Drafting and Design Presentation Standards Manual Volume 1: Chapter 5 – Project Electronic Models

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Queensland Government

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Amendment Register

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	5.2.2	Survey DTM Model section updated		
	5.2.3	Design String Attributes section updated		
	5.2.4	Cross Section section updated		
	5.2.5	Combination of Design Elements section updated		
	5.2.7	Design Triangulation section updated		
	5.3	Project Electronic Model Delivery section updated		
	5.3.1	Project handover section updated		
	5.3.2	Design to construct section updated		
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	5.2	Minor updates to references		
	5.2.1.3	Minor update to design string naming convention		
	5.4	Section removed		

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5.1 Introduction

5.1.1 Purpose

The purpose of this section is to specify the requirements for electronic modelling of road infrastructure projects for pre-construction and construction purposes. The project electronic model will be used to:

- verify 'the design', especially sight lines, design interfaces, including terrain/feature interfaces
- validate the design
- provide comprehensive design information to road constructors
- provide accurate quantities
- allow both the designer and constructor to produce engineering design drawings as required
- allow for incorporation of design variations during construction
- provide 'as constructed' details and drawings
- provide displays for public consultation purposes
- provide data/details of the road asset, including use in GIS systems, and
- enable the contractor to be able to extract design information in a form suitable for machine guidance equipment.

It is intended that this modelling specification provides the means for the standardisation of project electronic modelling for all Departmental road infrastructure projects.

5.1.2 Scope

This section establishes the basic principles of structuring and transferring road design data modelled electronically. It does not cover survey data feature coding and modelling, except for the requirements relating to the creation of the original surface and features to which design modelling is applied.

5.1.3 Application

The principles and guidelines in this chapter are applicable to all parties involved in preparing, using and distributing electronic models on computer systems. Although these principles are primarily for computer users, system developers and instrument manufacturers are expected to provide software tools capable of implementing and supporting this modelling specification.

5.1.4 Definitions

The following definitions are used in the context of this document:

Attribute

An attribute is a user defined name/value pair with an associated data type (generally numeric or text) attached to a Project, Model, Point, String or Tin. Within an object, the attribute names must be unique.

Attributes on strings may be attached to either a vertex, segment or the string itself.

Attributes may also be structured by attribute groups that may consist of 0 or more attributes.

Point

A point is a single location in space. Points can be two-dimensional (X, Y) or three-dimensional (X, Y, Z), and may include an unlimited number of additional named attributes (dimensions and/or descriptions/notations) depending on their purpose. Many different natural and man-made features are modelled as points including trees, fire hydrants, poles, etc.

String

A string is a series of points linked sequentially to define a feature. Strings can be two-dimensional (X, Y) or three-dimensional (X, Y, Z), and may include an unlimited number of additional named attributes (dimensions and/or descriptions/notations) depending on their purpose.

Control line

A control line string is the basic horizontal and vertical location of a design. The string contains the definition of the significant points from which the geometry at any point along the string may be determined. For a road, the horizontal alignment is an assembly of straights, arcs and transitions (if required), and the vertical alignment is assembled from grades and parabolic curves.

For a road design, the horizontal alignment is defined first, followed by the vertical alignment and the cross section. Points in control line strings are stored in order of increasing chainage. These control lines may represent the centreline or any other convenient feature e.g. lip of channel.

Setting out line

A setting out line string is used for constructing more complex designs – such as designing the reverse curves where provision is made for turning lanes. A setting out line may be two-dimensional or three-dimensional, depending on the requirement.

Feature design strings

Feature design strings are strings that define the geometric features (shapes) of a road, and collectively they define all design surfaces which comprise the road model. Once the control line design is completed, feature design strings are created, and each control line may give rise to a series of features related to it, essentially by horizontal and vertical offsets. Any number of control lines and associated features may be used to fully model the geometric design surface and associated design elements (e.g. guardrail).

Cross section

A cross section is a vertical slice along a given line cutting through a series of strings, usually feature design strings, showing the various elements that make up the road's shape and structure. The plane in which the cross section is generated is generally perpendicular to a reference string, from which chainages for the cross sections are assigned. Exceptions to this would include drainage cross sections that are required to be skewed rather than perpendicular. At cross section locations, intersections of the cross section plane with the series of strings are calculated, and joined to form the cross section string. Cross sections are viewed in the direction of increasing chainage.

