Singapore LandXML Mapping and Structure

Technical Paper for Singapore Land Authority, Version 1.4.0

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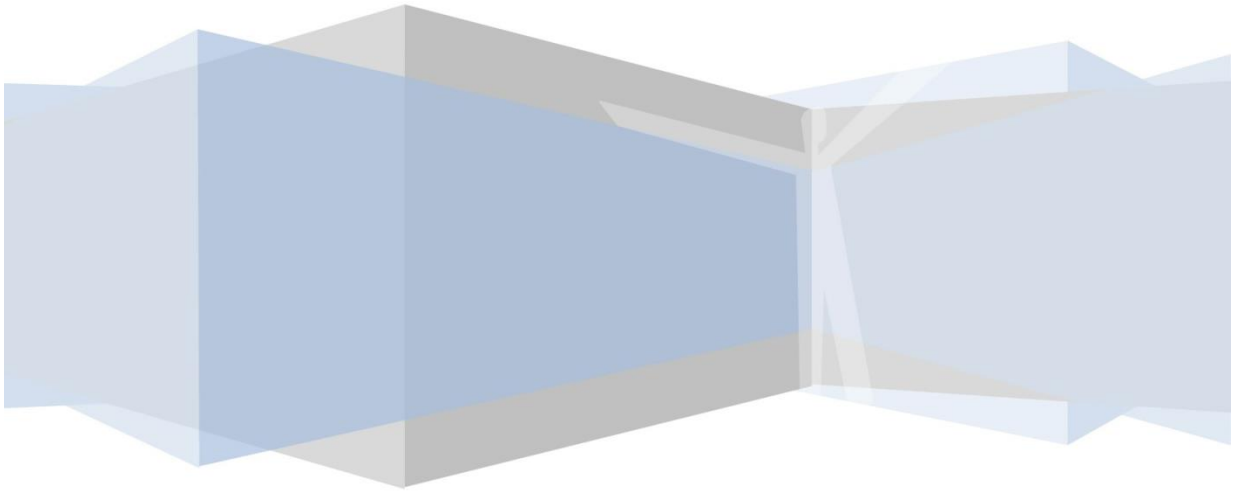


Contents

1 Introduction

LandXML is the designated survey data transfer platform for the CSMS project and ensuing production systems. The LandXML standard is further enhanced by the ICSM protocols. This document specifies the elements that are required for submissions to SLA as part of the future CSMS system. This Singapore protocol is both a subset and extension of the ICSM LandXML specification (also known as the ICSM ePlan Protocol).

This document was initially derived from *ePlan Protocol, LandXML Mapping*, Version 2.1.2 ICSM, 2011. It has been significantly altered and extended thereafter. However, Section 3 still retains much of the structure and content of the original document.

1.1 Purpose

This document specifies the requirements for the construction of a digital plan for submission to SLA. Its primary purpose is to define the SG LandXML schema for use by CSMS teams developing the new systems. Secondarily, it is intended for use by survey software vendors and surveyors to assist them in the development of Land XML functionality within their software and practices.

1.2 Abbreviations

CIF	Cadastral Information File (SLA intends to rename).
CPS	Control Points System
CSMS	Cadastral Survey Management System
ICSM	Intergovernmental Committee on Surveying and Mapping
ISO	International Standards Organisation
LADM	ISO Land Administration Data Model, a.k.a. ISO 19152
LandXML	XML schema for survey and construction
LX	LandXML
SG	Singapore
SGDRM	Singapore Data Reference Model
SGLX	Singapore LandXML
SLA	Singapore Land Authority
SGCDM	*SG Cadastral Data Model and ISO LADM Profile*, sister document
XML	Extensible Markup Language

1.3 Audience

The audience for this document includes:

- Singapore Land Authority and its contractors involved in the CSMS project and other projects implementing survey data transfer.
- Future SLA staff and contractors who are maintaining or modifying the SLA LandXML standards and subsequent implementations.
- The ICSM.

- Third party commercial software developers.

1.4 Using this document

This document's structure is derived from similar ICSM documents (ICSM, 2011 and 2010). It differs in that it combines what are often two or three different ICSM source documents into one. This facilitated the development of the SG specification; it incorporates the mapping of SG objects to the ICSM LX model, as well as sections discussing the structural manipulation of LX to achieve specific SG requirements.

Section 1 contains background information on this document, its intended purposes and references to other necessary information.

Section 2 provides a list of the XML elements that are used for plans being prepared for submissions to SLA. The elements appear in the order that they appear in the LandXML schema.

Section 3 is the main reference section of the document as it maps survey data to LandXML elements. The section describes each element and its attributes in detail. Elements are presented in the order that they appear in the LandXML schema, and each element's child and parent elements are provided along with an example of use.

In this document, tables are used to assist the formatting and reference clarity of diverse information. Most table attribution is relatively self-explanatory; however, the following have special meaning:

Cardinality specifies how many child elements of a particular type an element must have, e.g.:

0 - * means zero or more (i.e. the child is optional)

1 means exactly one

1 - * means at least one and possibly more

Type specifies the data type of an attribute. The type can be an XML base type such as "string", or custom type that is defined in the schema. Types used by the Protocol are listed as follows:

- *Base* – a raw value type, e.g. "string".
- *LandXML Enumerations* – an enumerated type defined in the LandXML Schema, e.g. "`stateType`".
- *Jurisdictional Enumerations* – an enumerated type defined by the NSW enumerations schema, e.g. "`parcelClass`". These are defined as skeleton types in the LandXML schema that are extended by the jurisdictional enumerations.
- *Custom Jurisdictional Enumerations* – defined as a base type in LandXML but with a custom enumeration type specified by a jurisdictional enumerations schema. For example, the `horizontalDatumType` – string is the type defined by LandXML. `horizontalDatumType` is the custom enumerated type specified by jurisdictional enumeration schemas with enumerated values. Fields must only contain values from this enumerations list.

- *Other Defined Types* – explicitly defined in as a type in LandXML but the underlying type is a base type. These are not extended in the jurisdictional schemas. The underlying LandXML base type is used.

For information on all the "type" definitions used by the ePlan Protocol, including LXML and SG specific enumerated types, please refer to **Chapter 5** in this document

Required specifies whether an attribute is**:**

- Required (R)—the attribute must be used when the element is used and must have a value that is not an empty string.
  e.g. `Parcel` elements must have a `name` attribute.
- Conditionally Required (**CR**)—the attribute must be used if some condition is met.
  e.g. `CoordinateSystem` element must have a `desc` if the plan is on MM orientation. The value will be the deposited plan to which the survey has been orientated
- Optional (**O**)—the attribute may be used
  e.g. `Amendment` elements have an optional `comments` attribute

NB: elements and attributes that are specified as optional in the ICSM specification may be required in this Singapore specification

Section 4 presents complex objects not defined in LandXML or ICSM yet required for Singapore. The section specifies LandXML structural requirements that are to be used in the construction of a submission.

SGLX heavily uses the Features and Properties approach (hereafter just called properties) to customize LX. This is the only allowed approach other than where an LX enumeration is not fixed. If an SGLX object is completely properties implemented, it will be in this section. If SG objects are encoded through LX elements, even if heavily modified by the properties approach, it will be in section 5.

Section 5 presents complex scenarios and special handling for Singapore. The section specifies LandXML structural requirements that are to be used in the construction of a CIF where necessary to handle scenarios that require LandXML to be structured in a certain way to correctly capture the data.

Section 6 presents a discussion of 3D encoding.

Section 7 presents a listing of enumerations.

Appendix A presents a listing and discussion of the existing ancillary files submitted by surveyors to SLA. This appendix may be removed in the future.

In All sections, XML code will be presented as **incomplete XML examples**

XML examples use two formatting styles in this document. The first is valid XML code, where brown texts are elements, red attributes and blue values. Many XML examples show ellipses which replace code unimportant to the example and the XML is not valid as

written. Also, any element may have more attributes or children than are shown in the example.

```
<?xml version="1.0" encoding="utf-8"?>
<LandXML ...>
   <Survey...>
       <InstrumentSetup
          id="IS-77"
          stationName="77"
          instrumentHeight="0">
          <InstrumentPoint pntRef="77" />
      </InstrumentSetup>
      <ObservationGroup .../>
     ...
   </Survey>
   ...
</LandXML>
```

Notes

1. Sections of code that are not important to the XML examples are replaced by an ellipsis (…)

2. The following conventions apply to element and attribute names and values:
   a. Element names start with a capital letter
   b. Attribute names start with a lower case letter.
   c. All attribute values defined by a LXML enumeration start with lower case letter.
   d. Where the attribute is a “string” the case is not sensitive.
   e. In LandXML, names reflect the purpose of the element. Capitalisation is used to assist readability, e.g. `CoordinateSystem`. This is called camel case in computer programming.
   f. All dates shown in the file must be in the format of yyyy-mm-dd

3. XPath notation is used to refer to elements in places, e.g.
   Full reference to Parcel elements: `/LandXML/Parcels/Parcel`
   Partial reference to Line elements: `//Parcel/Line`
   Reference to element attributes: `Line@name`

4. Where an attribute value says "set to…" the value should be exactly the stated value.

2 File Definition – Element Trees

A LandXML file for use in the SG CSMS will contain the LandXML elements that are shown in the diagrams below in the order they appear in the LandXML schema. Note that SG also has a number of custom XML objects encoded using the Feature/Property approach to extending LandXML.

Figure 1 SG LandXML Elements Used

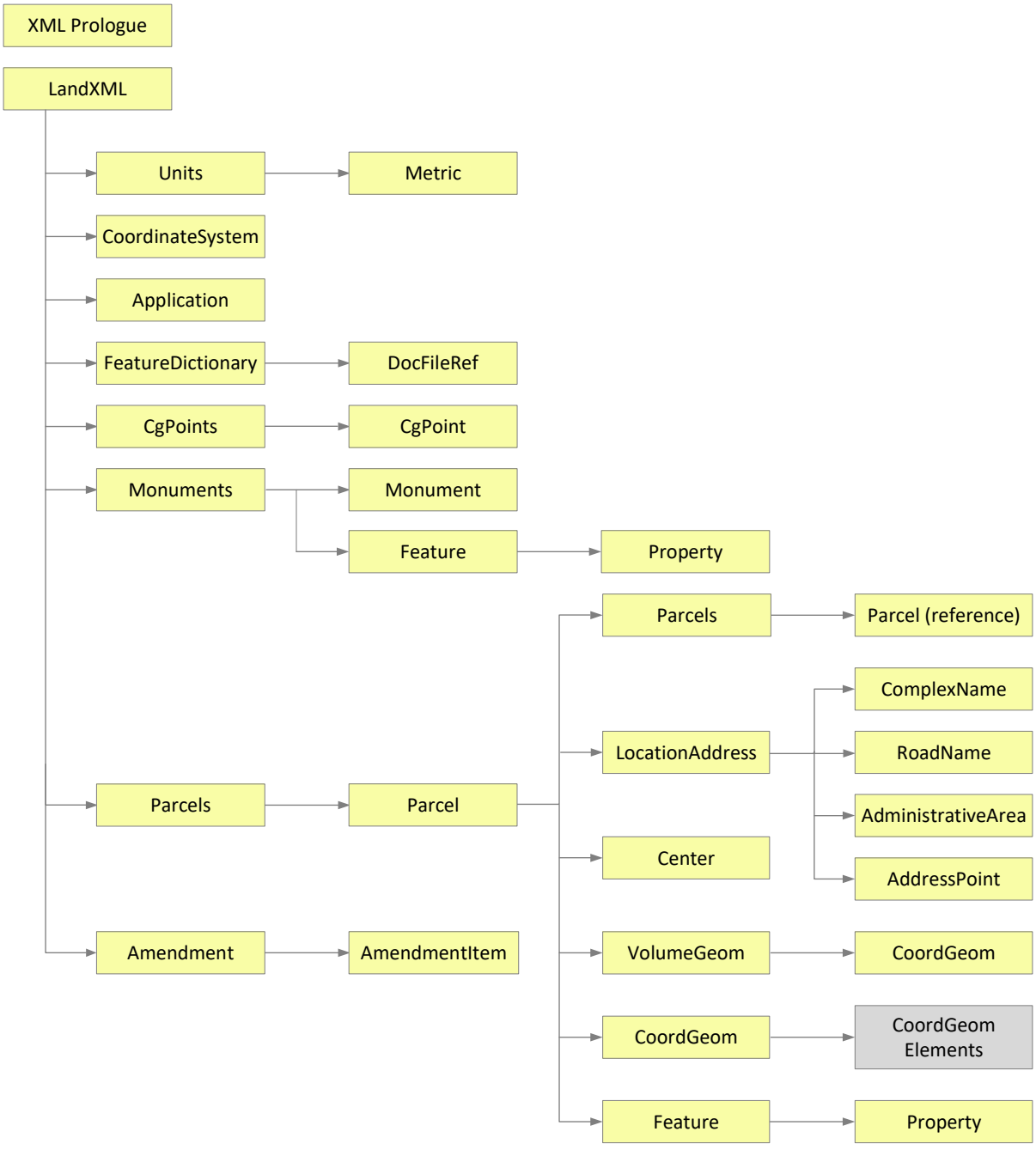


Figure 2 SG LandXML Elements Used (Continued)

