The Current Status and Ongoing Investigations of 2D and 3D Digital Cadastre (ePlan) in Victoria, Australia

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ABSTRACT

ePlan is a collaborative program between the Australian land authorities and the surveying industry, in conjunction with the Intergovernmental Committee on Surveying and Mapping (ICSM) which aims to replace paper and PDF plans with digital files based on a national standard. ePlan was introduced in Victoria in 2011 and has been operational in this jurisdiction for 2D (non-building) plans since 2013. On average, one ePlan application is currently submitted to a digital plan lodgement portal every fortnight. The low uptake of ePlan is caused by a number of challenges which includes surveyors acceptance of adopting a new method of producing plans, the quality of the visualisation service which converts the ePlan LandXML file into PDF as the legal title diagram, and support for 3D building subdivision plans. This paper aims to explore the current status of ePlan implementation in Victoria and discuss the ongoing research programs developed to address the aforementioned challenges.

1 Introduction

The paper/PDF-based method of cadastral survey and plan lodgements and registration has highlighted a number of challenges to the Australian jurisdictions (Falzon and Williamson, 2001). This method is not efficient for a number of reasons. The digital data produced by the surveyors is not available to other surveyors or other stakeholders of land development processes (e.g. developers, councils and referral authorities) for re-use. The survey and plan data cannot be utilised for validation and the DCDB[1] cannot perform updates in an automated fashion using paper/PDF-based plans.

In order to address the issues of paper/PDF-based plans, an ePlan Working Group (eWG) was formed by the ICSM which developed a national model to transfer digital cadastral survey data between the Australian surveying industry and government agencies in 2009 (Aien *et al.,* 2012). In 2011, an ePlan Protocol was developed to map the components of the ePlan data model to LandXML data format.

2D ePlan is currently operational in Queensland, New South Wales and Victoria. Other jurisdictions have also participated in the eWG and are investigating their options. The Singapore Land Authority also joined the eWG in 2013 and have adopted the ePlan Protocol for their cadastral surveying modelling and electronic lodgements (Soon, 2012).

Similar to other states, the ePlan uptake is low in Victoria because of a number of challenges, e.g. surveyors acceptance of adopting a new business process, the quality of the visualisation service (for visualising legal PDF plans from ePlan LandXML files), and supporting building subdivision. In order to enhance the ePlan services and overcome the identified challenges, the ePlan team have developed a collaborative program with the researchers from the Centre for Spatial Data Infrastructure and Land Administration (CSDILA) at the University of Melbourne. As part of this collaboration, the technical aspects of a 3D digital cadastre for Victoria including 3D data modelling, validation and visualisation are being investigated.

[1] Digital Cadastre Data Base

This paper explores the current status of ePlan implementation in Victoria, and discusses the ePlan project challenges, the ongoing research programs and their recent outcomes. Finally, the paper proposes the future directions for the Victorian ePlan project.

2 Current Status of the Victorian ePlan Implementation

From 2011 to 2013, ePlan was piloted in Victoria by the land authority, surveying industry and software vendors. In May 2013, the digital plan lodgement portal namely 'Surveying and Planning through Electronic Applications and Referrals (SPEAR[2])' was ePlan enabled and the following services were provided within this portal (Olfat *et al.*, 2015):

- ePlan Digital Data Download Service – This service is available through the LASSI-SPEAR application[3] and allows users to define a polygon on the map base and download a digital file in ePlan LandXML format that contains parcel line works, administrative areas, datum, location addresses, road abuttals, survey marks and monuments. The downloaded ePlan file can be imported into surveying software packages to pre-populate the known data for ePlan preparation, which saves the surveyors' time.
- ePlan Validation Service – This service identifies some of the errors and potential problems in plans at an early stage and allows the surveyor to correct them prior to the examination process. This will result in a reduction in the number of refusals and requisitions. SPEAR currently has 130 ePlan validation rules which cover three main areas of 'survey accuracy (e.g. parcel area, parcel observations closure)', 'survey examination rules (e.g. appropriate title connections)' and 'metadata completeness (e.g. easement purpose)'.
- ePlan Data Viewer – This service provides a tabular view of both graphical and textual data that can be used to review the content of an ePlan.
- ePlan Visualisation Service – This service converts the ePlan LandXML file into PDF. The PDF plan is the legal title document in Victoria. Automatic visualisation of an ePlan file is fundamental to streamline processes and dissemination of digital cadastral data.