Interface

An interface is where slopes projected from one surface intersect another surface. For a point on a string, an interface point is calculated at right angles to the string along a line of specified slope until either a specified surface is intersected or a specified (horizontal) distance is travelled. Calculating the interface points at specified intervals along the string, and then joining the interface points together forms an interface string. In all road designs, the surface defined by the feature design strings is projected onto the existing terrain surface, and the interface strings define the extent of the design. In more complex road designs, additional interfaces may need to be calculated between design element surfaces.

Model

A model is a collection of relevant data, used to separate and store string or tin (triangular irregular network) information into components within a project. It is defined by a unique name that reflects the nature of the information it contains. Data is organised into models according to the physical features represented, for example strings defining an existing terrain surface or a design surface. A design model is a collection of three dimensional strings representing the true shape of a roadway project that when triangulated will produce a complete and accurate surface representing the design.

Project model

A project model is a collection of models selected to comprise the road infrastructure project.

In a project model:

- all strings are comprised of points with specified attributes
- all strings are named using the standard convention (Reference 1)
- all models are named using the standard convention (Reference 1)
- triangulation models are required for all design surfaces, including subgrade and materials layers.

5.2 Project model organisation

5.2.1 Naming conventions for modelling systems

Models are usually named to reflect the type of data being stored.

The department has adopted a standard naming convention for strings and models for use with all corporately mandated modelling software packages, and variations will not be accepted.

It must be remembered that the data has a number of potential users, both now and in the future, and it is important that the provision of data is uniform across the department.

5.2.1.1 Model naming convention

To take full advantage of current and proposed automated procedures within our modelling packages, a standard model naming convention is required. Surveyors, designers and constructors then will have immediate recognition of model contents no matter where the project originated.

This naming convention follows closely the names associated with the types of models and the surfaces they contain. Appendix 2C, Section 9 - Model Naming Conventions (Chapter 2 General Standards – DDPSM Volume 1) shows the model names to be adopted together with a brief description of their contents and general uses.

5.2.1.2 Survey feature codes

All survey feature coding and modelling must be in accordance with the current department's *TMR Surveying Standards*. No variations will be allowed to the codes, symbols, line styles or designated models for each code.

5.2.1.3 Design string naming convention

The department has adopted a standard convention for the naming of design strings. The use of a labelling convention during design will allow for a more efficient use of current and future automated features available within existing design software - such as the transfer of data.

Appendix 2A in Chapter 2 General Standards – DDPSM Volume 1, contains the department's string naming convention. Appendix 2A provides details such as string label names, design feature descriptions, their associated line styles and CAD layers, as well as their respective model names.

5.2.2 Survey DTM model

The existing ground surface triangulation model, must be capable of being recreated directly from the existing survey model supplied without further editing. A boundary string should be used to define the extent of the survey and the data to be triangulated as well as being used as a reference to trim unwanted triangles as required.

A boundary model should be included in the submitted Project Model data so that when a user re-triangulates the existing survey model, any triangulation data originally excluded by the surveyor will not be included in any subsequent re-triangulation.

5.2.3 Preparation for earthworks

The preparation of the ground surface for any stepping under embankments must be included. Models for stepping should contain the strings used to define the stepping and associated stripping for the length of the job and be suitable for triangulation. Boundary strings should be used to define the extent of the stripping and stepping areas.

A second ground surface triangulation model should also be created. This triangulation model will be generated from the original survey data with the stepping data substituted where necessary. This will form a true representation of the prepared surface for the roadway design suitable for accurate volume calculations.

5.2.4 Design string attributes

In order to provide design information to road constructors, it is necessary to ensure that the appropriate string types are used when defining the design features of a road. Each string type stores a number of attributes (x, y, z values and information) at each point. The designation of string type, and therefore the assignment and storage of attribute data is largely managed automatically by the modelling package.

Not all stored attributes for each string type are relevant for road constructors in terms of defining the geometric design surface of a road. However, some are vital and must be included by the time that the electronic model is finalised for construction. For use in road construction, all design strings can be categorised into one of three types – control line strings, feature design strings derived from control lines and all other feature design strings.

The control line strings should include XYZ co-ordinates, chainage, bearing, horizontal radius, vertical grade and vertical curvature at any point. Chainage intervals on Control Lines should be at a maximum of 5 metres.