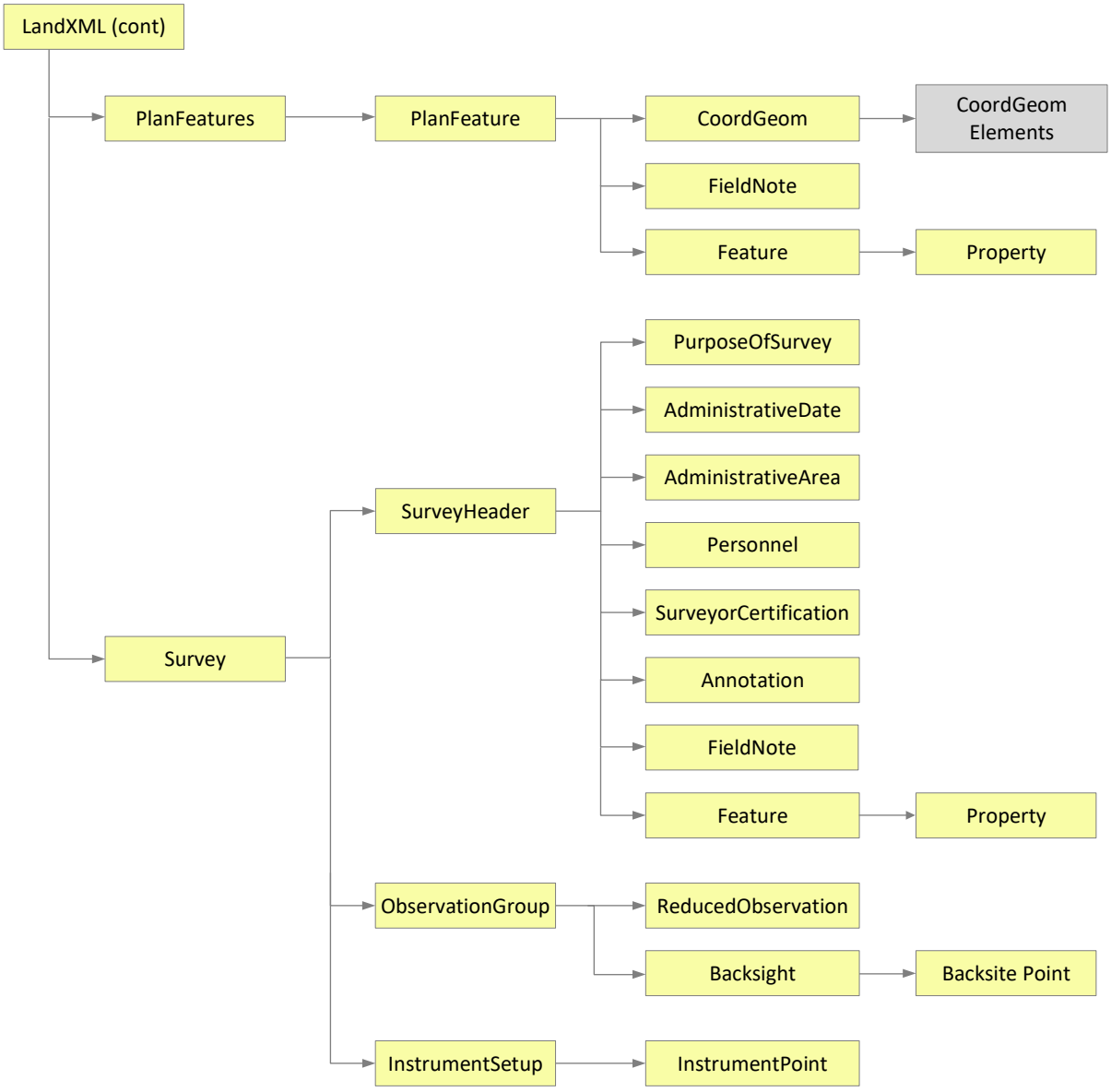
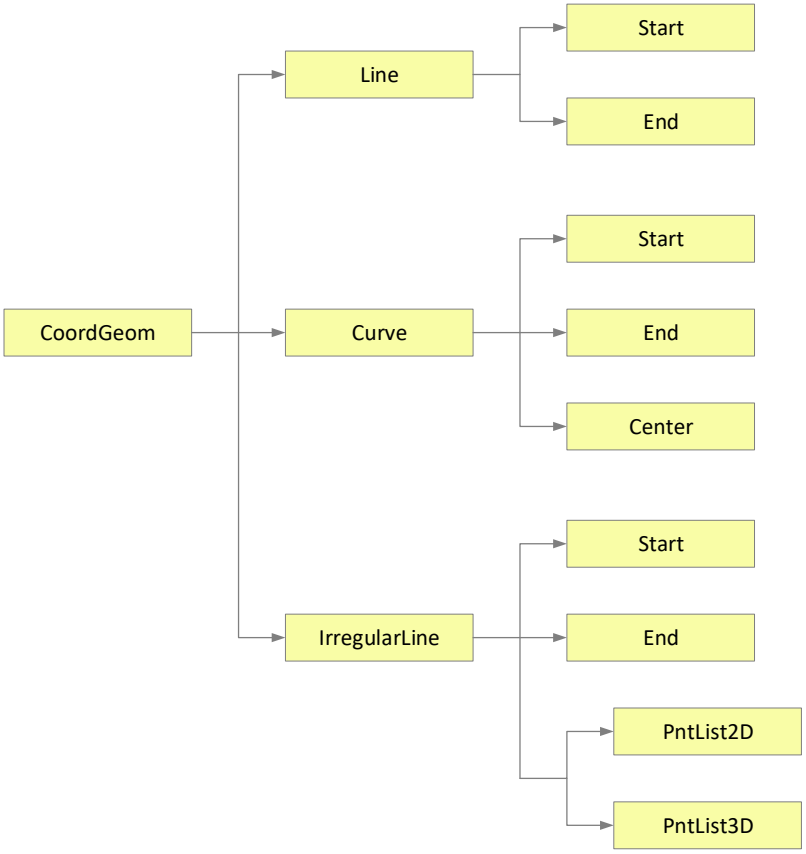


Figure 3 LandXML CoordGeom Elements



3 Elements and attributes

The file will contain the following data elements:

3.1 XML Prolog

Description	All XML files must start with a prolog element that declares the version of XML being used and the character encoding. The XML prolog element is a requirement of the XML specification,		
Example	`<?xml version="1.0" encoding="utf-8"?>`		
Parent Elements	None		
Child Elements			**Cardinality**
None			
Attribute	**Type**	**Required**	**Description**
version	string	R	Set to 1.0
encoding	string	R	Set to utf-8

3.2 LandXML

Description	The first element in the CIF must be a LandXML root element. All other elements are contained inside this element. A CIF must contain one LandXML element.

Example	`<LandXML xmlns="http://www.landxml.org/schema/LandXML-1.2"`
	`version="1.0" date="2010-11-29" time="15:01:49"`
	`xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"`
	`xsi:schemaLocation=`
	`"http://www.landxml.org/schema/LandXML-1.2/LandXML-1.2.xsd">`
	`…`
	`</LandXML>`

Parent Elements	None

Child Elements	**Cardinality**
Units	1
CoordinateSystem	1
Application	1
FeatureDictionary	1
CgPoints	1
Parcels	1
PlanFeatures	0 - *
Survey	1
Monuments	0 - 1
Amendment	0 - *

Attribute	Type	Required	Description
date	date	R	Date that this version of the CIF was created. ISO 8601 format. e.g. 2010-10-31
time	time	R	Time that this version of the CIF was created. ISO 8601 format. e.g. 13:56:25
version	string	R	Version number of this CIF. e.g. 1.2
xmlns	string	R	XML namespace, set to: http://www.landxml.org/schema/LandXML-1.2
xmlns:xsi	string	R	XML schema instance, set to: "http://www.w3.org/2001/XMLSchema-instance
xsi:schemaLocation	string	R	LandXML Schema Location for validation, set to: "http://www.landxml.org/schema/LandXML-1.2/LandXML-1.2.xsd"

3.3 Units

Description	This element defines the measurement units used by the CIF.		
Example	<LandXML> <Units> <Metric></Metric> </Units> </LandXML>		
Parent Elements	LandXML		
Child Elements			Cardinality
Metric			1
Attribute	Type	Required	Description
			None

3.4 Metric

Description	This element specifies the metric units used in the file.
Example	<LandXML> <Units> <Metric linearUnit="meter" temperatureUnit="celsius" volumeUnit="cubicMeter" areaUnit="squareMeter" pressureUnit="milliBars" angularUnit="decimal dd.mm.ss" directionUnit="decimal dd.mm.ss"> </Metric> </Units> </LandXML>
Parent Elements	Units

Child Elements			Cardinality
None			
Attribute	**Type**	**Required**	**Description**
linearUnit	metLinear	R	Set to "meter"
temperatureUnit	metTemperature	R	Set to "celsius"
volumeUnit	metVolume	R	Set to "cubicMeter"
areaUnit	metArea	R	Set to "squareMeter"
pressureUnit	metPressure	R	Set to "milliBars"
angularUnit	angularType	CR	Set to "decimal dd.mm.ss" angular values expressed in "decimal dd.mm.ss" units have the numeric format "45.3025" representing 45 degrees 30 minutes and 25 seconds. Both the minutes and seconds must be two characters with a numeric range between 00 to 60.
directionUnit	angularType	R	Set to "decimal dd.mm.ss"

3.5 CoordinateSystem

Description	The CoordinateSystem element defines the coordinate system used for CgPoint coordinates in the CIF.
Example	<LandXML> <CoordinateSystem desc="only if not SVY21, otherwise do not write" datum="SVY21" horizontalDatum="SVY21" verticalDatum="SHD"> </CoordinateSystem> </LandXML>
Parent Elements	LandXML

Child Elements			Cardinality
None			
Attribute	**Type**	**Required**	**Description**
desc	string	CR	Defines the orientation of the survey, if not SVY21.
datum	String(surveyDatumType)	R	SVY21 datum
horizontalDatum	string (horizDatumType)	R	Datum of CgPoint horizontal coordinates.
verticalDatum	string (vertDatumType)	CR	Required if 3D points are used. Singapore Height Datum (SHD).

3.6 Application

Description	The `Application` element records information about the surveying software application used to create the CIF.

Example	`<LandXML>`
	`  <Application`
	`  name="PlanTest"`
	`  manufacturer="Seaconis Inc."`
	`  version="2.0.7"`
	`  manufacturerURL="www.seaconis.com" />`
	`</LandXML>`

Parent Elements	`LandXML`

Child Elements	**Cardinality**
None	

Attribute	**Type**	**Required**	**Description**
name	string	R	The name of the application that created the CIF. e.g. `MyApp`
manufacturer	string	O	The name of the manufacturer of the application.
version	string	R	The version of the application e.g. `2.1.3`
manufacturerURL	string	O	The web site or URL of the manufacturer.

3.7 FeatureDictionary

Description	The `FeatureDictionary` element specifies the version of the reference data and enumerations list used when building the SG LandXML. Following ICSM, only one feature dictionary is used to refer to the collection of jurisdictionally specific schemas, see ICSM document "ePlan Protocol – Schema Architecture". For example, local government reference data lists may be changed more frequently than state level jurisdictional enumerations list and therefore are versioned as a separate feature dictionary. In SG, we may use the `FeatureDictionary` more generally as needed. If we do, we will need to ensure that the ICSM model is not broken.

Example	`<FeatureDictionary`
	`  name="ReferenceDataContext"`
	`  version="SG-01">`
	`  <DocFileRef`
	`  name="referencedata.xml"`
	`  location="url ...referencedata.xml"/>`
	`</FeatureDictionary>`

Parent Elements	`LandXML`

Child Elements	**Cardinality**
`DocFileRef`	0 - *

Attribute	**Type**	**Required**	**Description**
name	string	R	The name of the feature dictionary. Names are specified at the jurisdictional level based on the organisation of jurisdictional enumeration and reference data lists.
version	string	R	The version of the feature dictionary used for this CIF.

3.8 DocFileRef

Description	The `DocFileRef` element is a reference to any external document file containing related information for the associated element. In SG, it is used for several purposes. 1) It is used to record the details about the `FeatureDictionary` including the names, locations and attributes of the files that comprise the feature dictionary. 2) Associated files are referenced in DocFileRef elements contained in a `Feature`@name = “RefDocs” under the `SurveyHeader`. 3) As a container for image and supporting documents for HCP and VCP.
Example	`<DocFileRef name="SLA/LPB/40.49.4-V6" location="./referencedata.xml"></DocFileRef>`
Parent	`Feature, FeatureDictionary`

Child Elements	**Cardinality**
None	

Attribute	**Type**	**Required**	**Description**
name	string	R	File name
location	anyURI	R	URI of file. This may be a location on the jurisdiction web site.
fileType	fileType Type	O	The type of file. For example, “ReferencePlan” to identify the reference plan for the survey submission.
fileFormat	string	O	The format of the file.

3.9 CgPoints

Description	The `CgPoints` element is a container for all the `CgPoint` elements in the file.

Example	`<LandXML...>`
	`...`
	`<CgPoints>`
	`<CgPoint ...="">...</CgPoint>`
	`<CgPoint ...="">...</CgPoint>`
	`...`
	`</CgPoints>`
	`...`
	`</LandXML>`

Parent Elements	`LandXML`

Child Elements	**Cardinality**
`CgPoint`	1 - *

Attribute	**Type**	**Required**	**Description**
			none

3.10 CgPoint

Description	`CgPoint` may represent boundary points, traverse points, reference marks, permanent survey marks and various administrative points. Elements link to `CgPoints` to attach survey information. The datum for these coordinates is specified by `LandXML:CoordinateSystem.`

Example	`<CgPoints>`
	`  <CgPoint name="3" desc="final" code="L01" pntSurv="traverse">`
	`  29568.716 30286.225`
	`  </CgPoint>`
	`  ...`
	`  <CgPoint name="24" desc="final" code="L01" pntSurv="control">`
	`  29568.716 30286.225 101.5`
	`  </CgPoint>`
	`</CgPoints>`

Element Content	Coordinate values for the point. Two dimensional coordinates are a coordinate pair of the Northing followed by Easting. Three dimensional coordinates are a coordinate triplet: Northing, Easting and Height. Coordinates are separated by a single space.
Parent Elements	`CgPoints`

Child Elements	**Cardinality**
None	

Attribute	**Type**	**Required**	**Description**
name	string	R	Unique (to file) identifier for the point. Also called station number in most cases.
desc	approvalStateType	R	SLA enumeration related to process state of approval.
pntSurv	survPntType	R	The point type, LandXML enumeration.
code	methodType	R	SLA enumeration of survey method to define the point.
oID	string	O	The universally unique identifier (UUID) in the SG cadastre. It is a large integer number that identifies existing points, and is exported from the CSMS database at the beginning of survey projects.

3.11 Monuments

Description	The `Monuments` element is a container for `Monument` elements. `Feature` elements are referenced by `Monument` elements via `featureRef` to access additional properties not envisioned by LandXML.

Example	`<LandXML...>`
	`  ...`
	`  <Monuments>`
	`  ...`
	`  <Monument/>`
	`  ...`
	`  <Feature/>`
	`  ...`
	`  </Monuments>`
	`  ...`
	`</LandXML>`

Parent Elements	LandXML		
Child Elements			**Cardinality**
Monument			1 - *
Feature			0 - *
Attribute	**Type**	**Required**	**Description**
none			

3.12 Monument

Description	The Monument element holds information on Survey Marks placed or referenced in the SLA surveys. A Monument is always linked to a CgPoint using the pntRef attribute, which in Singapore is the station number. The CgPoint defines the survey mark's position and identification. Multiple Monuments can be linked to the same CgPoint. For example, there may be a nail in concrete for the corner and a reference to a brick wall at the same point. This element defines the physical attributes of all survey marks on the plan including boundary, reference and survey control marks. A Monument may reference Feature elements under the Monuments element to encode complex situations, like vertical control witness marks. See the structural discussion sections.

Example	`<Monuments>`
	`  <Monument name="27" pntRef="33" featureRef="2"`
	`  type="NL" state="found">`
	`  </Monument>`
	`</Monuments>`

Parent Elements	Monuments

Child Elements			**Cardinality**
Attribute	**Type**	**Required**	**Description**
name	string	R	SG use to hold ISN number, unique number otherwise. Prefix of “SM” for horizontal control, and “VCP” for vertical control.
pntRef	pointNameRef	R	Reference to the name attribute of the linked CgPoint, for Singapore this is the station number.
featureRef	featureNameRef	O	Reference to a Feature element. Used in vertical control encoding.
type	monumentType	R	SLA jurisdictional list of monument types.
state	monumentState	R	SLA jurisdictional list of states. (found, refixed, new…)
desc	String	O	Can be used to describe the location or for other purposes.

3.13 Parcels

Description	The Parcels element is a container for individual Parcel elements. Parcels containers can be nested within Parcel elements to capture parcel relationships.

Example	<LandXML...> ... <Parcels> <Parcel.../> ... </Parcels> ... </LandXML>		
Parent Elements	LandXML		
Child Elements			**Cardinality**
Parcel			1 - *
Attribute	**Type**	**Required**	**Description**
			None

3.14 Parcel

Description	The Parcel element provides a basic unit to describe a spatial area. A Parcel element can contain a nested Parcels element that has Parcel child elements. This is how we will reference the internal (island) lots. There are fewer required attributes for these "sub" parcels, generally only requiring a name and pclRef. Coordinate geometry used to define the lines that form each parcel are stipulated to be written in a counter-clockwise sequence in SG LandXML. This is opposite the current ICSM convention and the ESRI convention, but in agreement with ISO, OGC and the much larger computer graphics community and software products. Parcel may have many Feature/Property sets. See structural discussions.
Example	<LandXML…> ... <Parcels> <Parcel name="TS30-00385M" desc="CP1234, CP2345" area="1245.8" class="final" parcelType ="land" parcelFormat="Standard"> <CoordGeom> ... </CoordGeom> <Parcels> <Parcel/> </Parcels> </Parcel> </Parcels> ... </LandXML>
Parent Elements	Parcels

Child Elements			Cardinality
Center			0 - 1
CoordGeom			0 - 1
VolumeGeom			0-1
Parcels (island parcels only pclRef)			0 - *
LocationAddress			0 - *
Feature			0 - *
Attribute	**Type**	**Required**	**Description**
name	string	R	Concatenation of these several identifiers • District is either MK (Mukim) or TS (Town Subdivision) (char (2)) • District number (number (2)) • Lot number (integer (5)) • Check digit (char (1)) Lot numbers can be for proposed or existing lots. Lot numbers are issued by SLA. For allocation, lot names can follow a different pattern (PLOT<alphanumeric>).
desc	string	CR	Formatted string of plan numbers. These are the plans that show the parcel.
area	double	CR	The legal area. Required for new lots. Must be in units as specified in Units element
class	parcelClass	R	In the context of the survey, this describes the role of a parcel.
parcelFormat	parcelFormat	R	Describes the physical format of a parcel.
volume	double	O	Mandatory where parcelFormat format is extruded or 3D.
parcelType	parcelTypeType	R	Describes the general category of the parcel.
useOfParcel	useOfParcelType	CR	Describes the use of the parcel, in SG is used for “vacant” lots.
pclRef	parcelNameRef	CR	Reference to a parcel by name. Used for island parcels, accessory parcels, and other associations between parcels.
buildingNo	string	CR	The block number (house) of the building.
buildingLevelNo	string	CR	The level (storey) where lot is located.