Most 2D cadastral plans (e.g. Plan of Subdivision/Consolidation) are supported in ePlan. Currently there are three fully functional ePlan-enabled surveying software packages in Victoria; LISCAD, ePSALON and Stringer ePlan from LISTECH, Geocomp Consulting and Civil Survey Solutions respectively. In addition, the Plan functionality within 12d Model and Magnet Office (previously known as CivilCad) applications developed by 12D Solutions and Position Partners respectively is currently under test.

On average one ePlan application is currently submitted to SPEAR every fortnight. Similar to other states, the ePlan uptake is low in Victoria because of a number of challenges:

- surveyors acceptance of adopting a new business process – ePlan is basically seen by surveyors as a change in their subdivisional practices
- the visualisation service limitations – this service struggles to display dimensions along small bends, narrow easements (e.g. party walls) and the general display of plan information for detailed and large estate subdivisions. It cannot also support the creation of enlargement diagrams, which is a key component of plan presentation. Feedback received from the surveying industry also indicated that in general the surveyors would like to have control over the plan presentation of the PDF visualised from an ePlan.
- Lack of support for building subdivisions in ePlan – the boundaries defined by buildings on 2D plans are supported in ePlan, however building subdivision plans, which have cross sections are not yet supported.

In order to address the above challenges and increase the ePlan uptake, the ePlan team has defined the research programs explained in sections 3, 4 and 5 below.

3 ePlan Engagement Program

This program aims to investigate the subdivisional processes of the surveying firms and better understand how ePlan can fit into their processes. The program also enables surveyors to provide immediate feedback on the current visualisation of plans and to participate in the future development of ePlan. In the first round of this program (May 2015-Sep 2016), the ePlan team conducted workshops with eleven surveying firms, investigating their business requirements. As part of this program, a case study was undertaken with data provided by SMEC Australia, which is one the largest surveying firms in Victoria. The outcomes of this case study have been described below. The second round of the ePlan Engagement Program commenced in Nov 2016, with 18 expressions of interest received. This round is scheduled to conclude in March 2017.

[2] www.spear.land.vic.gov.au
[3] https://www.spear.land.vic.gov.au/lassi/SpearUI.jsp

The aim of SMEC's case study was to align ePlan with their current business practices and product quality. SMEC provided the ePlan team a copy of a large computed plan of Laurimar estate, located in the north of Victoria. The AutoCAD Civil3D Stringer ePlan application was used to convert one of the stages of the computed plan (stage 5) to an ePlan. Figure 1 provides a comparison between SMEC's current process and the ePlan process for creating a plan of subdivision for stage 5 of Laurimar estate.