Feature design strings derived from the control line should be designed to a standard compatible with electronically controlled construction equipment. This means that all horizontal curves should have a chord-to-arc tolerance of a maximum of 10 mm and preferably be true geometric curves.

All other feature design strings must contain XYZ co-ordinate values at all points along the strings.

5.2.5 Cross section

Cross sections are used for viewing and plotting profiles defining interface strings and calculating volumes using the end area method. Apart from some locations where generation of a cross section is vital, it is generally a matter of judgement to decide at what intervals sections should be taken.

Cross section strings should be grouped by reference to the control line to which they are related and the surface through which they cut, and are stored in separate cross section models; they should not be stored in design models.

Cross sections must be provided at the following locations:

- horizontal control points (e.g. TS, SC, CT etc)
- regular intervals nominated by the designer. For example,10 to 12.5 m in flat terrain, 5 m elsewhere (a longer interval may be appropriate in straight forward situations in flat terrain with few transitions from cut to fill)
- changes in shape. For example where a change in template definition or string modifier occurs – note that changes in shape on one side of an alignment often occur independently of the other side, however modelling packages generate a full cross section regardless of which side is changing
- special chainages nominated by the designer. For example joining to another feature or in earthworks transition areas.

The interval for the insertion of additional chainage points required to be generated for control line and feature design strings derived from the control line is dependant on the curve radius. Modelling software should automatically insert additional points on Control Line arcs depending on the chord-to-arc tolerance maximum distance setting. The required chord-to-arc maximum distance is 0.01 m. If this distance is exceeded when analysing curves by chords, extra points are inserted into the curve so that the chords all have chord-to-arc distances less than this value.

5.2.6 Combination of design elements

Complex road design projects often involve modelling of separate design elements, which must ultimately be triangulated to form a single finished design surface. This is usually achieved by the use of separate control lines. These elements are generally separated horizontally and vertically, as in the case of an interchange involving bridges and ramps.

Where design elements merge at locations such as ramps and through carriageways, strings at the joins must meet with no gaps, extensions or crossing strings.

Strings representing bridge designs are to be stored in separate bridge models. Do not continue road design strings across bridge structures. End them at the abutment and continue either the existing survey strings or lower roadway design strings under the bridge as if the structure was not present. Control line strings should be kept separate and placed in a separate model. Strings defining bridge spillthroughs must be duplicated for inclusion in both the bridge and design models, and these strings must join to the strings defining the road design surface to provide the complete design surface triangulation.

Tunnels should also be kept in a separate tunnel model. Do not continue road design strings through the tunnel. End them at the tunnel face. Do not include control line strings. Because of the shape of tunnels, it is necessary to keep the lower tunnel roadway surface separate from the upper tunnel roof and place into different models. Both models must be suitable for triangulation.

The tunnel face must contain strings that define the tunnel entrance and the interface with the road design surface and the existing natural surface. The tunnel face strings are added to the design model strings to provide the complete design surface triangulation.

(NOTE: Because of the nature of the triangulation process, the tunnel face must be slightly off vertical).

5.2.7 Bridge feature design strings

Examples of strings required for inclusion in the bridge model are included as Figure 2.1.6.3(j) to Figure 2.1.6.3(n) in Chapter 2 General Standards (Reference 1). The figures indicate the minimum required strings to be included in the project electronic model to allow for setting out during the construction phase.

5.2.8 Design triangulation

5.2.8.1 Design surface

The design triangulation model must be capable of being recreated directly from the design model/s supplied without the need for further editing, except for the trimming of unnecessary triangles along the edges of the data.

Boundary strings should be created to define the extents of the design data. These boundary strings should be stored in separate models. They are to be used to trim unwanted triangles in design triangulation models.

These boundary strings should be included in the submitted project electronic model so that when a user re-triangulates the design model(s), any triangulation data not intended to be included in the design surface can easily be excluded by the user.

5.2.8.2 Subgrade layer surfaces

Strings must be generated by the designer to define the subgrade layer surface. It is necessary to correctly model the interface with the earthworks batter and ensure that strings that should join are modelled with no gaps, extensions or crossing strings to allow correct triangulation of the subgrade surface to create a subgrade triangulation model.

Similarly, each pavement layer should be modelled and triangulated to create pavement layer models and associated pavement layer triangulation models.