3.15 LocationAddress

Description	The `LocationAddress` element contains street address information for its parent element. This is a complex element, and modelling to match the CS Directive 4.0 requires use of the child elements `ComplexName`, `RoadName`, and additional `Property` elements for the postal code and the sources of the building name and address. The example below shows the structure of a Singapore address. The `AddressPoint` is necessary for linking the feature/property construct to the `LocationAddress` due to LandXML rule that such constructs are not allowed in the `LocationAddress` itself. A corresponding `CgPoint` and `pntRef` for the `AddressPoint` element are not necessary, but the reference is LandXML required so give it any value, and when reading ignore.

Example	`<Parcel ...="">`
	`  <LocationAddress`
	`  flatNumber="02"`
	`  floorLevelNumber="05"`
	`  numberFirst="35">`
	`  <ComplexName desc="Wedge Mount Industrial Building"/>`
	`  <RoadName roadName="Jalan Pemimpin"/>`
	`  <AddressPoint pntRef="no" featureRef="addRef1"/>`
	`  </LocationAddress>`
	`  <Feature name="addRef1">`
	`  <Property label="addressSource" value="IRAS"/>`
	`  <Property label="buildingSource" value="URA"/>`
	`  <Property label="postalcode" value="577176"/>`
	`  </Feature>`
	`  ...`
	`</Parcel>`

Parent Elements	`Parcel`

Child Elements	**Cardinality**
`ComplexName`	0 - *
`RoadName`	1 - *
`AddressPoint`	0 - *

Attribute	**Type**	**Required**	**Description**
flatNumber	string	O	SGDRM AddressUnitNumber, CS Unit Number
floorLevelNumber	string	O	SGDRM AddressFloorNumber, CS Level Number
numberFirst	string	R	SGDRM AddressBlockHouseNumber, CS 4 House Number (CS 3.4 Block Number)

3.16 ComplexName

Description	The `ComplexName` element is used to store the site name and building name.

Example	`  <LocationAddress ...>`
	`  <ComplexName desc="Wedge Mount Industrial Building"/>`
	`  <RoadName .../>`
	`  <AddressPoint .../>`
	`  </LocationAddress>`

Parent Elements	`LocationAddress`

Child Elements	**Cardinality**
None	

Attribute	Type	Required	Description
desc	string	R	SGDRM AddressBuildingName. CS 4 Building name. In LandXML, the site name, building name or other name.
priority	Int	R	The priority of the `ComplexName` in relation to other `ComplexName` (s) defined in the `LocationAddress`.

3.17 RoadName

Description	The `RoadName` element is used to store the details of the road fronted by the property.		

Example	`<LocationAddress ...>`
	`<ComplexName .../>`
	`<RoadName roadName="Jalan Pemimpin"/>`
	`<AddressPoint .../>`
	`</LocationAddress>`		

Parent Elements	`LocationAddress`		
Child Elements			**Cardinality**
None			
Attribute	**Type**	**Required**	**Description**
roadName	string	R	SRGDM AddressRoadName. CS 4 street name. In LandXML, the name of the road (without Type or suffix)

3.18 AddressPoint

Description	The `AddressPoint` element describes the geographic location of an address using coordinates either contained in a linked `CgPoint` element or as a space delimited list inside the element. The `AddressPoint` is necessary for linking the feature/property construct to the `LocationAddress` due to LandXML rule that such constructs are not allowed in the `LocationAddress` itself. A corresponding `CgPoint` and `pntRef` for the `AddressPoint` element are not necessary, but the reference is LandXML required so give it any value, and when reading ignore.		

Example	`<LocationAddress ...>`
	`<ComplexName .../>`
	`<RoadName .../>`
	`<AddressPoint pntRef="no" featureRef="addRef1"/>`
	`</LocationAddress>`		

Parent Elements	`LocationAddress`		
Child Elements			**Cardinality**
None			
Attribute	**Type**	**Required**	**Description**
pntRef	pointNameRef	R	The `CgPoint` representing the location of the address point. ICSM states “Value must be a `CgPoint@name` attribute in the CIF”. However, we can just use a nonsense value, and ignore.

featureRef	string	O	Reference to `Feature@name`. In SG, this is used to extend the properties of LocationAddress. Other required values in this use can be meaningless.

3.19 Center

Description	The `Center` element represents either: A nominal centre point for a `Parcel` element, or The centre `of curve` element The coordinates are stored in a `CgPoint` element. The `pntRef` attribute references the `CgPoint@name` attribute.		

Example	`<LandXML...>`
	`...`
	`<Parcels>`
	`<Parcel ...="">`
	`<Center pntRef="1" ></Center>`
	`...`
	`<CoordGeom...>`
	`<Curve>`
	`<Start.../>`
	`<Center pntRef="23" />`
	`<End.../>`
	`</Curve>`
	`</CoordGeom>`
	`</Parcel>`
	`</Parcels>`
	`<CgPoints>`
	`<CgPoint name="1" ...="">123.123 321.321</CgPoint>`
	`<CgPoint name="23" ...=""> 344.543 834.565</CgPoint>`
	`</CgPoints>`
	`...`
	`</LandXML>`		

Parent Element	`Parcel` `Curve`		
Child Elements			**Cardinality**
None			
Attribute	**Type**	**Required**	**Description**
pntRef	pointNameRef	R	Value must be a `CgPoint@name` attribute in the CIF.

3.20 CoordGeom

Description	The `CoordGeom` element is a container for the spatial components of its parent element. This section is used to define the lines that form each parcel in a counter-clockwise sequence. (This is opposite the current ICSM convention and the ESRI convention, but in agreement with a larger community of graphic and spatial software).

Example	`<LandXML...>`
	`...`
	`<Parcels>`
	`<Parcel ...="">`
	`<CoordGeom name="1">`
	`<Line ...="">`
	`<Start ...="" />`
	`<End ...="" />`
	`</Line>`
	`...`
	`</CoordGeom>`
	`</Parcel>`
	`</Parcels>`
	`...`
	`<PlanFeatures ...="">`
	`<PlanFeature ...="">`
	`<CoordGeom`
	`name="Wall2 "`
	`desc=""`
	`state="Retaining Wall">`
	`<Line>`
	`<Start name="62" pntRef="62"/>`
	`<End pntRef="77"></End>`
	`</Line>`
	`<Line>`
	`<Start name="77" pntRef="77"/>`
	`<End pntRef="57"></End>`
	`</Line>`
	`...`
	`</CoordGeom>`
	`</PlanFeature>`
	`</PlanFeatures>`
	`...`
	`</LandXML>`

Parent Elements	`Parcel` `PlanFeature`

Child Elements	**Cardinality**
`Line`	0 - *
`Curve`	0 - *
`IrregularLine`	0 - *

Attribute	**Type**	**Required**	**Description**

name	string	o	Unique identifier (file). Also used for LSA adjusted lines identification.
desc	string	o	Free text description of the element. E.g. use for describing an occupation

3.21 Line

Description	The `Line` element represents a line between two points. The line may be 2D or 3D depending on the coordinates of the points that define it.

Example	`<LandXML...>`
	`...`
	`<Parcels>`
	`<Parcel ...="">`
	`<CoordGeom ...="">`
	`<Line desc="face of wall">`
	`<Start ...=”” />`
	`<End ...=”” />`
	`</Line>`
	`...`
	`</CoordGeom>`
	`</Parcel>`
	`</Parcels>`
	`...`
	`</LandXML>`

Parent Elements	`CoordGeom`

Child Elements	**Cardinality**
`Start`	1
`End`	1

Attribute	**Type**	**Required**	**Description**
desc	string	O	Free text description of the line- e.g. when the boundary of a parcel is along a face of a wall, desc= “face of wall” This will “monument” the wall for use in future surveys
dir	direction	O	Represents a normalized angular value that indicates a horizontal direction, expressed in the specified Direction units. Assume 0 degrees = north. See Units. Used in AdjustedLines and Occupations.
length	double	O	Length of line in specified Units. Used in AdjustedLines and Occupations.

3.22 Curve

Description	A `Curve` is a specific type of regular line between two points. It is defined by its start and end points, its radius, direction of rotation and centre point (i.e. radius point).

Example

```
<LandXML...>
   ...
   <Parcels>
      <Parcel ...="">
         <CoordGeom ...="">
            <Curve radius="1" rot="cw">
               <Start ...="" />
               < Center ... />
               < End... />
            </Curve>
         </CoordGeom>
      </Parcel>
   </Parcels>
   ...
</LandXML>
```

Parent Elements	`CoordGeom`

Child Elements	**Cardinality**
`Start`	1
`End`	1
`Center`	1

Attribute	**Type**	**Required**	**Description**
radius	double	R	The radius of the curve
rot	clockwise	R	Direction from `Start` to `End` Value will be “cw” (clockwise) or “ccw” (counter clockwise)

3.23 IrregularLine

Description	Irregular lines are used to capture non-surveyed lines (e.g. river boundary). ICSM requires a `CgPoint` as its start and finish point, whereas LandXML only requires the use of the `Start` and `End` elements, which can contain either a `pntRef` attribute, or coordinates. In Singapore, coordinates are used to start and end occupation irregular lines. In all cases, a point list defines the line between the start and end points.

Example	`<LandXML...>`
	`...`
	`<Parcels>`
	`<Parcel ...="">`
	`<CoordGeom ...="">`
	`<IrregularLine desc="bank of river" source="">`
	`<Start ...="" />`
	`<End ...="" />`
	`<PntList2D ...=""/>`
	`</IrregularLine>`
	`</CoordGeom>`
	`</Parcel>`
	`</Parcels>`
	`...`
	`</LandXML>`

Parent Elements	`CoordGeom`

Child Elements	**Cardinality**
`Start`	1
`End`	1
`PntList2D or PntList3D`	1

Attribute	**Type**	**Required**	**Description**
desc	string	O	Free text description of the irregular line If the boundary is an irregular feature then the feature must be described e.g. "The Left Bank of the Darling River"
source	string	O	The origin, if the line has been adopted from another source. E.g. as in a previous CP

3.24 Start

Description	The `Start` element represents the start of a number of linear elements such as `Curve`, `Line`, `IrregularLine` (*cf.* `End`).

Example	`<LandXML...>`
	`...`
	`<Parcels>`
	`<Parcel ...="">`
	`<CoordGeom ...="">`
	`<Curve ...="">`
	`<Start pntRef="214"/>`
	`<centre ...="" />`
	`<End ...="" />`
	`</Curve>`
	`</CoordGeom>`
	`</Parcel>`
	`</Parcels>`
	`...`
	`</LandXML>`

Parent Elements	`Curve` `Line`

Child Elements			**Cardinality**
None			
Attribute	**Type**	**Required**	**Description**
pntRef	pointNameRef	R	Value must be a `CgPoint@name` attribute in the CIF.

3.25 End

Description	The `End` element represents the end of a number of linear elements such as `Curve`, `Line`, `IrregularLine` (*cf.* `Start`).

Example	`<LandXML...>`
	`...`
	`<Parcels>`
	`<Parcel ...="">`
	`<CoordGeom ...="">`
	`<Curve ...="">`
	`<Start ...=""/>`
	`<Center ...="" />`
	`<End pntRef="215" />`
	`</Curve>`
	`</CoordGeom>`
	`</Parcel>`
	`</Parcels>`
	`...`
	`</LandXML>`

Parent Elements	`Curve` `Line`

Child Elements	**Cardinality**
None	

Attribute	Type	Required	Description
pntRef	pointNameRef	R	Value must be a `CgPoint@name` attribute in the CIF.

3.26 PntList2D

Description	The `PntList2D` element is used with associated `Start` and `End` elements to define a two dimensional line using a sequence of space separated (y, x) or (northing, easting) coordinate pairs that are the content of the element. The first and last coordinate pair must be the same as the associated `Start` and `End` points respectively (therefore the element must contain at least two coordinate pairs).

Example	`<LandXML...>`
	`...`
	`<Parcels>`
	`<Parcel ...="">`
	`<CoordGeom ...="">`
	`<IrregularLine ...="">`
	`<Start ...=""/>`
	`<End ...=""/>`
	`<PntList2D>`
	`11.11 22.22`
	`...`
	`33.33 44.44/>`
	`</IrregularLine>`
	`</CoordGeom>`
	`</Parcel>`
	`</Parcels>`
	`...`
	`</LandXML>`

Element Content	A space delimited list of coordinate values in Northing Easting pairing. `<PntList2D>`N_0 E_0 N_1 E_1 ... N_n E_n`</PntList2D>`
Parent Elements	`IrregularLine`

Child Elements	Cardinality
None	

Attribute	Type	Required	Description
			None

3.27 PntList3D

Description	The `PntList3D` element is used with associated `Start` and `End` elements to define a three dimensional line using a sequence of space separated (y, x, z) or (northing, easting, height) coordinate sets that are the content of the element. The first and last coordinate set must be the same as the associated `Start` and `End` points respectively (therefore the element must contain at least two coordinate sets).		
Example	<LandXML...> ... <Parcels> <Parcel ...=""> <CoordGeom ...=""> <IrregularLine ...=""> <Start ...=""/> <End ...=""/> <PntList3D> 11.11 22.22 33.33 ... 44.44 55.55 66.66/> </IrregularLine> </CoordGeom> </Parcel> </Parcels> ... </LandXML>		
Element Content	A space delimited list of coordinate values in Northing Easting Height. <PntList3D>N_0 E_0 H_0 N_1 E_1 H_1 ... N_n E_n H_n</PntList3D>		
Parent Elements	`IrregularLine`		
Child Elements			**Cardinality**
None			
Attribute	**Type**	**Required**	**Description**
			None

3.28 VolumeGeom

Description	Defines the properties of a 3D Coordinate Geometry collection. LandXML and ICSM. SG use for 3D Volumetric definitions of Airspace, Subterranean, Strata and Accessory lots.

Example	`<LandXML...>`
	`...`
	`<Parcels>`
	`<Parcel ...="">`
	`<VolumeGeom name="" desc="" state="" oID="">`
	`<CoordGeom ...="" />`
	`<CoordGeom ...="" />`
	`<CoordGeom ...="" />`
	`<CoordGeom ...="" />`
	`</VolumeGeom>`
	`</Parcel>`
	`</Parcels>`
	`...`
	`</LandXML>`

Parent Elements	Parcel

Child Elements	**Cardinality**
CoordGeom	4 - *

Attribute	**Type**	**Required**	**Description**
name	string	O	Unique identifier
desc	string	O	Free text description of the element
state	stateType	O	For use with amendments. LandXML enumeration.
oID	string	O	Jurisdictional identifier

3.29 PlanFeatures

Description	A container for PlanFeature elements. In SG, it is used for occupations, encroachments and where required, additional miscellaneous cartographic elements.

Example	`<LandXML...>`
	`...`
	`<PlanFeatures name="Occupations">`
	`<PlanFeature.../>`
	`</PlanFeatures>`
	`<PlanFeatures name="Encroachments">`
	`<PlanFeature.../>`
	`</PlanFeatures>`
	`...`
	`</LandXML>`

Parent Elements	LandXML

Child Elements			Cardinality
PlanFeature			1 - *
Attribute	**Type**	**Required**	**Description**
name	string	R	Unique ePlan identifier in ICSM. Use “Adjusted” for element parent of adjusted lines, and “Occupations” for details. These are containers.
desc	string	O	A description.