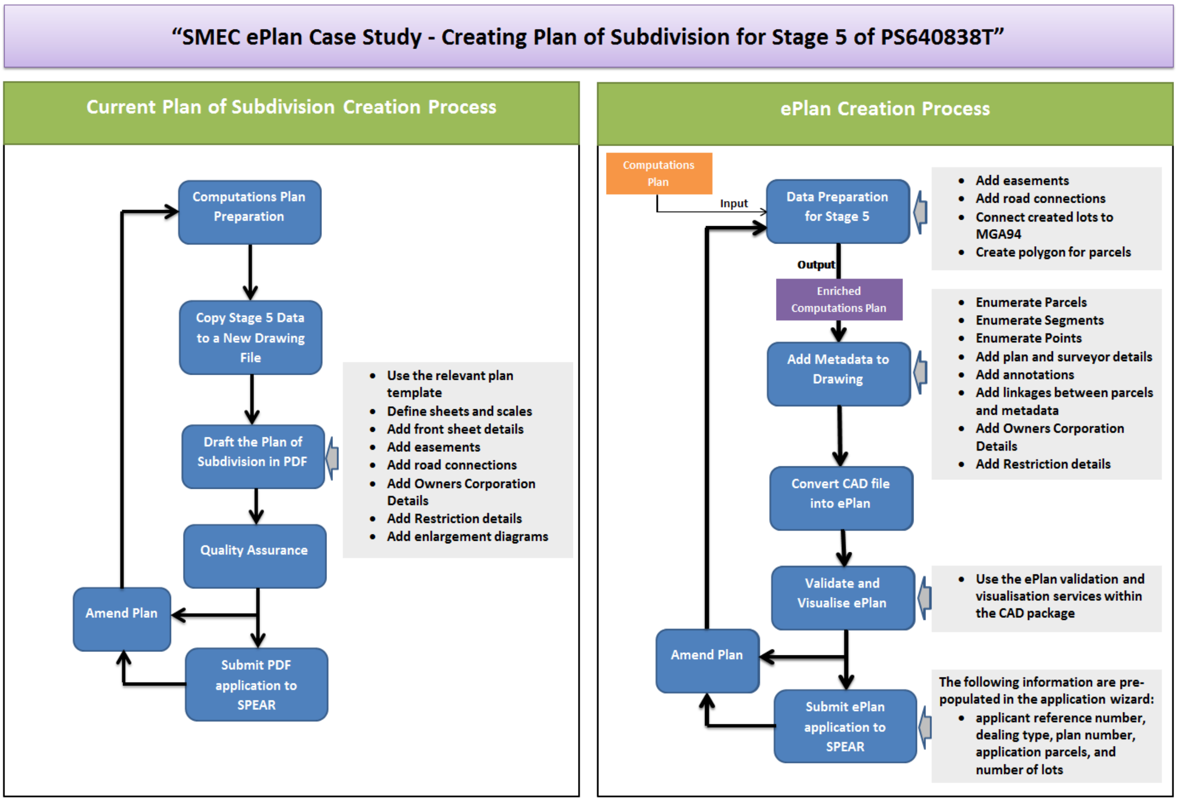


Figure 1: Comparing SMEC's current process and the ePlan process for creating a plan of subdivision

As shown in the above figure, SMEC prepares a computations plan which is a survey-accurate plan that includes only the minimal data required by all stakeholders such as parcel numbers, distances, bearings, areas, stage parcel boundaries, survey mark connections, significant trees, etc. The Laurimar estate plan includes 98 stages and 2027 parcels. In their current process, SMEC copies the data of each stage into a new drawing file in CAD format and the plan of subdivision is drafted for that stage. As part of the drafting exercise, the diagram and textual information (e.g. easement details, land information, owners corporation details, etc.) needs to be added to the plan template. The current process results in a duplication of drawing files for any stage/estate subdivision. The quality assurance takes place once the plan is prepared. If changes are required by the stakeholders, the computations plan is updated first and then the plan of subdivision is updated accordingly.

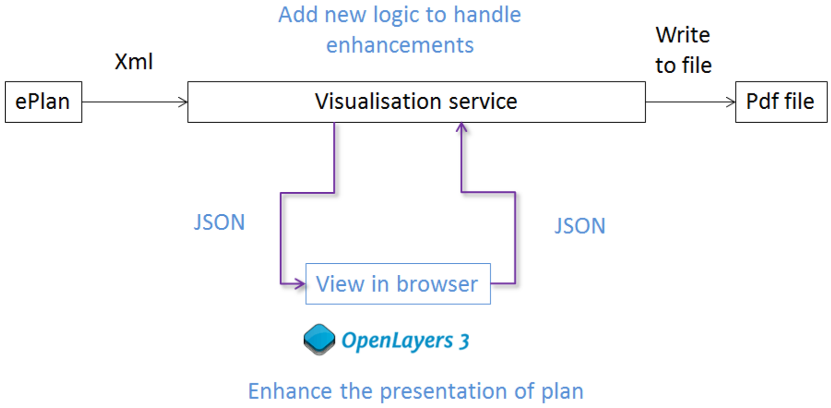
Within the ePlan creation process, the computations plan was used as the input file. This plan was enriched with the required information e.g. easements and road connections. The enriched computations plan was then used as a single data source for creating the plan of subdivision for stage 5. In other words, there was no need for duplicating the drawing files for creating the plan of subdivision. The required attributes such as parcel, land, parent title and survey mark details were added to the diagram using the Stringer ePlan module. The stage 5 data was exported to LandXML, which was subsequently validated and visualised by SPEAR.

The case study confirmed that the validation checks automatically performed by SPEAR would provide streamlined quality assurance checks within SMEC's process. The visualisation service within SPEAR also converts the LandXML file into a PDF, which significantly saves time in drafting the plan of subdivision. Any amendments required to the plan needs to be undertaken only once in the computations plan, with the corresponding ePlan subsequently updated automatically.

4 ePlan Visualisation Enhancement Tool Development

Through a collaborative program with the University of Melbourne, the ePlan team has been developing a new tool for surveyors, which will enable them to improve the quality of the PDF visualised from the ePlan data, using the functions such as editing labels/arrows, defining sheets, creating enlargement diagrams and exaggerating features.

Figure 2 illustrates the high level architecture of this tool.



