, their boundaries should be digitised (feature *'swamp outline'*). Where such a zone occurs at a change of grade, a breakline should also be observed (see paragraph 7.9).

3.4.7.6.3. Vegetation

3.4.7.6.3.1.

The limits and density of vegetation cover should be shown. Individual trees should only be digitised in rural areas where very few trees exist. Trees can be an aid when relating the aerial photography to the digital terrain model in these areas.

At scales of 1:1,000 or larger in built-up areas, however, individual trees should be digitised where detail may be obscured.

3.4.7.6.3.2.

Vegetation should be identified as feature 'timber/scrub' with densities as follows:

Dense: Ground rarely or not visible. Relief portrayed by short breaklines in small clearings where possible.

Medium: Crowns of trees sometimes touching. Ground generally visible. Relief portrayed by contours, by contour segments or breaklines in significant gaps in vegetation and by short breaklines in small clearings.

Scattered: Trees well separated. Relief portrayed by contours and breaklines.

3.4.7.6.3.3.

The limits of orchards and cultivated pasture should be digitised (if not enclosed by a fence, etc. see paragraph 6.1).

3.4.7.6.4. Terrain

Rock ledges, cliff faces (where the relative height exceeds the standard contour interval) and areas where a landslide or eroded banks exist should be digitised (with feature 'cliff/escarpment' and 'landslide/eroded bank' respectively). Generalised rock outcrop areas should be digitised with feature 'rock area'.

Other physical features required to be digitised are listed in the Feature Listing (see appendix 'A').

3.4.7.6.5. Cultural Features

All major cultural features are to be digitised, including buildings, fences, retaining and other walls, railways, roads and tracks, embankments, cuttings and bridges.

Power and telephone poles should be added, showing the transmission lines between them where these are visible.

Other cultural features required to be digitised are listed in the Feature Listing (see appendix 'A').

3.4.7.7. Relief

3.4.7.7.1. Contour lines

3.4.7.7.1.1.

Contours should be digitised at the standard contour interval specified in Schedule 'A'.

3.4.7.7.1.2.

Parallel, close and regularly spaced contours do not increase the definition of the terrain's shape. Where the distance between successive contour lines would be less than 2 mm (at the scale specified in Schedule 'A') over a significant area, only index contours need be digitised.

This limit may be increased to 4 mm provided an auxiliary contour is observed midway between the index contours to indicate the uniformity of the terrain's shape in these areas (but only if a steep and constant slope exists).

3.4.7.7.1.3.

Contours are not required on the faces of cuttings, embankments, cliffs or riverbanks. Contours are required, however, when crossing road formations, railway tracks, creeks or rock outcrops.

3.4.7.7.1.4.

Contours may be digitised in point to point mode in almost flat and horizontal terrain where contour definition is very difficult.

3.4.7.7.2. Index Contours

Index contours should be digitised at the index contour interval specified in Schedule 'A'.

3.4.7.7.3. Auxiliary Contours

On natural surface where adjacent contours are separated by more than 50 mm (at the scale specified in Schedule 'A') over a significant distance, auxiliary contours at half the contour interval should be digitised to define the terrain's shape (see the standard contour interval specified in Schedule 'A').

3.4.7.7.4. Decimetre Contours

The use of 'decimetre contour' strings applies only when the digitised photogrammetric data will be supplied to the Authority in 3DD (3 Dimensional Digitising software) format.

Decimetre contours (e.g. 2.5 m) must be differentiated from whole metre contours by using the correct string identifier. If they are not correctly identified, the decimetre value will be rounded off when the contour data is processed by the RTA.

In order to correctly identify decimetre contours, the following separate set of 3DD feature identifiers are available (see appendix 'A'):

- contour: index (decimetre)
- contour: index depression (decimetre)
- contour: standard/intermediate (decimetre)
- contour: standard/intermediate depression (decimetre)
- contour: auxiliary (decimetre)

3.4.7.7.5. Form lines

Form lines (approximate contours) in timbered areas or areas of shadow must not be digitised because their accuracy is not known. A field completion boundary should be digitised around those areas where form lines would have been plotted in the past.