Subgrade, pavement layer and associated triangulation models must be included in the project electronic model.

5.2.8.3 Materials layer surfaces

All subsurface materials layers should be modelled, triangulated and included in the electronic project model.

5.3 Project electronic model delivery

The current departmental standard for the provision of project electronic model data is the 12d®Model™ (12d Model) format in the form of native 12d Model files and associated 12d Model project files.

The electronic model is a key component of the road infrastructure delivery process. The department is working towards an ultimate outcome where electronic models of road infrastructure will be developed and enhanced using 12d Model software from the earliest stages of survey through to design, tendering, construction and as-constructed.

The use of an electronic model that is a complete representation of the proposed works, and which is accessible by 12d Model in all phases of the road infrastructure delivery process is important for the following reasons:

- Different phases of the road design project may be performed by different officers or in different office locations by departmental designers or external consultants.
- Verification of designs can be performed by the department's issuing office using 12d Model functionality and custom developed 12d Model tools and utilities.
- Data re-use is achieved by enabling the modelling of future works based upon electronic modelling of previous road designs.
- The electronic model can be passed between phases without losses due to data translation.
- Supports the idea that the electronic model should also encapsulate the design approach/intent.
- The integrity of the design is ensured by the ability to archive the complete electronic model as a digital record.

The electronic model data must be suitable for direct transfer to constructors' computer systems and be directly accessible by the department so that data can be viewed, checked or re-used as required. Each component of the project electronic model should contain relevant information only, and any extraneous or unnecessary data must be deleted before delivery to the department.

5.3.1 Project handover

The project electronic model is to be used in all phases of the road infrastructure delivery process and should be part of any handover between phases.

Apart from any other deliverables specified in a brief, the department requires that electronic model information in the form of 12d Model models and associated 12d Model project files and subfolders be included in the project electronic model. In Microsoft® Windows® this includes the folder level above the 12d Model [named].project folder which encompasses all the 12d Model project files and associated folders. For typical contents refer to Figure 5.3.2(a) and associated Tables 5.3.2(a) to 5.3.2(f).

5.3.2 Design to construct

An electronic copy of the complete project model, including the survey and the design model data, is to be supplied for construction. The department is committed to improving the design/construction interface through the continuing process of consultation with construction industry representatives and software and hardware developers. The department is continually evolving design and design management processes, and will continue to monitor and adopt data exchange formats that suit its needs.

These exchange formats must be capable of being used in innovative ways with existing and future data management systems within the department and within the construction industry.

Figure 5.3.2(a) - Top level of a 12d Model project folder and typical contents

Name	Size	Type
backups.4d		File Folder
Culvert		File Folder
Fingerprints		File Folder
OSroad		File Folder
Palmerston.project		File Folder
A2861_55_10_2009_Far_North_Queensland_FastLook_15cm.ecw	714,966 KB	ECW File
BOXING.bf	4 KB	BF File
COLOUR DESIGN TRIANGLES.slf	1 KB	SLF File
CREATE_TERRAIN_TRIANGLES_AND_CONTOUR.rcn	7 KB	RCN File
CREATE_TERRAIN_TRIANGLES_AND_CONTOUR_PARAM.pvf	3 KB	PVF File
Design to ACAD.slf	4 KB	SLF File
geoinfo.12d	2 KB	12D File
MC10 volumes.rpt	3,549 KB	RPT File
MC10.mtf	3 KB	MTF File
MC11 volumes.rpt	20 KB	RPT File
MC11.mtf	2 KB	MTF File
MC12 volumes.rpt	33 KB	RPT File
MC12.mtf	2 KB	MTF File
MC20 volumes.rpt	325 KB	RPT File
MC20.mtf	2 KB	MTF File
Palmerston	1 KB	Shortcut
raster_panel.log	1 KB	Text Document
RD21A ftm 30062010.12da	7,184 KB	12DA File
RD21A ftm 30062010_METADATA_MRD.rpt	3 KB	RPT File
RERUN DESIGN.rcn	2 KB	RCN File
Survey to ACAD.slf	4 KB	SLF File
Test.rcn	1 KB	RCN File
Tin_Render_Texture.slf	1 KB	SLF File
VPATH_CHAIN.rcn	13 KB	RCN File
VPATH_PARAM.pvf	2 KB	PVF File