'Black' represents existing components of the visualisation service.
'Blue' represents new components developed for the enhancement tool.
Figure 2: High level architecture of the ePlan Visualisation Enhancement Tool

In addition to the PDF file, a JSON[4] file is exported from the visualisation service, which includes the diagrammatic representation of information, such as the placement of labels and arrows. This JSON file is then imported into the enhancement tool user interface (UI) where the aforementioned functions will be available. OpenLayers 3 has been selected as the main Javascript library for developing the tool UI. Once amendments are made by the surveyor, the updated version of the JSON file and the ePlan LandXML file will be uploaded to the visualisation service to produce an updated version of the PDF Plan. This tool is expected to be integrated into the SPEAR environment in May 2017.

5 3D Digital Cadastre Investigation

Following the progress of implementation ePlan in Victoria for 2D cadastral plans and also in order to be aligned with the ICSM Cadastre 2034 Strategy (ICSM, 2015), the ePlan team investigated the technical aspects of a 3D digital cadastre platform in 2014. Among the technical requirements, the 3D cadastral data modelling, visualisation and validation have been investigated thus far. The main results of these studies are outlined below.

5.1 3D Data Modelling

Data modelling defines data elements, their relationships and attributes to model the real world (Aien *et al.*, 2011). A data model is required in 3D digital cadastres to model ownership spaces and to store data in a proper manner. In this investigation, the national ePlan LandXML Protocol was studied to determine how it can handle modelling of different types of building subdivisions.

3D modelling in ePlan has been previously investigated to some extent. Cumerford (2010) identified that the ePlan model can support 3D object definition. He also discussed some of the challenges in validating 3D objects. Karki *et al.* (2011) investigated supporting 3D objects in the ePlan Protocol for building format plans and volumetric format plans. Shojaei *et al.* (2012) tested the feasibility of modelling 3D legal objects in the ePlan Protocol and developed a web-based service to visualise 3D ePlans. Soon (2014) used the same method as Cumerford (2010) to reference the flat faces and create 3D objects. However, 3D modelling approaches in ePlan were not completely investigated and evaluated. As a result, this research focused on investigating the potential of the ePlan Protocol in modelling of different building subdivisions in three phases.

5.1.1 Phase 1: modelling a simple building subdivision

3D modelling in ePlan is based on boundary representation using a collection of connected faces. In this phase, a simple building subdivision was modelled in ePlan using three possible approaches, including CoordGeom, VolumeGeom, and Referencing (Shojaei, *et al.*, 2016). In all approaches, the 3D objects were modelled using flat faces. The difference between the approaches was the way those flat faces could join together. In the first and second approaches, the faces common between two parcels (medium faces) had to be captured twice, however in the last approach, all the faces were captured once and could be used multiple times for capturing neighbouring parcels. The results of this phase confirmed that the referencing approach is the most efficient for capturing 3D objects in ePlan due to its capability of supporting topology and reducing data redundancy.

[4] JavaScript Object Notation

5.1.2 Phase 2: modelling a complex building subdivision

In this phase, a complex building subdivision including 12 lots and 2 common properties in a three storey building was modelled in ePlan based on the referencing approach. This plan is a typical complex plan with above and below ground ownership spaces. Similar to the previous phase, this phase confirmed that the ePlan Protocol can support complex building subdivisions with flat faces. For modelling this building, Autodesk Revit was used to create 3D objects in IFC[5] format. Then, the IFC file was converted into ePlan LandXML format and visualised in a prototype (See section 5.2).

5.1.3 Phase 3: modelling curve shaped building subdivision

In this phase, modelling of curve shaped buildings in the ePlan Protocol was studied. This phase confirmed that the building with curved surfaces should be approximated in ePlan by flat faces (triangles/rectangles). As a result, 3D objects with curved surfaces in ePlan would be an approximation of the real objects, which would have different area and volume.

The detailed outcomes of these three main phases have been presented in (Shojaei *et al.*, 2016). As an alternative to the ePlan Protocol, the potential of Building Information Modelling (BIM) for modelling building subdivisions is also under investigation by the ePlan team.

5.2 3D Data Visualisation

As part of this investigation, the ePlan team has developed an interactive web-based 3D visualisation prototype[6] based on WebGL technology to illustrate how the legal and physical objects of a building subdivision can be presented and queried in a 3D digital system. In this prototype, users are able to see the 3D ownership spaces as well as 3D physical objects in a building to understand the ownership spaces. It has several tools, such as parcel identification, cross-section, measurement and search. In addition, the mobile version of the prototype was also enabled by adding touch functions in the latest version. This prototype system is being used for communicating with other stakeholders of a 3D digital cadastre for Victoria, e.g. planners, developers, surveyors, Owners Corporation managers, Utilities, etc. Figure 3 shows a screen of this prototype.