3.4.7.7.6. Spot heights

3.4.7.7.6.1.

Spot heights should be digitised on index contours where embedded annotation (not permitted) would have traditionally been placed.

3.4.7.7.6.2.

Spot heights are to be digitised at crests and sags of all formed roads and of railway tracks, at road intersections, on bridges and culverts, on summits of isolations and the lowest points of depressions and saddles.

3.4.7.7.7. Completing the Terrain's Modelling

Areas may exist where either a contour and/or 'X, Y and height' string starts and/or finishes on the digitising extent string, leaving this enclosed part of the required area inadequately modelled. A breakline string should therefore be observed along (or if this is not possible, adjacent to and outside) the digitising extent string to complete the terrain's modelling.

3.4.7.7.8. Relative Heights, Vertical Walls and Overhanging Cliffs

Relative heights are not permitted. The appropriate line string should define abrupt changes of grade on either physical or cultural features.

If no appropriate string exists, such as for the bottom of a retaining wall or for the base of a cliff, a breakline should be observed to model the change of grade. These base strings, however, must be offset out from the top of the wall or cliff since the Authority's modelling software does not permit superimpositions or overhangs. Similarly, where bridges exist, the strings under the structure must be terminated vertically beneath the outer edges of the structure.

3.4.7.7.9. Breaklines

Since the RTA's modelling software makes no use of single points for interpolation purposes (unless triangles are formed), strings (called breaklines) should be observed to define the shapes of features where using spot heights would traditionally have done this.

Examples of these features are isolations, saddles, spurs, depressions and flat areas.

3.4.7.7.9.1.

In the case of isolations, a breakline should be observed from the highest contour on one side of the isolation (first point of breakline) thence over the top (1 or more points) and down the other side to the same contour (last point) through the longest dimension of the isolation.

Similar observing procedures should be used for saddles and depressions in order to model those features. Breaklines should also be observed along the tops of spurs, where contours change direction significantly.

3.4.7.7.9.2.

For flat areas, where spot heights would have traditionally been shown between widely spaced contours, breaklines should be observed so that no point is greater than 25 mm (at the scale specified in Schedule 'A') from a contour, auxiliary contour or other breakline.

3.4.7.7.9.3.

Breaklines should also be used along changes of grade in order to improve the modelling of the ground surface, e.g. along the bottoms of cliffs, eroded banks and retaining walls.

3.4.7.7.9.4.

Breaklines cancel the need for spot heights except where required in paragraph 3.4.6.7.6.

3.4.7.7.10. Modelling in Areas of Vegetation Cover

3.4.7.7.10.1.

Where contours cannot be digitised continuously (in medium timber or scrub) contour segments should be digitised (preferably in point to point mode) in gaps in the vegetation.

If contours do not exist in these small gaps, breaklines should be digitised where the ground can be seen, even though their density may be greater than that required by paragraph 7.9.

3.4.7.7.10.2.

In areas where the vegetation is so dense that no gaps exist, the string '*Timber/Scrub - Dense'* must partly or wholly surround the area.

3.4.7.8. Edge Matching

The digitised strings should be matched with any 'edge matches' supplied by the RTA, and along stereomodel joins, producing a smooth butt join. No overlaps should occur.

3.4.7.9. Preliminary Data Files and Paper Plots

3.4.7.9.1.

Before the RTA can accept a project, preliminary copies of the data files, paper plots and the RTA for checking each stereomodel's digitised data must receive orientation records. The data files must be on floppy disks and in the same format as the final copies of the data files.

The subcontractor should supply a legend naming the symbols used by the software for producing the paper plots.

3.4.7.9.2.

Following examination by the RTA, the disks and the paper plots will be returned to the subcontractor who will be informed of any corrections to be made before supplying the final data files and paper plots.

3.4.7.9.3.

The subcontractor on suitable computer files must retain all digitised information until the RTA has received the final copies of the data files, and the final progress payment has been made to the subcontractor indicating that the work is acceptable.

3.4.7.10. Data Files

3.4.7.10.1. Stereomodels

Stereomodel files should not be merged. A separate file should be maintained and supplied for each stereomodel.