3.30 PlanFeature

Description	The PlanFeature element is used as a container for multiple purposes. It is used to define and facilitate rendering of occupations on the plan. Including walls fences buildings and kerbs etc.
Example	<LandXML...> ... <PlanFeatures ...> <PlanFeature name="Wall-1" desc="Retaining Wall"> <CoordGeom ...> <Line ...> <Start ... /> <End ... /> </Line> ... </CoordGeom> </PlanFeature> </PlanFeatures> ... </LandXML>
Parent Elements	PlanFeatures

Child Elements			Cardinality
CoordGeom			0-1
FieldNote			0 - *
Feature			0 - *
See section 4 for structural…			
Attribute	**Type**	**Required**	**Description**
name	string	R	Used to indicate the type of PlanFeature.
desc	string	R	Free text description of the element

3.31 Survey

Description	The Survey element contains the survey components of the CIF (job).
Example	<LandXML...> ... <Survey> <SurveyHeader ...=""/> <ObservationGroup ...=""/> <InstrumentSetup ...=""/> </Survey> ... </LandXML>

Parent Elements	LandXML		
Child Elements			**Cardinality**
SurveyHeader			1
ObservationGroup			0 - *
InstrumentSetup			0 - *
Attribute	**Type**	**Required**	**Description**
			None

3.32 SurveyHeader

Description	The SurveyHeader element contains administrative information about the survey.
Example	<LandXML> <Survey> <SurveyHeader name="3786-2010" jurisdiction="Singapore" surveyorFirm="TANG TUCK KIM REGISTERED SURVEYOR" surveyorReference="3786-2010" <PurposeOfSurvey name="Refinement Coordinates"/> <AdministrativeDate adminDateType="Commenced" adminDate="2010-12-18" /> <AdministrativeDate adminDateType="Completed" adminDate="2010-12-21" /> <Personnel role="Surveyor" name="TANG TUCK KIM " /> <Personnel role="Assistant Surveyor" name="CHIA KOK KENG" /> </SurveyHeader> <ObservationGroup/> <InstrumentSetup/> </Survey> </LandXML>
Parent Elements	Survey

Child Elements	**Cardinality**
PurposeOfSurvey	1
AdministrativeDate	1 - *
AdministrativeArea	0 - *
Personnel	1 - *
SurveyorCertificate	0 - *
Annotation	0 - *
FieldNote	0 - *
Feature	0 - *

Attributes	**Type**	**Required**	**Description**

name	string	R	Identifier of the survey. In SG, this is the job number which has a format of NNNNN-YYYY
jurisdiction	jurisdictionType	R	Set to “Singapore”.
surveyorFirm	string	O	The name of the surveying firm or organisation that submitted this file.
surveyorReference	string	O	Reference file or job name for surveyor use.

3.33 AdministrativeArea

Description	The `AdministrativeArea` element contains the administrative areas relevant to this survey. It defines a number of different types of administrative areas such as local government and locality. Each entry can link to a parcel element that defines the boundaries of the administrative area. So we can model the Singapore Administrative Area, like “Central Singapore” as well as the Survey Districts. The most obvious use is for survey districts in SG, but it is unclear that the surveyor needs to submit alterations to the boundary of the survey district. Rather, reassignment of a lot, or redefinition of a lot boundary that forms the survey district boundary is used to modify the district boundary as part of inspection/post functions.

Example	`<LandXML>`
	`<Survey>`
	`<SurveyHeader>`
	`<AdministrativeArea adminAreaType="MK" adminAreaCode="4" adminAreaName="Tanglin" pclRef="MK4" />`
	`</SurveyHeader>`
	`<ObservationGroup/>`
	`<InstrumentSetup/>`
	`</Survey>`
	`</LandXML>`

Parent Elements	`SurveyHeader`

Child Elements	**Cardinality**
None	

Attribute	**Type**	**Required**	**Description**
adminAreaType	adminAreaTypeType	R	SG enumerations for administrative area types: Mukim or Township Subdivision.
adminAreaName	string	O	The full name of the administrative area. For SG this could be the combined adminAreaType, MK or TS, and the adminAreaCode, a number. For example, MK34 or TS30. Or it could be used to store a text name for the admin area, if there is such a thing: eg. “Novela”, or “Ang Mo Ko”.

adminAreaCode	string	R	The admin area number.
pclRef	parcelNameRefs	O	A reference to the `name` of a parcel element representing this administrative area. In the cause of modelling for survey district polygons, this would be the references to the 'parcel' spatial unit representing the survey district boundary.

3.34 PurposeOfSurvey

Description	The `PurposeOfSurvey` element describes the purpose of the survey. Multiple purpose values are permitted as per jurisdictional requirements.		
Example	<LandXML...> ... <Survey> <SurveyHeader> <PurposeOfSurvey name="CPLNDALN"/> </SurveyHeader> <ObservationGroup/> <InstrumentSetup/> ... </Survey> </LandXML>		
Parent Elements	`SurveyHeader`		
Child Elements			**Cardinality**
None			
Attribute	**Type**	**Required**	**Description**
name	purpSurvType	R	SG jurisdiction type to indicate purpose of LandXML file submission.

3.35 AdministrativeDate

Description	The `AdministrativeDate` element captures a list of relevant administrative dates used in the jurisdictions plan lodgement process. This element could be used in SG LandXML files exported from the cadastre, to hold the date of official submission, official legal date of registration, or any other administrative dates. We should consider both the CIFs submitted and given out in the modelling.
Example	<LandXML...> ... <Survey> <SurveyHeader ...=""> <AdministrativeDate adminDateType="Commenced" adminDate="2010-12-18" /> ... </SurveyHeader> <ObservationGroup ...=""/> <InstrumentSetup ...=""/> </Survey> ... </LandXML>
Parent Elements	`SurveyHeader`

Child Elements			Cardinality
None			
Attribute	**Type**	**Required**	**Description**
adminDateType	adminDateTypeType	R	Type of date. We can use this to record legal or processing dates.
adminDate	xs:date	R	Date associated with the event defined in adminDateType. Format yyyy-mm-dd

3.36 Annotation

Description	Annotation is a descriptive string use to describe an action on survey. The Annotation element is used in conjunction with the jurisdictional annotations schema. This element can be used for a number of purposes: cartographic annotation, specific legal text for certain parcel types, or for storing a list of plans used or referenced by a survey.
Example	<SurveyHeader …="" > … <Annotation type="RoadLabel" name="Newton Road" desc=" 38240.710 30381.185 38240.588 30381.140 "/> <Annotation type="PlanNote" name="1. The common property extends to those parts indicated on the plans annexed hereto. " desc="33629.100 34631.591 33627.194 34621.774"/> <Annotation type="PlanNote" name="Legend" desc="33669.317 34618.715 33716.567 34627.785"/> <Annotation type="ParcelNote" name="remark1" desc="Allotted for Foreshore" pclRef="MK34-23456F"/> <Annotation type="AbuttalLine" name="" desc="33629.100 34631.591 33627.194 34621.774"/> <Annotation type="AbuttalLot" name="MK23-06354T" desc="33716.567 34627.785"/> <Annotation type="HouseNumber" name="45" desc="33669.317 34618.715"/> <Annotation type="OccupationNote" name="No details along boundary line" desc="33669.317 34618.715 33716.567 34627.785"/> <Annotation type="HWMNote" name="2.515m H.W.M." desc="33669.317 34618.715 33716.567 34627.785"/> … </SurveyHeader>

Parent Elements	SurveyHeader		
Child Elements			**Cardinality**
None			
Attribute	**Type**	**Required**	**Description**
type	annotationType	R	Jurisdictional enumeration of annotations that can be used in SG.
name	string	R	The annotation textual content.
desc	string	O	Depending on the type, this could be textual content for longer descriptions, or it may be coordinates necessary for placing the annotation.
pclRef	string	CR	Reference of the parcel to the ParcelNote. This attribute is used only by annotationType “ParcelNote”.

3.37 SurveyorCertificate

Description	The SurveyorCertificate element is used in conjunction with the jurisdictional certificates schema (see § 1.3 References - 3 ICSM, ePlan Protocol – Schema Architecture, version 2.0, 19 October, 2010). The text contained in textCertificate should conform to the layout specified in the jurisdiction's certificates schema.
Example	<LandXML> <Survey> <SurveyHeader> <SurveyorCertificate name="Cert1" certificateType="CP" textCertificate="I, Sean Tan, a surveyor registered under the Land Surveyors Act (Cap. 156), certify that this document has been prepared by me or under my immediate supervision, in accordance with the Boundaries and Survey Maps (Conduct of Cadastral Surveys) Rules 2005 (G.N. No. S 155/2005)." surveyDate=""/> </SurveyHeader> <ObservationGroup/> <InstrumentSetup/> </Survey> </LandXML>

Parent Elements	SurveyHeader		
Child Elements			**Cardinality**
None			
Attribute	**Type**	**Required**	**Description**
name	string	R	Unique identifier.
certificateType	certificateTypeType	R	The jurisdictional enumeration of certificate type in SG.
textCertificate	string	R	The text of the certificate information.
surveyDate	Date	O	The date the survey was completed if applicable. Format yyyy-mm-dd

3.38 Personnel

Description	The `Personnel` element captures information about the personnel who participated in the survey and the surveyor who endorsed the survey.

Example	`<LandXML>`
	`  <Survey>`
	`  <SurveyHeader>`
	`  <Personnel`
	`  name="Tang Tuck Kim"`
	`  role="Surveyor"`
	`  regNumber="006" />`
	`  <Personnel`
	`  name="Sean Connery"`
	`  role="Authorised Assistant"`
	`  regNumber="0007" />`
	`  </SurveyHeader>`
	`  <ObservationGroup/>`
	`  <InstrumentSetup/>`
	`  </Survey>`
	`</LandXML>`

Parent Elements	`SurveyHeader`

Child Elements	**Cardinality**
None	

Attribute	**Type**	**Required**	**Description**
name	string	R	Full name of the surveyor as registered.
role	surveyorRoleType	R	The role the surveyor played in the survey.
regNumber	string	O	Surveyor's board registration number

3.39 FieldNote

Description	Notes are added as content of the `FieldNote` element. Plain text or any valid XML structure may be placed inside this element. It is the responsibility of the jurisdiction to supply XML schemas or DTDs for the XML content of this element.

Example	`<LandXML...>`
	`  ...`
	`  <Survey>`
	`  <SurveyHeader ...="">`
	`  <FieldNote>This is a field note.</FieldNote>`
	`  </SurveyHeader>`
	`  ...`
	`  </Survey>`
	`  ...`
	`</LandXML>`

Parent Elements	`SurveyHeader, PlanFeature, ReducedObservation`

Child Elements	**Cardinality**
None (If custom XML is used, child elements of the custom XML will be shown.)	

Attribute	Type	Required	Description

3.40 ObservationGroup

Description	The `ObservationGroup` element is a container element for all types of observation elements. Primarily in SG we will use it to hold traverses, Side-shots and observations. The stations are linked to the `CgPoints` by reference. The example here is for a Main Loop traverse.

Example

```
<LandXML ...>
   <Survey...>
      <ObservationGroup id="Main">
         <Backsight .../>
         <ReducedObservation name="1" .../>
         <ReducedObservation name="2" .../>
         <ReducedObservation name="3" .../>
         . . .
      </ObservationGroup>
      ...
   </Survey>
   ...
</LandXML>
```

Parent Elements	`Survey`

Child Elements	Cardinality
`ReducedObservation`	1 - *
`Backsight`	1

Attribute	Type	Required	Description
id	ID	R	As LandXML allows multiple observation groups, each observation group has an “id”. ID value should be unique within the file. Must start with an alpha character and may not contain spaces. SG use will be “Main”, Sub1”, “Sub2”, … “Observation1” … “SideShot1” …

3.41 ReducedObservation

Description	The `ReducedObservation` element contains a reduced horizontal measurement being the bearing and distance. The measurement is related to `CgPoint` elements using references to `InstrumentSetup` elements for the `setupID` and `targetSetupID` attributes. (See `InstrumentSetup`) for details.)

Example	`<LandXML ...>`
	`<Survey...>`
	`<ObservationGroup id="Main">`
	`<Backsight circle="270.0000" setupID="IS-2">`
	`<BacksightPoint pntRef="1" />`
	`</Backsight>`
	`<ReducedObservation`
	`name="1"`
	`equipmentUsed="NIKON NPL-632"`
	`purpose="traverse"`
	`horizDistance="81.762"`
	`azimuth="166.5331"`
	`setupID="IS-2"`
	`targetSetupID="IS-3" />`
	`<ReducedObservation name="2" .../>`
	`<ReducedObservation name="3" .../>`
	`<ReducedObservation name="4" .../>`
	`. . .`
	`</ObservationGroup>`
	`...`
	`</Survey>`
	`...`
	`</LandXML>`

Parent Elements	`ObservationGroup`

Child Elements	**Cardinality**
`FieldNote`	0 - *

Attribute	**Type**	**Required**	**Description**
name	string	R	Unique identifier.
equipmentUsed	equipmentType	O	JOB file does not match EDM to stations. Ignore for now.
purpose	purposeType	R	LandXML enumeration, which describes the purpose of this observation in reference to the whole survey. Values include normal, check, backsight, foresight, traverse, etc. See LandXML Schema for complete list.
setupID	IDREF	R	A reference to the `InstrumentSetup id` that this measurement is made from
targetSetupID	IDREF	R	A reference to the `InstrumentSetup id` that this measurement is made to
azimuth	direction	CR	Bearing. Not required for calculated lines.

horizDistance	double	R	Horizontal distance

3.42 Backsight

Description	A `Backsight` is a reading taken on a position of known coordinate(s). Since a survey progresses from a point of known position to points of unknown position, a backsight is a reading looking "backward" along the line of progress

Example

```
<LandXML ...>
   <Survey...>
      <ObservationGroup id="Main">
         <Backsight circle="260.0000" setupID="IS-2">
           <BacksightPoint name="-1" pntRef="23" />
         </Backsight>
         <ReducedObservation name="1" .../>
         <ReducedObservation name="2" .../>
         <ReducedObservation name="3" .../>
         . . .
      </ObservationGroup>
      ...
   </Survey>
   ...
</LandXML>
```

Parent Elements	`ObservationGroup`

Child Elements	**Cardinality**
`BacksightPoint`	1

Attribute	**Type**	**Required**	**Description**
~~azimuth~~	~~angle~~	~~R~~	~~Could replace circle, as we use azimuth in SG, and circle just silly. But circle is required, so we will break validation if it is not used.~~
circle	angle	R	LandXML required. Represents a normalized angular value in the specified Angular units. Assumes 0 degrees = east. We will use as if azimuth (angle from North).
setupID	IDREF	R	A reference to the `InstrumentSetup id` that this measurement is made from

3.43 BacksightPoint

Description	BacksightPoint is the target of a Backsight, a previously occupied known position.
Example	<LandXML ...> <Survey...> <ObservationGroup id="Main"> <Backsight circle="260.0000" setupID="IS-2"> <BacksightPoint name="-1" pntRef="23" /> </Backsight> <ReducedObservation name="1" .../> <ReducedObservation name="2" .../> <ReducedObservation name="3" .../> . . . </ObservationGroup> ... </Survey> ... </LandXML>
Parent Elements	Backsight

Child Elements	**Cardinality**
none	

Attribute	**Type**	**Required**	**Description**
name	string	R	Our backsight is always another station, so we use the pntRef to indicate the station that is the target of the backsight. Since name is required by LandXML (through inheritance of PointType) we set as "-1" (and ignore).
pntRef	pointNameRef	R	Reference to the name attribute of the linked CgPoint. So this the target point of the backsight.

3.44 InstrumentSetup

Description	The `InstrumentSetup` element links observation setup points to a `CgPoint`. This is purely a structural requirement of LandXML to link observation start and end points to a physical location. See the example box for an explanation of this structure. See Linking Observations to CgPoints in Structural Discussions section for detailed description on use.

Example	`<LandXML ...>`
	`<Survey...>`
	`<InstrumentSetup`
	`id="IS-77"`
	`stationName="77"`
	`instrumentHeight="0">`
	`<InstrumentPoint pntRef="77" />`
	`</InstrumentSetup>`
	`<ObservationGroup .../>`
	`...`
	`</Survey>`
	`...`
	`</LandXML>`

Parent Elements	`Survey`

Child Elements	**Cardinality**
`InstrumentPoint`	1

Attribute	**Type**	**Required**	**Description**
id	ID	R	ID value should be unique within the document. Must start with an alpha character and may not contain spaces.
stationName	string	R	Set to the station name of the setup.
instrumentHeight	double	R	Required by LandXML but optional for ICSM? Can be ignored if not needed. Set to “0”. For SG, it is not currently submitted, so we can ignore.