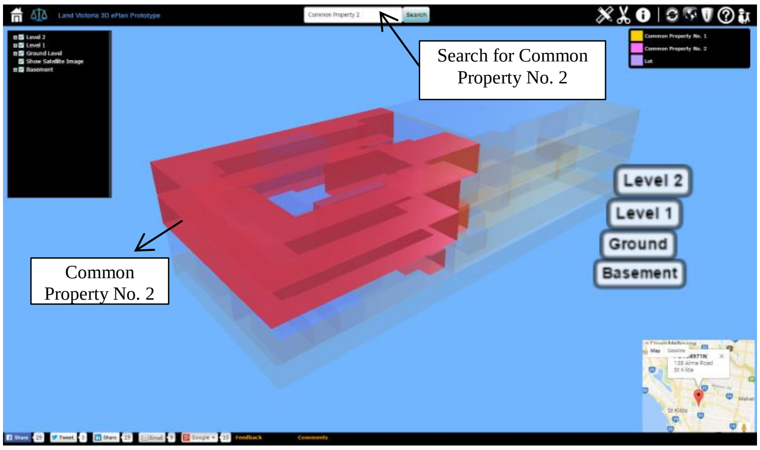


Figure 3: The Land Use Victoria 3D ePlan Prototype. The result of searching for Common Property No. 2.

According to the feedback received thus far, the prototype can significantly assist in the understanding of a 3D digital cadastre and its benefits to the wider community. Since 2015, the prototype has been viewed over 1300 times across 27 countries.

5.3 3D Data Validation

Automated quality assurance check is an important topic to consider in 3D cadastre as data ambiguity and invalidity cause significant expensive issues (e.g. legal disputes) in cadastres. However, there is little research on the 3D digital cadastre data validation (Karki *et al.*, 2010, 2013; Thompson & van Oostterom 2011, 2012). 3D validation in the Victorian cadastre is under investigation and several 3D geometrical validation rules are being developed. These are mainly geometrical rules to test the data quality. For instance, "created parcels must occupy the whole of cancelled parcels without any gap" and "easements must be fixed in the space" are two of the validation rules

[5] Industry Foundation Classes

[6] www.spear.land.vic.gov.au/spear/pages/eplan/3d-digital-cadastre/3dprototype/prototype.html

developed thus far. These rules are applied to check the individual parcels and their relationships with other parcels. These validation rules have been formalised using mathematical expressions and are being tested with different data sets. This study shows that due to the complexity of 3D cadastral objects, a large number of validation rules are required to cover various scenarios.

6 Conclusion and future directions

This paper explored the current progress of the ePlan project in Victoria, Australia. Currently, the subdivision plans can be submitted to SPEAR in ePlan LandXML format, which is an intelligent digital data. As compared to PDF plan, an ePlan file provides the subdivision process stakeholders with many benefits such as providing pre-lodgment checks via validation report, eliminating the drafting step from plan preparation via visualisation service, standardising the presentation of plans, eliminating the duplication of drawing files by storing all required data in computed plan, speeding up the application creation process in SPEAR, saving time in constructing the subsequent surveys by having access to digital files, pre-populating the Victorian Online Title System (VOTS) and automating the creation of new titles, reducing lodgement to registration turnaround time, providing the data for digital plan examination, and upgrading the spatial accuracy of map base.

This paper also discussed the main challenges that have impacted the uptake of ePlan in this jurisdiction. The most critical challenges include the surveyors acceptance of adopting a new method of producing plans, quality of the visualisation service, which converts the ePlan LandXML file into PDF as the legal title diagram, and support for 3D building subdivisions. The paper also introduced the research programs defined by the ePlan team in order to address the ePlan challenges. The research programs discussed in the paper include the 'ePlan Engagement Program', which aims to gain a greater understanding of surveying firms' subdivision processes and how ePlan can fit into them, the development of an online tool through the collaboration with the University of Melbourne to empower surveyors to improve the plan presentation of the PDF plan visualised from the ePlan data, and the investigation of the technical aspects of a 3D digital cadastre for Victoria comprising 3D data modelling, validation and visualisation components.

In addition to the above research programs, the ePlan team will continue to enhance the quality of its current ePlan visualisation service. Supporting the field notes (known as abstract of field records) in ePlan format, and designing an Oracle database for storing registered ePlan files are on the ePlan team's agenda for 2017. The ePlan team will also continue its collaboration with the Office of Surveyor General on a pilot project to utilise back captured plans in ePlan format for upgrading the spatial accuracy of the Victorian Mapbase.

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