Stereomodel files should be supplied to the RTA on a floppy disk that may contain one or more stereomodel files, however, no individual file should span two disks.

All stereomodel files should be named AIMODL.EXT where:

A = All (specified features digitised)

I = First initial of subcontractor's company name

MODL = 4 digit stereomodel number consisting of the last 2 digits of each photo number in the direction of the project (from left to right).

.EXT = file name extension either .INP (for MX GENIO files)

or .MAF (for 3DD ASCII files)

3.4.7.10.2. Media

The digitised data is to be supplied to the RTA on 3½" disks of 1.4 Mb capacity, suitable for IBM compatible desktop computers, running the MS-DOS operating system.

Each disk must have a label attached (external paper label) showing:

Subcontractor's		Name
Project:		
Run:	Model(s):	
Directory		Name:
Date:	Disk _ of _	

A printout of the directory and file names should be included with each disk.

3.4.7.10.3. Format

The digitised data (in full MGA coordinates and AHD heights - no false origin) is to be supplied in either

- MX GENIO format (GENeralised Input and Output) or
- 3 Dimensional Digitising (3DD) ASCII format (.MAF file).

Only point and line strings are required (i.e. no area, symbol, or text strings are required).

3.4.7.10.3.1. MX GENIO

The current MX Users Manual should be referred to for the correct format when outputting data in a MX GENIO format.

The nominated string labels and string dimensions must correspond with those specified in the Feature Listing (see appendix 'A').

3.4.7.10.3.2. 3 Dimensional Digitising (3DD) ASCII format (.MAF file)

Copies of the chapter from the 3DD Reference Manual with the relevant sections outlined (see appendix 'B'), and an example (see appendix 'C'), are included (or have been previously supplied) for your reference.

The nominated feature identifiers, feature types and their number of axes (2D, 3D or fixed height) must correspond with those specified in the Feature Listing (see appendix 'A').

Other matters concerning the 3DD ASCII format are:

- Map Header Record

  A map header record is not required. The RTA will complete and attach this record to your data.

- Point Feature Records

  Adopt a source number of 1.

  Do not include a point description.

- Symbol Feature Records

  Symbol feature records are not required.

- Line and Area Feature Records

  Area features are not required for symbolisation purposes.

  Adopt a source number of 1 for line features.

  Do not include a feature description.

  Adopt a V (vertex) point flag for all points.

  Do not include a point description.

  Do not include embedded annotation.

- Text Feature Records

  Text feature records are not required.

- Group and Feature Tree Records

  Group and feature tree records are not required.

- Feature Identifier

  When translating the data into 3DD ASCII format (.MAF file), a feature identifier is required for each string. The feature identifier is used to identify a string type in the digital terrain model (e.g. 1.1 headwall, 7.2 index contour, etc.).

  A list of features and their corresponding feature identifier are shown in the Feature Listing (see appendix 'A').

- Feature Type

  When translating the data into 3DD ASCII format (.MAF file), a feature type is required for each string. The feature type is used to distinguish between point and line features (e.g. a contour is a line type, a spot height is a point type).

  A feature type may be either point or line, but not both.

  A list of features and their corresponding feature type are shown in the Feature Listing (see appendix 'A').

- Number of Axes

  When translating the data into 3DD ASCII format (.MAF file), the number of axes is required for each string.

  The number of axes may be either:-

2 (X, Y)	e.g. a gate
2 (X, Y) with fixed height	e.g. contours only
3 (X, Y, height)	e.g. a breakline

  A list of features and their corresponding number of axes (i.e. dimensions) are shown in the Feature Listing (see appendix 'A').

PROJECT

Road No/Name:

Council Area:

Project Name:

3.4.7.11. Project's Special Requirements

3.4.7.11.1.

A preliminary data file and paper plot (see paragraphs 9 and 10) for the first stereomodel should be supplied to the RTA when the digitising has been completed. The RTA will inform the subcontractor as soon as possible of any major problems (particularly with the data acquisition) before the digitising of the second and subsequent stereomodels is well advanced.