3.45 InstrumentPoint

Description	The `InstrumentPoint` element contains the reference to the `CgPoint` for the `InstrumentSetup`.
Example	See example for InstrumentSetup
Parent Elements	`InstrumentSetup`

Child Elements	**Cardinality**
None	

Attribute	**Type**	**Required**	**Description**
pntRef	pointNameRef	R	Reference to the `CgPoint` for this `InstrumentPoint`.

3.46 Feature

Description	`Feature` is used to include additional information that is not explicitly defined by the LandXML schema. Feature may contain one or more `Property`, `DocFileRef` or nested `Feature` elements.

Example	`<PlanFeature name="-" ...`
	`  <Feature name="Thing">`
	`  <Property label="organisation" value="owner of…" />`
	`  <Property label="observer" value="name" />`
	`  <Property label="date" value="YYYY-MM-DD" />`
	`  </Feature>`
	`</PlanFeature>`

Parent Elements	`LandXML` and many other elements but not all.

Child Elements	**Cardinality**
`Property`	0 - *
`Feature`	0 - *
`DocFileRef`	0 - *

Attribute	**Type**	**Required**	**Description**
name	string	R	Used to identify the object.

3.47 Property

Description	`Property` is used to include additional information that is not explicitly defined by the LandXML schema. Each `Property` element defines one piece of data.

Example	`<Feature name="occProps">`
	`  <Property label="code" value="column"/>`
	`  <Property label="geometry" value="polygon"/>`
	`  <Property label="pclRef" value="MK18-U12345A"/>`
	`</Feature>`

Parent Elements	`Feature`

Child Elements	**Cardinality**
none	

Attribute	**Type**	**Required**	**Description**
label	string	R	Used to identify the data
value	string	R	Value of the data

3.48 Amendment

Description	The `Amendment` element is used to record amendments made to the file. This is a LandXML element.

Example	<LandXML...> ... <Amendment dealingNumber="CP12345" amendmentDate="2010-02-09" comments="Lot MK12-12345A added to plan"> <AmendmentItem elementName="Parcel" newName="MK12-12345A"/> </Amendment> ... </Amendment> ... </LandXML>
Parent Elements	LandXML

Child Elements	**Cardinality**
AmendmentItem	1 - *

Attribute	**Type**	**Required**	**Description**
dealingNumber	string	CR	This could be the SLA amendment file number
amendmentDate	date	R	The date that the amendment was made. Format yyyy-mm-dd
comments	string	R	Description of the amendment - see example above

3.49 AmendmentItem

Description	The AmendmentItem element contains information about individual amendments. AmendmentItem elements require that the LandXML element being amended is uniquely identifiable in the file using its name attribute. Therefore, AmendmentItem requires that every element in the file subject to an amendment must be named uniquely across the entire file. AmendmentItem is used primarily for the "strikeout" method where amendment history is tracked within the CIF rather than in a separate dataset. Specific requirements on this element can be found in section 2.4.1 of the ICSM LandXML Structural Requirements document.
Example	<LandXML...> ... <Amendment ...=""> <AmendmentItem elementName="Monument" oldName="402" newName="709"/> </Amendment> ... </LandXML>
Parent Elements	Amendment
Child Elements	Cardinality
none	

Attribute	**Type**	**Required**	**Description**
elementName	string	R	The name of the element being amended, e.g. if a ReducedObservation element is being replaced then the value of elementName is "ReducedObservation"

oldName	string	CR	Required if an element is being deleted or replaced. If no `oldName` is supplied, it means the element is a new addition to the file.
newName	string	CR	Required if a new element is being added to the file. If no `newName` is supplied, it means that an element is deleted from the file.

4 SG Specific Objects

Submissions to SLA include the reduced observations for traverse loops, observations and side-shots. The also include the results of Least Squares Adjustment (LSA) and the parameters of the LSA. There are two new survey objects: `Misclose` and `Parameters`. In order to keep this all in a single group, separate from the survey observation groups under `Survey`, we model them as `Feature`/`Property` structures under the SurveyHeader as they apply at the survey level and they have no spatial data. Under plan features we have placed a `PlanFeature` to hold the adjusted lines which could not be moved up to the `SurveyHeader`.

4.1 Transformation

Description	The Transformation properties and results are grouped under a Feature @Transformation element under SurveyHeader. In the sample below we show a larger than normal example so you can see how it works from the top level.
Example	<SurveyHeader> ... <Feature name="Transformation"> <Feature name="Parameters"> <Property label="a1" value="0.836544" /> <Property label="b1" value="-0.547919" /> <Property label="a2" value="212.398250" /> <Property label="b2" value="-88.061250" /> </Feature> <Feature name="Residuals"> <Feature name="Residual"> <Property label="station" value="1" /> <Property label="northing" value="-0.001" /> <Property label="easting" value="0.002" /> </Feature> <Feature name="Residual"> <Property label="station" value="7" /> <Property label="northing" value="-0.001" /> <Property label="easting" value="0.000" /> </Feature> ... as many as control </Feature> <Feature name="Misclosure"> <Feature name="Misclose"> <Property label="refName" value="Main" /> <Property label="angularMisclose" value="-16" /> <Property label="miscloseRatio" value="1:65787" /> </Feature> <Feature name="Misclose"> <Property label="refName" value="Sub1" /> <Property label="angularMisclose " value="-20" /> <Property label="miscloseRatio " value="1:44876" /> </Feature> ... (same numbers as traverse loops) </Feature> </Feature> </SurveyHeader>
Parent Elements	SurveyHeader

Child Elements	**Cardinality**
Feature – name set to “Misclosure”	1
Feature – name set to “Parameters”	1
Feature – name set to “Residuals”	1

Attribute	**Type**	**Required**	**Description**
name	string	R	name = “Transformation” This identifies the Feature as the container of the LSA results.

4.1.1 Parameters

Description	The transformation parameters are properties of a `Feature` with the specific name value of “Parameters”. The four properties are label value pairs, and their labels must be “a1”, “a2”,” b1” and “b2” the values are numeric entered as string.

Example	`<SurveyHeader>`
	`...`
	`<Feature name="Transformation">`
	`<Feature name="Parameters">`
	`<Property label="a1" value="0.836544" />`
	`<Property label="b1" value="-0.547919" />`
	`<Property label="a2" value="212.398250" />`
	`<Property label="b2" value="-88.061250" />`
	`</Feature>`
	`...`
	`</Feature>`
	`</Feature>`

Parent Elements	`Feature@name=“Transformation”`

Child Elements	**Cardinality**
`Property@label=“a1”`	1
`Property@label=“b1”`	1
`Property@label=“a2”`	1
`Property@label=“b2”`	1

Attribute	**Type**	**Required**	**Description**
name	string	R	Set to "Parameters". This identifies the Feature as the container of the transform parameters.

Property Label Value	**Value Type**	**Required**	**Description**
a1	double	R	double to six decimal places.
b1	double	R	double to six decimal places.
a2	double	R	double to six decimal places.
b2	double	R	double to six decimal places.

4.1.2 Residuals

Description	The differences between the original control coordinates and the adjusted coordinates are called residuals. We have as many residual values as we have points in common between the traverse and the control network. Residuals are SLA specific.

Example	<SurveyHeader> ... <Feature name="Transformation"> ... <Feature name="Residuals"> <Feature name="Residual"> <Property label="station" value="1" /> <Property label="northing" value="-0.001" /> <Property label="easting" value="0.002" /> </Feature> <Feature name="Residual"> <Property label="station" value="7" /> <Property label="northing" value="-0.001" /> <Property label="easting" value="0.000" /> </Feature> ... </Feature> </Feature> </Feature> </SurveyHeader>
Parent Elements	Feature@name="Transformation"

Child Elements	**Cardinality**
Feature@name="Residual"	*

Attribute	**Type**	**Required**	**Description**
name	string	R	Set to "Residuals". Identifies Feature as container of the Residuals.

4.1.3 Residual

Description	This Feature holds the information on the residuals for a particular control.
Example	<Feature name="Residual"> <Property label="station" value="1" /> <Property label="northing" value="-0.001" /> <Property label="easting" value="0.002" /> </Feature>
Parent Elements	Feature@name="Residuals"

Child Elements	**Cardinality**
Property@label="station"	1
Property@label="northing"	1
Property@label="easting"	1

Attribute	**Value Type**	**Required**	**Description**
name	string	R	must be set to "Residual"
Property Label Value	**Value Type**	**Required**	**Description**
station	string	R	station name

northing	double	R	the residual value in the y axis
easting	double	R	the residual value in the x axis

4.1.4 Misclosure

Description	The misclose values for traverse loops.		
Example	... <Feature name="Misclosure"> <Feature name="Misclose"> <Property label="refName" value="Main" /> <Property label="angularMisclose" value="-16" /> <Property label="miscloseRatio" value="1:65787" /> </Feature> <Feature name="Misclose"> <Property label="refName" value="Sub1" /> <Property label="angularMisclose " value="-20" /> <Property label="miscloseRatio " value="1:44876" /> </Feature> ... (same numbers as traverse loops) </Feature>		
Parent Elements	Feature@name="Transformation"		
Child Elements			**Cardinality**
Feature@name="Misclose"			*
Attribute	**Type**	**Required**	**Description**
name	string	R	Set to "Misclosure". Identifies Feature as container of the misclose data of loops.

4.1.5 Misclose

Description	The misclose values for a referenced traverse loop name. The three properties are label value pairs, and their labels must be "refName", "angularMisclose" and "miscloseRatio" both values are string.	
Example	<Feature name=" Misclose"> <Property label="refName" value="Main" /> <Property label="angularMisclose" value="-16" /> <Property label="miscloseRatio" value=" 1:65787" /> </Feature>	
Parent Elements	Feature@name="Misclosure"	
Child Elements		**Cardinality**
Property@label="refName"		1
Property@label="angularMislcose"		1
Property@label="miscloseRatio"		1

Attribute	Type	Required	Description
name	string	R	Set to "Misclose". This identifies the Feature as the container of misclose data.
Property Label Value	**Value Type**	**Required**	**Description**
refName	String	R	referenced traverse loop name
angularMisclose	string	R	the angular misclose
miscloseRatio	string	R	the fractional linear misclose

4.2 AdjustedLines

Description	The adjusted lines are the connecting lines between stations (correlating to the ReducedObservation) whose bearings and distances have been adjusted. They are subsumed under the CoordGeom element. The PlanFeature@name must be "AdjustedLines". Parent PlanFeatures must have name "Adjusted".		
Example	<LandXML> ... <PlanFeatures name="Adjusted"> <PlanFeature name=" AdjustedLines"> <CoordGeom> <Line dir="200.0654" length="81.763"> <Start pntRef="2" /> <End pntRef="3" /> </Line> <Line dir="199.3951" length="91.195"> <Start pntRef="3" /> <End pntRef="4" /> </Line> ... </CoordGeom> </PlanFeature> </PlanFeatures> </LandXML>		
Parent Elements	LandXML		
Child Elements			**Cardinality**
CoordGeom			*
Attribute	**Type**	**Required**	**Description**
name	string	R	Set to "AdjustedLines" This identifies the nested CoordGeom as holding the adjusted lines.

4.3 EDM

Description	EDM calibration data are grouped under a Feature with a name of "EDM". In the sample below we show a larger than normal example so you can see how it works from the top level. EDM attributes and properties are SLA specific. They are not in ICSM or LandXML.

Example

```
<LandXML>
   ...
   <SurveyHeader>
      <Feature name="EDM">
         <Feature name="Certificate">
            ...
         </Feature>
         <Feature name="Hardware">
            ...
         </Feature>
         <Feature name="Residuals">
            ...
         </Feature>
         <Feature name="Precisions">
            ...
         </Feature>
         <Feature name="Constants">
            ...
         </Feature>
      </Feature>
      <Feature name="EDM">
         ...
      </Feature>
      ...
   </SurveyHeader>
</LandXML>
```

Parent Elements	`Feature@name="EDM"`

Child Elements	**Cardinality**
`Feature@name="Certificate"`	1
`Feature@name="Hardware"`	1
`Feature@name="Residuals"`	1
`Feature@name="Constants"`	1
`Feature@name="Precisions"`	1

Attribute	**Type**	**Required**	**Description**
name	string	R	set to “EDM”

4.3.1 Certificate

Description	EDM certificate data is in a `Feature` with a name of “Certificate”. These certificates are structured within a `Feature` with the name of “EDM”. EDM attributes and properties are SLA specific.

Example	<Feature name="EDM" ... <Feature name="Certificate"> <Property label="certificateNumber" value=""TTK042009"/> <Property label="organisation" value="owner of…" /> <Property label="observer" value="name" /> <Property label="date" value="YYYY-MM-DD" /> </Feature> </Feature>
Parent Elements	Feature@name="EDM"

Child Elements	**Cardinality**
Property – see below	1 - *

Attribute	**Type**	**Required**	**Description**
name	string	R	set to “Certificate”
Property Label Value	**Type**	**Required**	**Description**
certificateNumber	string	R	the certificate number for the equipment
organisation	string	R	the name of the owner? /certifying? organisation
observer	string	R	the observer testing the equipment
date	date	R	the date of observation/certification. Format yyyy-mm-dd

4.3.2 Hardware

Description	EDM hardware info are properties under a Feature with a name of “Hardware”. In the sample below we show a larger than normal example so you can see how it works from the top level. EDM attributes and properties are SLA specific.
Example	<Feature name="EDM" ... <Feature name="Hardware"> <Property label="tsModel" value="Nikon NPL-632"/> <Property label="tsSerialNumber" value="021178"/> <Property label="tsHtAboveBase" value=".225"/> <Property label="prismModel" value="Topcon"/> <Property label="numPrisms" value="1"/> <Property label="prismHtAboveBase" value=".225"/> </Feature> </Feature>
Parent Elements	Feature@name="EDM"

Child Elements	**Cardinality**
Property – see below	6

Attribute	**Type**	**Required**	**Description**
name	string	R	set to “Hardware”

Property Label Value	Type	Required	Description
tsModel	string	R	Total Station model number.
tsSerialNumber	string	R	Serial number of Total Station.
tsHtAboveBase	number	R	Height from base plate (metres) of Total Station.
prismModel	string	R	Reflector(Prism) Model
numPrisms	integer	R	number of prisms
prismHtAboveBase	double	R	Height from base plate (m) of Reflector.

4.3.3 ResidualSeries

Description	EDM residuals are properties under a Feature with a name of “ResidualSeries”. The residuals relate to measures between seven stations. They are reported in a series, starting with the measures from station one to the others six (n-1), then station two to the remaining five (n-2), and so on until the single measure (n-6) from station six to station seven. We will not show diagrams for all Properties separately, this diagram shows Property Labels. The values are not placed in attributes, but are placed between the start and end tags. EDM attributes and properties are SLA specific. They are not in ICSM or LandXML.
Example	... <Feature name="ResidualSeries"> <Property label="series1" value="0.001, 0.000, 0.001, 0.002, 0.003, -0.002"/> <Property label="series2" value="0.001, -0.001, 0.002, 0.003, -0.001"/> <Property label="series3" value="-0.002, -0.001, 0.001, -0.004"/> <Property label="series4" value="0.000, 0.001, -0.003"/> <Property label="series5" value="0.004, -0.004"/> <Property label="series6" value="-0.001"/> </Feature> ...
Parent Elements	Feature@name=“EDM”

Child Elements	**Cardinality**
Property – see below	6

Attribute	**Type**	**Required**	**Description**
name	string	R	set to “ResidualSeries”

Property Label Value	**Type**	**Required**	**Description**
series1	double	R	six residual values
series2	double	R	five residual values
series3	double	R	four residual values
series4	double	R	three residual values
series5	double	R	two residual values

series6	double	R	one residual value

4.3.4 Constants

Description	EDM constants and coefficients are properties under a Feature with a name of Constants. In the sample below we show a larger than normal example so you can see how it works from the top level. EDM attributes and properties are SLA specific. They are not in ICSM or LandXML.		
Example	<Feature name="EDM" ... <Feature name="Constants"> <Property label="addConst" value="0.001"/> <Property label="addConstStdDev" value="0.001"/> <Property label="scale" value=".225"/> <Property label="scaleStdDev" value="-1.1"/> <Property label="firstOrderCycCos" value=""/> <Property label="firstOrderCycSin" value=""/> <Property label="secondOrderCycCos" value=""/> <Property label="secondOrderCycSin" value=""/> <Property label="smdStdDev" value="-1.1"/> </Feature> </Feature>		
Parent Elements	Feature@name="EDM"		
Child Elements			**Cardinality**
Property – see below			9
Attribute	**Type**	**Required**	**Description**
name	string	R	set to "Constants"
Property Label Value	**Type**	**Required**	**Description**
addConst	double	R	additive constant
addConstStdDev	double	R	standard deviation of additive constant
scale	double	R	scale in ppm
scaleStdDev	double	R	standard deviation of scale
smdStdDev	double	R	standard deviation of single measured distance
firstOrderCycCos	double	O	first order cyclic cosine coefficient
firstOrderCycSin	double	O	first order cyclic sine coefficient
secondOrderCycCos	double	O	second order cyclic cosine coefficient
secondOrderCycCos	double	O	second order cyclic sine coefficient

4.3.5 Precisions

Description	Instrument and target centring precision are implemented with the Feature/Property approach. These features and properties are SLA specific. They are not in ICSM or LandXML. Each EDM feature must have this section.