Table 5.3.2(a) - Top level 12d Model project folder contents

File Type	Description
*ecw	ECW image used in photogrammetry
*slf	Screen Layout File
*.rcn	Chain file
*.pvf	Parameter file which has a direct relationship to a respective chain file.
*.rpt	Report file
*.mtf	Many Template File
*.12da	12d Ascii file
*.bf	Boxing file

Table 5.3.2(b) - 12d - Model [named].project subfolder contents

File Type	Description
*.view	Named view in the 12d project
*.tin, *.tin.0 etc.	Tin model component files
*.model	Model files
*.template	Template Files
*.stin	Supertin files
*.function	Function files
*.4d	12d project configuration files
Preview.png	12d saved screen capture used by 12d on the start up panel.
Project.digitizer	12d project digitizer file
Project.drainage	12d project drainage file
Project.pipeline	12d project pipeline file
Project.sewer	12d project sewer file
Project.survey	12d project survey file
*.design.ppf	Applied design speed table.
*.def	Definition files called up by respective macros 12d Model.
*.trash	Trash models
Workspace.4dw	Workspace file
project	12d project file

Table 5.3.2(c) - 12d – Model backups.4d subfolder contents

File Type	Description
*.bf.1, *.bf.2 and so on.	Superseded boxing files
*.mtf.1, *.mtf.2 and so on.	Superseded mtf files
Note the backups.4d subfolder and contents are not required as part of the final electronic model	

Table 5.3.2(d) - Culvert subfolder contents

File Type	Description
CulSys.CFG	Culvert configuration file
Culvert.args	Culvert arguments file
*.txt	Culvert text file
*.dat	Culvert data file
*.cpj	Culvert project file
*.cpj.bak	Culvert project backup file
MR_CULVERT.ini	Culvert initialisation file

Table 5.3.2(e) - Fingerprint subfolder

File Type	Description
Fingerprint_check_log.csv	Fingerprint check log file in comma separated value format
*.12da	Fingerprinted 12d Ascii files

Table 5.3.2(f) - OSroad subfolder contents

File Type	Description
OSSys.cfg	OSroad configuration file
*.spe	OSroad speed analysis results file
*.osr	OSroad Alignment definition file

5.3.3 Control line index

An index of control lines in the Project Model is to be created and supplied with the project data. The index is to include the control line string label and a brief description of the control line. This file is to be in plain ASCII or .rtf Rich Text Format.

Table 5.3.3 - Control Line Index

PROJECT MODEL CONTROL LINE INDEX

Details of Project ____________________ Project Number ________________________

District ____________________ Local Authority ________________________

Road Name ____________________________________

Project Title ____________________

Control Line String Label	Description

Appendix 5A: Project electronic model checklist

- All strings are to be in accordance with the String Naming Convention. Where additional string names and codes can be justified (and agreed to by the Project Officer), documentation must be provided.
- All model names are to be in accordance with the Model Naming Convention. Where additional model names can be justified (and agreed to by the Project Officer), documentation must be provided.
- Remove all duplicate and identical points.
- Remove all unnecessary strings.
- There must be no crossing feature design strings when separate design components are combined into a single model.
- Check for string discontinuities, especially interface strings and critical shape control strings such as road crown, hinge points etc.
- Strings that should join or meet must not have gaps or extensions.
- A single triangulation of the complete design surface (including bridge spillthroughs or tunnel faces if present) is required for viewing and rendering. Check for null or zero height points.
- Road feature design strings must not continue across bridge structures or through tunnels. Bridge spillthrough strings (if present) must be duplicated in both the bridge and design models.
- Subgrade layer models should include strings that interface to the batter and allow triangulation of the surface. Pavement layer models should include strings that interface to the batter and allow triangulation of each surface.
- Strings defining the stepping and remaining stripping must be included in the stepping model.
- Contour the design triangulation at closely spaced (e.g. 0.2 m) intervals and thoroughly check the results for discrepancies especially at merging roadways.
- Check contours for correct drainage flows and length of flows.
- Run sight distance and check all situations.
- In a perspective view, run drive throughs along strings at the correct driver height and position along each roadway in all directions. Check for alignment discrepancies, sight distance problems and abnormalities in the triangulation especially at merging roadways.
- All corrections should be done to the original input data and not by post manipulation of the feature design strings. This can be checked by re-running the complete job and looking at the results.