Example	`<Feature name="EDM" ...`
	`  <Feature name="Precisions">`
	`  <Property label="direction" value="2"/>`
	`  <Property label="a" value="3"/>`
	`  <Property label="b" value="2"/>`
	`  <Property label="c" value="2"/>`
	`  <Property label="d" value="2"/>`
	`  </Feature>`
	`</Feature>`

Parent Elements	Feature@name="EDM"

Child Elements	**Cardinality**
Property – see below	5

Attribute	**Type**	**Required**	**Description**
name	string	R	set to “Precisions”
Property Label Value	**Value Type**	**Required**	**Description**
direction	integer	R	direction precision
a	integer	R	distance precision in mm
b	integer	R	instrument centring in ppm
c	integer	R	instrument centring precision
d	integer	R	target centring precision

4.4 Occupational Details

This section specifies the structures used to encode occupations and encroachments.

4.4.1 Introduction

The term “occupational details” is found within the CS Directive. It refers to features of the built environment which are surveyed or “picked up” by conventional Land Survey techniques. The CS directive does not specifically state what method to use when surveying these details.

Encroachment information consists of occupational details along a boundary line for the purposes of determining if there is encroachment. Occupation details are features which may be polygon, line or point based. Encroachment may be encoded as a property of an occupation feature, or determined by intersection of features.

The reason for inclusion of these features in LandXML is to provide a structure which could allow sketch information to be included in the LandXML, and thereby remove one of the reasons for sketch creation.

Occupational details have no requirement to be tied to the field survey objects. They are to be modelled with coordinates only, not stations of the survey.

4.4.2 Occupations

<table>
<tr><td>Description</td><td colspan="3">A single <code>PlanFeatures</code> element is the container for all occupation detail. It will have the name attribute set to “Occupations”. Encroachments, if occurring, will be held in separate <code>PlanFeatures</code> containing element. This is part of the custom structural ‘template’ for occupations in SG.</td></tr>
<tr><td>Example</td><td colspan="3"><pre><LandXML>
  ...
  <PlanFeatures name="Occupations">
    <PlanFeature name="Wall"…>
      ...
    </PlanFeature>
    ...
  </PlanFeatures>
</LandXML></pre></td></tr>
<tr><td>Parent Elements</td><td colspan="3"><code>LandXML</code></td></tr>
<tr><td colspan="3">Child Elements</td><td>Cardinality</td></tr>
<tr><td colspan="3">Occupation (templated PlanFeature)</td><td>*</td></tr>
<tr><td>Attribute</td><td>Type</td><td>Required</td><td>Description</td></tr>
<tr><td>name</td><td>string</td><td>R</td><td>Set to "Occupations" for this template type.</td></tr>
</table>

4.4.3 Occupation

Description	A custom `PlanFeature` element ‘template’ is used to represent an occupation in SG. The occupation may be related to an encroachment. The sizeable example shows the use of different `CoordGeom`.

Example

```
<PlanFeatures name="Occupations">
   <PlanFeature name ="Fence1">
      <CoordGeom>
         <Line>
            <Start>38247.074 30475.959</Start>
            <End>38244.076 30474.841</End>
         </Line>
         <Line>
            <Start>38246.938 30476.324</Start>
            <End>38251.719 30463.484</End>
         </Line>
         <Line>
            <Start>38244.075 30474.841</Start>
            <End>38243.939 30475.207</End>
         </Line>
         <Line>
            <Start>38246.938 30476.324</Start>
            <End>38243.939 30475.207</End>
         </Line>
      </CoordGeom>
      <Feature name="occProps">
         <Property label="code" value="fence" />
         <Property label="group" value="A" />
         <Property label="geometry" value="line" />
         <Property label="pclRef" value="MK18-40001B" />
      </Feature>
   </PlanFeature>
   <PlanFeature name ="PW1">
      <CoordGeom>
         <IrregularLine>
            <Start>38247.074 30475.959</Start>
            <End>38247.074 30475.959</End>
            <PntList2D>
               38247.074 30475.959
               38244.076 30474.841
               38246.938 30476.324
               38251.719 30463.484
               38244.075 30474.841
               38243.939 30475.207
               38246.938 30476.324
               38247.074 30475.959
            </PntList2D>
         </IrregularLine>
      </CoordGeom>
      <Feature name="occProps">
         <Property label="code" value="party-wall" />
         <Property label="group" value="Building B" />
         <Property label="geometry" value="polygon" />
         <Property label="pclRef" value="MK18-40001A" />
         <Property label="pclRef" value="MK18-40002B" />
      </Feature>
   </PlanFeature>
</PlanFeatures>
```

Parent Elements	PlanFeatures@name="Occupations"

Child Elements	**Cardinality**
CoordGeom	1
Feature/Properties	1

Attribute	Type	Required	Description
name	string	R	An identifier for the occupation.
desc	string	O	Description of the occupation.

4.4.4 Occupation Properties

Description	This is a custom Feature to contain occupation properties.		

Example	`<Feature name="occProps">`
	`  <Property label="code" value="fence" />`
	`  <Property label="group" value="one" />`
	`  <Property label="geometry" value="line" />`
	`  <Property label="pclRef" value="MK18-40001B" />`
	`</Feature>`		

Parent Elements	Occupation `PlanFeature`		
Child Elements			**Cardinality**
`Property@label="code"`			1
`Property@label="group"`			0-1
`Property@label="geometry"`			1
`Property@label="pclRef"`			0-*
Attribute	**Type**	**Required**	**Description**
name	string	R	Set to "occProps". This identifies the Feature as the container of the occupation parameters.
Property Label	**Value Type**	**Required**	**Description**
code	occCodeType	R	SG enumeration of allowed occupation types.
group	string	O	Allows grouping of occupations for easier referencing.
geometry	geomType	R	SG enumeration of geometry type: polygon, line and point.
pclRef	string	C	The name of the owning parcel. This use of pclRef matches the use as attribute of parcels. It establishes a composite relationship between occupations and the parcel.

4.4.5 Encroachments

Description	A single PlanFeatures element is the container for all encroachments. Encroachments can be polygons with a stated area, or linear with a stated length, or point.

Example	<LandXML> ... <PlanFeatures name="Encroachments"> <PlanFeature name="E1" desc=" Part of fence encroaching onto lot MK18-13579P "> ... </PlanFeature> ... </PlanFeatures> </LandXML>		
Parent Elements	LandXML		
Child Elements			**Cardinality**
Encroachment PlanFeature			0-*
Attribute	**Type**	**Required**	**Description**
name	string	R	Set to "Encroachments"
desc	string	O	Descriptive information

4.4.6 Encroachment

Description	An encroachment is encoded as a special structural 'template' of the PlanFeature element. An encroachment can be related to an occupation by reference to the Occupation@name attribute value.	
Example	<PlanFeatures name="Encroachments"> <PlanFeature name ="E1" desc="Part of fence encroaching onto lot MK10-123456M"> <CoordGeom> <IrregularLine> <Start>38244.076 30474.841</Start> <End>38243.939 30475.207</End> <PntList2D> 38244.076 30474.841 38246.938 30476.324 38246.938 30476.324 38244.076 30474.841 </PntList2D> </IrregularLine> </CoordGeom> <Feature name="encProps"> <Property label="code" value="fence" /> <Property label="geometry" value="polygon" /> <Property label="pclRef" value="MK18-40001B" /> <Property label="occRef" value="Fence1" /> <Property label="area" value="3.4" /> </Feature> </PlanFeature> </PlanFeatures>	
Parent Elements	PlanFeatures@name="Encroachments"	
Child Elements		**Cardinality**
CoordGeom		1

Feature/Property			1
Attribute	**Type**	**Required**	**Description**
name	string	R	Set to "encProps". This identifies the Feature as the container of the encroachment parameters.
desc	string	R	Descriptive information

4.4.7 Encroachment Properties

Description	A special structured Feature element to hold the properties of encroachments.

Example	`<Feature name="encProps">`
	`<Property label="code" value="fence" />`
	`<Property label="geometry" value="polygon" />`
	`<Property label="pclRef" value="MK18-40001B" />`
	`<Property label="occRef" value="Fence1" />`
	`<Property label="area" value="3.4" />`
	`</Feature>`

Parent Elements	Encroachment PlanFeature

Child Elements			**Cardinality**
Property@label="code"			1
Property@label="geometry"			1
Property@label="pclRef"			0-1
Property@label="occRef"			0-1
Property@label="area"			0-1
Property@label="length"			0-1
Attribute	**Type**	**Required**	**Description**
name	string	R	Set to "encProps". This identifies the Feature as the container of the encroachment properties.
Property Label	**Value Type**	**Required**	**Description**
code	occCodeType	R	SG enumeration of allowed occupation types
geometry	geomType	R	SG enumeration of geometry type: polygon, line, point.
pclRef	string	C	Name of the encroached parcel. Same function as the pclRef attribute of parcels. Typically lot number in SG.
occRef	string	C	Name of the encroaching occupation. Optional if occupation is in fact entirely encroaching.
area	double	C	Double to one decimal place. The stated area of encroachment. Conditional on geometry type.
length	double	C	Double to three decimal places. The stated length of an encroachment. Conditional on geometry type.

4.5 Levelling

The common method for determination of elevation in SG is levelling. A levelling loop begins from a position of known elevation, typically a Vertical Control Point (VCP), and continues through a number of positions until arriving back where it began. Points where elevations are needed are visited along the levelling loop. Changes in height along the loop are used to calculate elevations for these specific stations of interest in the survey. Distance should be recorded between the positions and can then be used in misclose (vertical) calculations as defined in the CSD4.

Since there are no northings or eastings for change points, normal LandXML encoding as traverses and CgPoint are not appropriate. Instead, we encode the levelling field information in a manner similar to Level Detail Sheets (Level Booking forms); either all point to point calculations or only raw values. If only raw values are recorded, resultant adjusted elevations can be calculated against the CgPoint z values for the named stations in the levelling data.

```
<SurveyHeader>
  ...
   <Feature name="LevellingDetails">
      <Feature name="Loop1">
         <Property label="from" value="VCP80172"/>
         <Property label="to" value="VCP80172"/>
         <Property label="misclose" value="0.002"/>
         <Property label="totalDistance" value="1.3"/>
         <Feature name="VcpIntegrityCheck">
            <Feature name="VCP">
               <Property label="stn" value="VCP80172"/>
               <Property label="bs" value="1.463"/>
               <Property label="al" value="110.891"/>
            </Feature>
            <Feature name="detail">
               <Property label="stn" value="W2"/>
               <Property label="is" value="1.462"/>
               <Property label="rl" value="110.892"/>
               <Property label="al" value="110.894"/>
               <Property label="rmk" value="witness mark 2"/>
            </Feature>
            <Feature name="detail">
               <Property label="stn" value="W1"/>
               <Property label="is" value="1.492"/>
               <Property label="rl" value="110.862"/>
               <Property label="al" value="110.863"/>
               <Property label="rmk" value="witness mark 1"/>
            </Feature>
         </Feature>
         <Feature name="detail">
            <Property label="stn" value="VCP80172"/>
            <Property label="bs" value="1.538"/>
            <Property label="rl" value="110.891"/>
            <Property label="al" value="110.891"/>
         </Feature>
         <Feature name="detail">
            <Property label="stn" value="CP1"/>
            <Property label="bs" value="1.196"/>
            <Property label="is" value=""/>
            <Property label="fs" value="1.412"/>
            <Property label="rl" value="110.017"/>
            <Property label="al" value="110.017"/>
```

```
            <Property label="d" value=""/>
            <Property label="rmk" value="change point"/>
         </Feature>
      </Feature>
      <Feature name="Loop2">
         <Property label="from" value="stn35"/>
         <Property label="to" value="stn35"/>
         <Property label="misclose" value="0.000"/>
         <Property label="totalDistance" value="0.7"/>
         <Feature name="detail">
            <Property label="stn" value="stn35"/>
            <Property label="bs" value="1.433"/>
            <Property label="rl" value="110.024"/>
            <Property label="al" value="110.023"/>
            <Property label="rmk" value="N. Cut Mark"/>
         </Feature>
         <Feature name="detail">
            <Property label="stn" value="stn502"/>
            <Property label="bs" value="1.496"/>
            <Property label="is" value=""/>
            <Property label="fs" value="1.397"/>
            <Property label="rl" value="110.060"/>
            <Property label="al" value="110.059"/>
            <Property label="d" value=""/>
            <Property label="rmk" value="N. Cut Mark"/>
         </Feature>
      </Feature>
   </Feature>
</SurveyHeader>
```

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LEVEL DETAILS

Levels from VCP 80172 to VCP 80172

Station	Back Sight	Inter-mediate	Fore Sight	Rise/Fall	Reduced Level	Adjusted Level	Distance	Remarks
VCP 80172	1.463					110.891		
W2		1.462		+.001	110.892	110.894		witness Mark 2
W1		1.492		-.030	110.862	110.862		witness Mark 1
VCP 80172	1.538				110.891	110.891		
C.P. 1	1.196		1.412	+.126	112.017	110.017		Change point
C.P. 2	1.371		1.450	-.254	110.763	110.763		Change point
C.P. 3	1.370		1.400	-.029	110.734	110.734		Change point
C.P. 4	1.443		1.449	-.079	110.655	110.654		Change point
C.P. 5	1.354		1.396	+.047	110.702	110.701		Change point
C.P. 6	1.924		1.415	-.061	110.641	110.640		Change point
C.P. 7	1.305		1.282	+.642	111.283	111.282		Change point
C.P. 8	1.036		1.056	+.249	111.532	111.531		Change point
C.P. 9	1.331		1.198	-.162	111.370	111.369		Change point
Stn 28	1.349		1.711	-.372	110.998	110.998		Change point
C.P. 10	1.353		1.251	+.098	111.096	111.094		Change point
Stn 10	1.413		1.722	-.369	110.727	110.726		N. Cut Mk
Stn 8	1.494		1.493	-.080	110.647	110.645		N. Cut Mk

Sample levelling details

The rise/fall values are not encoded as these values can be calculated from the rod readings and the reduced level so we will not need to do additional checks to see if the rise and fall values are correct as the main focus is on the reduced level and adjusted level.

Property@label	Full name
stn	station

Property@label	Full name
bs	back sight
is	intermediate sight
fs	fore sight
rl	reduced level
al	adjusted level
d	distance
rmk	remarks

Conventions are needed for:

1. Standardization of naming the points so that traverse stations and VCPs can be identified.
2. Values to standardize to be recorded meters.

5 Complex Structures and Scenarios

This section introduces higher level use of LandXML elements in the preparation of LandXML files for submission to SLA using CSMS. The section describes SG specific situations and conditions along with a “recipe” for creating a valid SGLX file.

5.1 Parcels

This section describes aspects of parcels (lots), including common attributes and special SG enumerations and properties required to represent the complexity of lots and areas in Singapore.

There are a number of non-lot polygons that are represented as Parcels. Only lots have lot numbers assigned by SLA, which must be used in the submissions. Areas and volumes may not be required. These non-lot areas include state reserves, voids, level outlines and common properties.

5.1.1 Parcel

The following shows the complete LandXML Parcel structure including all the sub elements that reside within a Parcel.

```
<!-- Root LandXML element, container for all CIF elements -->
<LandXML...>
   ...
   <!-- Container for all Parcel elements -->
   <Parcels>
      <!-- Each discrete parcel is described by a parcel element -->
      <Parcel ...="">
```

```
            <!-- Container for parcels related to this parcel (linkages -->
            <Parcels ...="">
               <!-- References to related parcels (linkages) -->
               <Parcel pclRef="..." ...="" />
               <Parcel pclRef="..." ...="" />
               ...
            </Parcels>
            <!-- Title references -->
            <Title ...=""/>
            <!-- Street Addressing -->
            <LocationAddress ...="" />
            <!-- Exclusion Areas -->
            <Exclusions ...=""/>
            <!-- Coordinate Geometry (parcel polygon) -->
            <CoordGeom ...=""/>
         </Parcel>
         <!-- More parcels -->
         <Parcel ...="">
            ...
         </Parcel>
      </Parcels>
      ...
      </LandXML>
```

A `Parcels` element is used as a container or grouping element for `Parcel` elements. Each parcel element may have one or more nested parcels elements that have further parcel elements. While LandXML allows for further (essentially unlimited) nesting, SG uses one level of nested Parcels. Nested parcel elements within the main Parcel element are used for parcel linkages (see below). SG uses island parcel (lot) references to define boundaries within the outer hull of a parcel.

Island parcels in SG LandXML are denoted only by their 'nesting' as parcels within the subject parcel. These are really references to parcels (through the `pclRef` attribute), which are parcel elements defined at the same level as the subject parcel.

5.1.2 Parcel Class

The `parcelClass` attribute of the `Parcel` element indicates the role of a lot in survey. (Note that it refers to the "lot" role, so non-lot parcels do not use this attribute.)

The enumeration is:

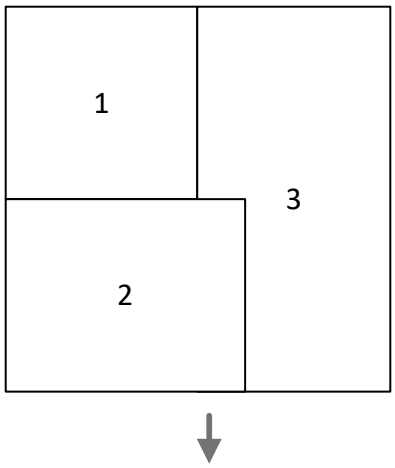
- **parent** – parent lot or lots. These lots would be extinguished by the new lots (final).
- **interim** – lots used as temporary structures within the survey to represent amalgamation and subdivision in one action. These have standard lot names.
- **final** – the lots to be created (same as provisional but with new survey geometry).
- **reference** –lots adjacent to the parents, if present. This could include island lots that are enclosed by a parent lot.
- **other** – not one of the standard roles.

In one sense, the parcel classes are states used to track the provenance of a lot through its life stages. In another, they combine with lineage to describe the process of the survey.

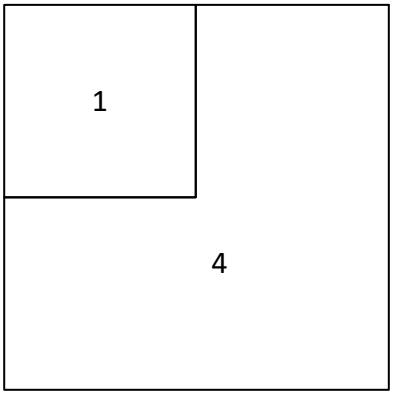
5.1.3 Parcel Lineage

Given the parcel class, we can track changes to parcels from parents through final, with the addition of lineage information. There are two basic operations (processes): subdivision and amalgamation. These are expressed using the equality and addition symbols and a few rules to create a type of algebra. Equality is the suggestion of conservation of area.

1. A process is represented by an equation.
2. Input parcels are on the left of the equal sign and output parcels are on the right.
3. Subdivision is represented by one input parcel and multiple output parcels: A = B+C
4. Amalgamation is shown as multiple input parcels and one output parcel: A+B = C
5. Alteration of a single parcel by A = B
6. Single lot survey or verification can be represented by A = A
7. A new parcel can be represented by NEW = A



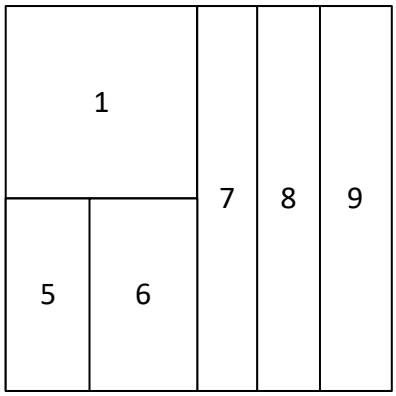
These parcels have a parcel class of “parent”. They are the currently active lots in the CSMS fabric.



Parcels 2 and 3 have been amalgamated to yield parcel 4.

This is represented as:

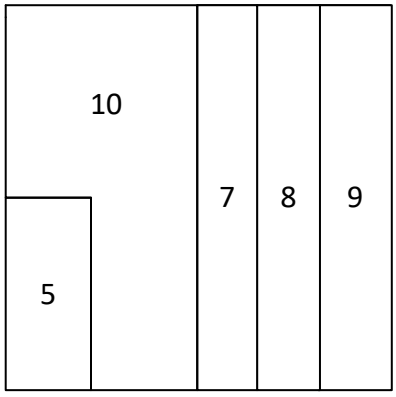
P2+ P3 = P4



Parcel 4 is then subdivided, yielding parcels 5,6,7,8 and 9.

This is represented as:

P4 = P5 + P6 + P7 + P8 + P9



Parcel 1 and parcel 6 are then amalgamated to give parcel 10.

This is represented as:

P1 + P6 = P10

So given a LandXML with the parcel geometry and the parcel class, a single character string of “P2+P3=P4; P4=P5+P6+P7+P8+P9; P1+P6=P10” could convey the entire sequence. Parcels to the left of the equals sign are extinguished and those on the right are created. The final diagram shows all parcels with a class of “final”.

In practice, the names would be replaced by lot numbers are interim names. It is also possible that not all geometry would need to be included in the LandXML. Interim parcels that are amalgamations can be represented just as a name.

The lineage would be held in a property that is a child to the `SurveyHeader` as shown below.

```
<Feature name="Lineage">
   <Property
        label="lineage"
        value="P2+P3=P4;P4=P5+P6+P7+P8+P9;P1+P6=P10"/>
   <Property
        label="physicalRelation"
        value="P5=P2;P7=P2+P3;P8=P3;P9=P3;P10=P1+P2"/>
</Feature>
```

This approach can represent known SG processes. The representation is focused on the use of lot names.

For instance:

1. Subdivision: P1 = P2 + P3
2. Amalgamation: P1 + P2 = P3
3. Alteration: P1 = P2
4. Verification P1 = P1
5. Proclamation NEW = P1

NEW is not a lot name, but is used to indicate that there is no parent. Process representations should be extensible to handle new situations.

Clearly, there is a relationship between the process types shown here and the PurposeOfSurvey aspect JobType. The usefulness of the relationship in quality control and testing is complicated by the multiplicity of processes possible within some types of submissions.

Examples

Amalgamation and subdivision:

```
<Property
        label="lineage"
        value="MK28-07437T+MK28-07436P=MK28-07412N"/>
```

In the case of submission:

```
<Property
       label="lineage"
       value="MK28-07412N=MK28-07437T+MK28-07436P"/>
```

Alteration:

```
<Property
        label="lineage"
        value="MK12-12345A=MK13-23456D"/>
```

Verification:

```
<Property
        label="lineage"
        value="MK12-12345A=MK12-12345A"/>
```

Proclamation:

```
<Property
        label="lineage"
        value="NEW=MK12-U12345A;NEW=MK12-12346B"/>
```

The same processes apply to Strata parcels in the submission file.

Amalgamation and subdivision:

```
<Property
        label="lineage"
        value="MK12-U123456A+MK12-U123467B=MK12-U123560A;MK12-U123560A=MK12-
        U123511B+MK12-U123512C+MK12-U123513D"/>
```

Alteration:

```
<Property
        label="lineage"
        value="MK12-U123456A=MK13-U234567D"/>
```

Verification:

```
<Property
        label="lineage"
        value="MK12-U123456A=MK12-U123456A"/>
```

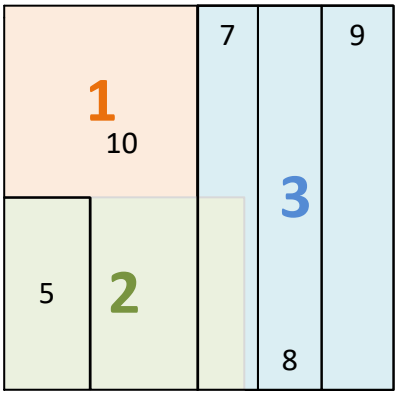
Proclamation:

```
<Property
        label="lineage"
value="NEW=MK12-U123456A;NEW=MK12-U123467B"/>
```

5.1.4 Physical Relationship

A second, physical, relationship maps the final lots back to the parent lots which they overlie. This is also described with our lineage algebra, but with a different contextual meaning. In the example above, the physical relation property shows that lot P5 has only lot P2 as its physical origin. However, lot P10 overlies some or all of each of the parent lots P1and P2. This gives a direct relationship regardless the possible convolutions on amalgamations and subdivisions in the interim and dummy lots.

The `physicalRelation` property should be formulated with the final lot on the left, and the physical parent lots on the right of the equals sign. This is the opposite of lineage which has parent lots to the left.



This shows the physical relationships derived from a geometric intersection of the parent lots and the final child lots. Lots 1,2 and 3 are parents, and 5,7,8,9,10 are final lots. The physical relation of lot 7 is 2 and 3.

This is an example of the lineage construct with both the lineage and physical relation properties

```
<Feature name="Lineage">
   <Property label="lineage"
             value="MK28-07412N=MK28-07437T+MK28-07436P" />
   <Property label="physicalRelation"
             value="MK28-07437T=MK28-07412N;MK28-07436P=MK28-07412N" />
</Feature>
```

5.1.5 State Reserve

The state reserve (SR) is similar to an easement in other cadastres. The SR is a polygon overlying all or some part of a lot. It does not have a Lot Number, but contains a reference to the Lot Number of the burdened lot.

5.1.5.1 Name Convention

State Reserve areas do not currently have a name assigned by SLA, yet they are tracked. Yet preparation of the submission must follow a naming convention that CSMS software can use to correctly identify these areas, and names are required by LandXML for all parcel elements.

The convention is ”SRxxxx” where the x values are a number series assigned by the surveyor and unique to the submission file.

5.1.5.2 Attributes

State Reserves are an oddity in SG. Although we model them using the Parcel element, they are not lots, and are not treated as lots. Important attributes are defined below.

1. name – follows convention “SRxxxx” assigned unique number by surveyor.
2. parcelFormat – “standard”. No SR’s for other than land survey.
3. parcelType – “stateReserve”.
4. parcelClass – “other”

5.1.6 Balance Lot

A balance lot has some geometry from a preceding survey, and some from the subject survey. It is created when a portion of the parent lot is “cut” from the parent, but only the cut portion is surveyed. The remainder is the balance lot.

```
<Feature name="Balance">
   <Property label="isBalanceLot" value="Y"/>
</Feature>
```

5.1.7 Area Class and Description

SG requires, for LandXML export of old records, the properties of an area class to describe the method or source of an area, and an area description, which is a textual description. There are no attributes in the LandXML to accomplish this. We use `Feature` and `Property` elements as shown below:

```
<Feature name="Area">
   <Property label="class" value="S"/>
   <Property label="description"
             value="INCLUDES STRATA VOID OF 20 SQ M"/>
   <Property label="description"
             value="INCLUDES ACCESSORY VOID OF 1 SQ M"/>
</Feature>
```

The need for this property will be rarely encountered, and never in a new survey. However, software to read or write the LandXML must test for the existence or need when reading or writing.

5.1.8 Old Format Lot Numbers

Old format lot numbers exist for titles that have not changed during the last update of the lot number format. It is used as a reference for the land owners to refer to the old format lot number as stated in their title deeds. So some lots will have both new lot number and old format lot number. Surveyors are required to submit the old format lot number along with the new format lot numbers for surveys and submissions that are initiated with lots using the old format lot number. Therefore, Parcel needs a property to hold the old format lot number in these cases. The property will be optional, and SG LandXML readers must test for its existence.

```
<Feature name="OldFormat">
   <Property label="oldFormatLotNumber" value="4287/U71"/>
</Feature>
```

5.1.9 Survey Type

Indicates the survey type, and must be of type surveyTypeType: resurvey, substandard or modern.

```
<Feature name="SurveyType">
   <Property label="code" value="resurvey"/>
</Feature>
```

5.2 Voids

The term void covers two classes of parcel areas. The first is a situation which occurs when land lots surround a not-a-lot, or void. This is a relatively rare situation, generally found in foreshore areas, and probably always resulting from “new” land creation. The second class of void lot is characteristic of airspace, subterranean, strata lots and building outlines.

5.2.1 Parcels

Voids will be modelled in LandXML as parcels, using the Parcel element. This has the benefit of using a well attributed element of fundamental use in LandXML, which is most efficient and will allow for future enhancement of the void model. All the attributes of the Sg specific parcel can be used in their selection and treatment by CSMS software.

5.2.2 Name Convention

Void areas do not currently have a name assigned by SLA, yet they are tracked. However, preparation of the submission must follow a naming convention that CSMS software can use to correctly identify these areas, and names are required by LandXML for all parcel elements.

The convention is ”Sx” where the x value is a number in a series assigned by the surveyor and unique to the submission file.

5.2.3 Attributes

Voids are identified by the name prefix, but also by their attributes.

1. name – follows convention
2. parcelFormat = standard
3. parcelType = ”empty”
4. parcelClass = ”other”

Area and volume need not be calculated and reported by the surveyor. In cases where they are reported, it will be assumed there was a specific reason.

5.2.4 Land Lot Void

The void land lot in Singapore is not just a “gap” created by a mistake in the adjoining boundaries of lots. In a few cases in Singapore, large areas have been enclosed by lots. This seems to be solely an issue with foreshore areas, where the creation of new land for breakwaters, linking roads, seaports and shipyards, encloses a body of water.

This creates two situations, each with a different outcome and need for resolution. Firstly, if a void area is created by multiple lots, then the enclosure is “outside of each. As we have proposed a “foreshore” survey method for points, and therefore boundary points, we have a hook for analysis of the situation. Also, the foreshore point or monument is by definition not expected to fall on a shared boundary. So, although there is an enclosure of water, it does not break any rules we have in lot formation. If we want to measure the area enclosed, we can do so by finding “rings” of foreshore boundaries.

The second situation is not easily resolved without forming a new concept of “lots”. If a single lot encloses a body of water, then we have created a boundary definition issue for the

lot. In our current land model, lots are allowed to have an “implied” inner boundary. This boundary is the boundary of an island lot, which has its own boundary definition. So without an island lot representing the enclosed water body, we cannot fit this oddity into our model. Such a situation might arise through an amalgamation of all lots participating in the enclosure. Perhaps such things might be disallowed. Alternatively, we should look to the solution of a general void lot, needed for subterranean, airspace and strata, for a way to handle the same problem with voids in land lots.

5.3 Airspace and Subterranean Lots

Airspace and subterranean lots have distinctive characteristics that separate them from land lots. They are three dimensionally defined parcels, but represented as 2D in current practice. This section addresses unique aspects of these lots, and makes suggestions for new approaches.

Airspace and Subterranean lots have levelling field data and calculations to yield the elevations required for definition of the surveys. The specific format of levelling detail is shown in its own section (4.5 Levelling).

5.3.1 Airspace Lot Boundaries

Airspace lot boundaries are defined by demarcation (observations) from the standard land survey. The “outside” points defining each lot are connected to traverse stations. These airspace lots are defined as extrusions from the 2D lot definitions using lower and upper elevations defining the vertical extent of each lot.

The elevation defining the separation between overlying lots is generally established as the middle of a physical structure between the lots (middle of the occupation).

Levelling is used to define the elevations of at least a part of the stations of the traverse, though not necessarily all stations defining the lot boundaries. Engineering and architectural plans are often used as supporting documentation of the elevations defining the lots. Elevation reference pairs, discussed in the section on `Elevations` (section 5.14), are used to encode the upper and lower elevations of airspace and subterranean lots, as a child `Feature` construct within the `Parcel` element, as shown below.

```
<Feature name="ElevRefPair">
   <Property label="lower" value="level 3"/>
   <Property label="upper" value="level 3 false ceiling"/>
</Feature>
```

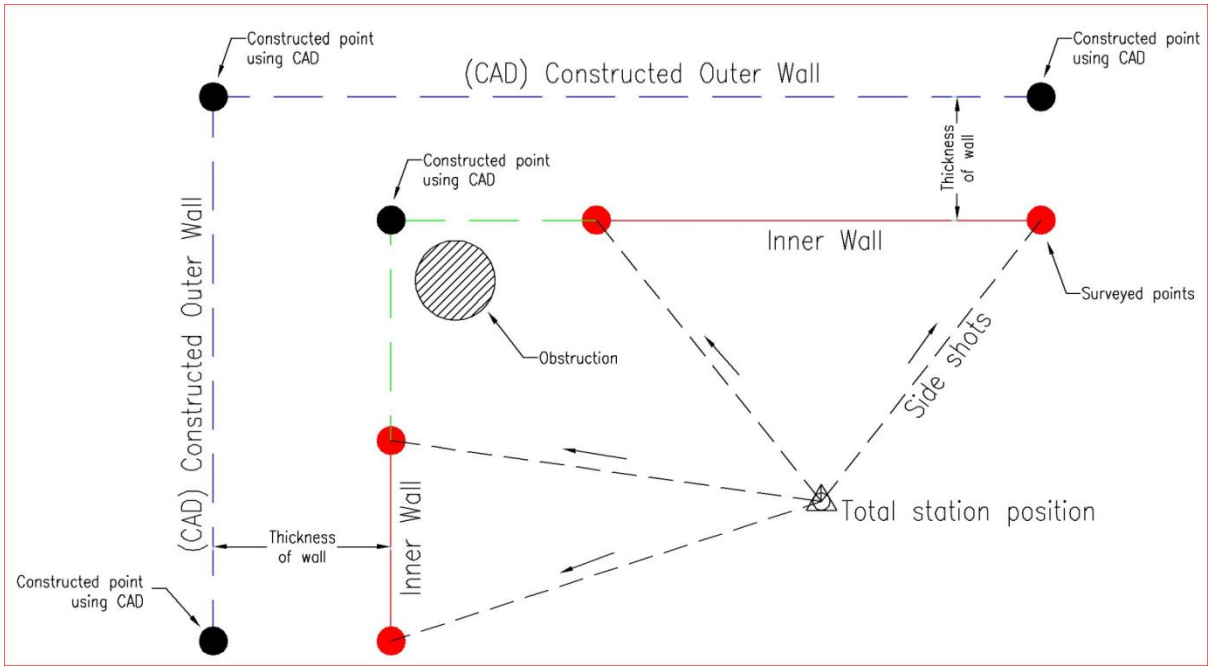
The referenced elevations can be retrieved from the `Elevations` structure of the `SurveyHeader`. Airspace lots may also be Part Lots, which have a special encoding and lot naming convention described in a following section.

5.3.2 Subterranean Boundaries

Subterranean (sub) lots have a very distinct characteristic. The boundary points of the underground structures are on the outside of the walls, and not accessible to direct measurement. That is, they are not connected to the traverse, side shots, observations, and demarcations of the survey. Instead, their values must be calculated from interior measurements.

The current survey and data models do not reflect the calculation of the outer wall boundary points. That is, there is no calculated line connecting the boundary point to the nearest side shot.

The outer wall of a subterranean lot is considered as the boundary of the lot. The outer wall is typically constructed (using CAD) via the input of an offset value. The thickness of wall information is typically found from the architectural design / building plan. The figure below shows how the outer wall is constructed (via CAD) from the side shots.



5.4 Part Lots

Airspace, subterranean, and strata lots (see later section) can be lots that are a composition of multiple parcels. This is necessary to combine lots on different levels (elevations) into one ownership lot.

Current practice for part lots is of two sorts: one that shows the part lots with their areas, and another that shows just the part lot of largest extent with the summation of area for all lots.

In the first type the part lots may be designated by appending a “PT” plus sequence number to the lot name, although this is not a convention. These lots are not recorded in CGS or in LIMS. It is assumed that the CSMS will record only the one lot, until such time as CSMS is fully 3D.

In the second current convention, a single lot represents all part lots. Its extent (outline) and stated area are the greatest extent of all part lots overlying each other, and the summation of the stated individual areas.

1. In LandXML, airspace and subterranean lots must record individual part lots and the greatest extent part lot (n+1 part lots).
2. Strata lots do not record the greatest extent part lot, just each part lot parcel with its part lot number.

3. Part lot naming convention is to append “PT” + sequential number to the lot names.

Part lots including a greatest extent part lot:

```
<Parcel name="MK05-70002K-PT1" area="2000.0" …>
   ...
   <Feature name="PartLot">
      <Property label="TotalArea" value="3000.0"/>
   </Feature>
</Parcel>
<Parcel name="MK05-70002K-PT2" area="1000.0" …>
   ...
</Parcel>
<Parcel name="MK05-70002K-GE" area="2445.6" …>
   ...
</Parcel>
```

5.5 SG Modified ICSM Structuring Spatial Elements

The following elements in a CIF contain spatial information:

- All elements under `CoordGeom` (e.g. `Line`, `Curve`, `IrregularLine`)
- All elements under `ObservationGroup`
- `CgPoint` elements

Coordinate geometry (`CoordGeom`) elements are used to store 2D and 3D line and polygon structures for `Parcel` and `PlanFeature` elements. A `CoordGeom` element must be a child of a `Parcel` or `PlanFeature` element.

`Observation` elements are contained within an `ObservationGroup` element and are used for measurement and dimension information.

Note: In Singapore, traverses have a strong role and will each be modelled as an `ObservationGroup`.

`CgPoints` are single points that are used to build more complex structures such as lines, arcs and polygons and:

- To associate observation and monument information with a point.
- To store the position of a point for rendering purposes.

`CgPoint` elements are all contained within a `CgPoints` element and are referenced using their name attribute. Other elements that are associated with a particular `CgPoint` have a `pntRef` attribute whose value is the name of the related `CgPoint` element. These include `Line`, `Curve`, `Monument`, `ReducedObservation` and others. For example, a `Line` in a `CoordGeom` has `Start` and `End` nodes, which in turn reference `CgPoint` elements. Where a measurement or dimension is required between two points, they are referenced by `Observation` elements through `InstrumentSetup` elements.

`CgPoint` elements can store coordinate information for the node. In the Australian ICSM national standard, they state that coordinates are used only for rendering purposes and should not be used for any purpose requiring survey accurate data as `CgPoint` coordinates may be distorted for display optimisation. The opposite is true for the Singapore LandXML standard. CgPoint coordinate values are a product of the survey processes only, and reflect the best estimate of locations. These coordinates are used for analytic as well as cartographic purposes.

The `CoordinateSystem` element specifies the coordinate system used to interpret the `CgPoint` coordinates.

5.6 Linking Observations to CgPoints

To link observation and dimension information to parcel coordinate geometry, links are made from the relevant Observation elements to the `CgPoints` representing the parcel's corners as follows:

- The `ReducedObservation` and `ReducedArcObservation` elements are linked using the `setupID`, `targetSetupID` and (if angles are being used) targetSetup2ID attributes. These attributes contain the value of the name attribute of an `InstrumentSetup` element.
- The `InstrumentSetup` element contains a nested `InstrumentPoint` element that contains a `pntRef` attribute that references the name attribute of a `CgPoint` element.
- The `InstrumentSetup` element must have:
  - a unique name value
  - a `stationName` (which may use the `CgPoint` name or some other value)
  - an `instrumentHeight` (which may be a default value of zero)

The following diagram shows the links between observations, `CgPoints` and `Monuments`.

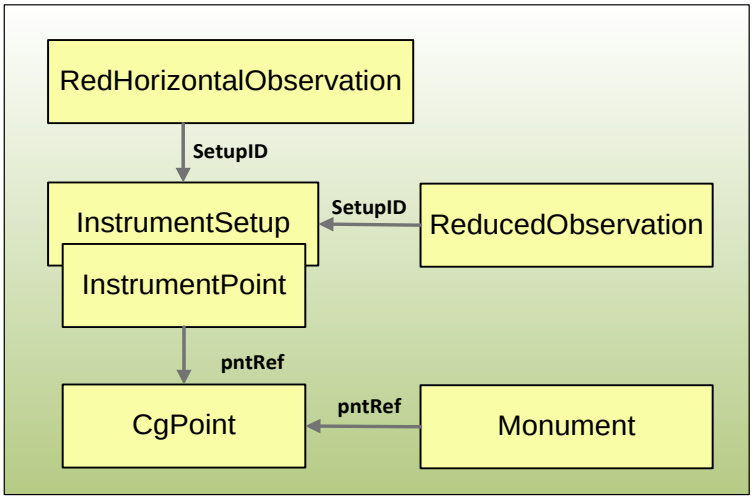


Figure 4 Observation, CgPoint and Monument element relationship

Below is a LandXML example that shows links between observations, CgPoints and a boundary line.

```
<CgPoints>
   <CgPoint name="AAA" oID="1-PS123456" pntSurv="boundary">111.111 222.222</CgPoint>
   <CgPoint name="BBB" oID="2-PS123456" pntSurv="boundary">148.779 184.006</CgPoint>
</CgPoints>
<Survey>
   <InstrumentSetup id="IS-1-PS123456" instrumentHeight="0" stationName="1">
      <InstrumentPoint pntRef="AAA"/>
   </InstrumentSetup>
   <InstrumentSetup id="IS-2-PS123456" instrumentHeight="0" stationName="2" >
      <InstrumentPoint pntRef="BBB"/>
   </InstrumentSetup>
   <ObservationGroup id="OG-1">
      <ReducedObservation setupID="IS-1-PS123456"
```

```
      targetSetupID="IS-2-PS123456"
      horizDistance="53.66" azimuth="314.3510" ...=""/>
   </ObservationGroup>
</Survey>
<Parcels>
   <Parcel name="" ...="">
      <CoordGeom>
         <Line>
            <Start pntRef="AAA"></Start>
            <End pntRef="BBB"></End>
         </Line>
         ...
      </CoordGeom>
   </Parcel>
</Parcels>
```

The above example shows how a line (`Parcel/CoordGeom/Line`) and its dimensions (attributes of `ReducedObservation`) and rendering information (`CgPoint` coordinates) are related using the `CgPoint` and `InstrumentSetup` elements in a CIF.

The following diagram is a representation of the above LandXML (note that `CgPoint` coordinates are ordered northing, easting or y, x):

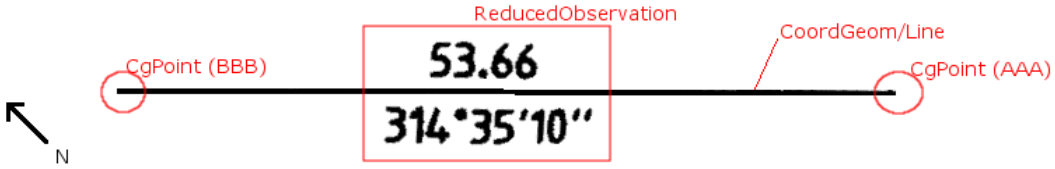


Figure 12: Linking observations and dimensions to lines

5.7 Horizontal Control

This section directly addresses the encoding of SG horizontal control in LandXML. Alternative structural modes are proposed for efficiency in the standard transactions.

Note: ICSM LandXML, and to a large degree LandXML itself, treat control coordinates separate from the station coordinates because they are not coordinated cadastres. In SG, we use control in the field as another station; one who's coordinates must match the coordinates on record, but then we expect that for all existing points. This is fundamentally different, and allows us to use a much simpler model of control in LandXML.

5.7.1 Referenced in Surveys

The main use of control in SG surveys is as a reference, the control marker coordinates are used to locate the survey traverse. In this use, there is no intention of changing the coordinates of the control, or to make special measurements. The observations to the control marker are the same as all other legs of the traverse, or in some cases - side shots. The important thing is that the survey data file indicates which control marker is related to which station of the traverse.

This model uses only the `CgPoint` and the `Monument` to hold information for the survey submission. We rely on the `Monument` for CP related attribution. Since there are no `RedHorizontalPosition` or `RedVerticalObservation` elements, there is no need for integration in the core body of the `Survey` or the `ObservationGroup`.

```
<CgPoints> ...
   <CgPoint name="4" desc="final" code="L01" pntSurv="control">
      38311.396 30303.307 16.640
   </CgPoint>
</CgPoints>  ...
   <Monuments> ...
   <Monument name="SM80001" pntRef="4" type="SM" state="found" />
</Monuments>
```

This simple model requires no additional and unnecessary information in the survey files.

5.7.2 Detailed HCP Model

A single model for HCP supports both distribution from CSMS, and the encoding of information for submission. Multiple HCP may be contained in a single LandXML.

The processes and data transfers for new control are extensive, and managed by on-line submission of many files and forms, ranging from GPS certifications, to RINEX files and graphics composite photographs. It is unclear how any LandXML adaptation to satisfy encoding the complete set could itself be a functional and useful standard for SG.

Instead, a portion of the data will be encoded as LandXML, as close to the standard as possible, and the other processes should support the balance. This proper subset of data will be used for the distribution and submission purposes.

The only difference between distribution and submission for this protocol is:

- The WGS84 latitude and longitude are not required in the submission.
- The last updated date is not relevant for a submission.

Standard for CP Transactions. Asterisk indicates not in both download and new.

Standard HCP Transaction	
Combined	**LandXML**
cp number	`Monument@name`
marker type	`Monument@type`
Administrative	
surveyor	`Feature/Property@label=”Surveyor”`
assistant	`Feature/Property@label=”Authorised Assistant”`
survey date	`Feature/Property@label=“SurveyDate”`
Coordinates and Elevations	
northing	`<CgPoint>` **northing** easting elevation `</CgPoint>`
easting	`<CgPoint>` northing **easting** elevation `</CgPoint>`
reduced level	`<CgPoint>` northing easting **elevation** `</CgPoint>`
latitude (WGS84) *	`CgPoint@latitude`
longitude (WGS84) *	`CgPoint@longitude`

ellipsoidal height	CgPoint@ellipsoidHeight
Miscellaneous	
remarks	Feature/Property@label=”Remarks”
station diagram	Feature/DocFileRef@name="StnDgm_*.jpeg"
other documents	Feature/DocFileRef

Latitude and longitude are written with a special format to increase the significant digits of the seconds. They should be parsed as strings, not double values. The format is ddd.mmsssssss, where ddd=degrees, mm=minutes, and sssssss is to be read as ss.sssss decimal seconds.

To support multiple HCP per document, Feature/Property constructs are used for administrative data, instead of the document level attributes of the SurveyHeader.

```
<CgPoints>
   <CgPoint name="1" desc="final" code="L01" pntSurv="control"
      latitude="1.361266835" longitude="103.853318276"
      ellipsoidHeight="19.723">34066.987 29406.184 10.997</CgPoint>
   <CgPoint name="2" desc="final" code="L01" pntSurv="control"
      latitude="1.432606933" longitude="103.803475547"
      ellipsoidHeight="26.34 ">46035.934 24678.919</CgPoint>
</CgPoints>
<Monuments>
   <Monument name="SM15374" pntRef="1" type="SM"
      desc="Shan Road / Irrawaddy Road (LP 14)">
      <Feature>
         <Property label="Surveyor" value="Heng Fook Hai"/>
         <Property label="SurveyDate" value="2006-02-22T00:00:00"/>
         <Property label="Remarks" value="Gum stuck to monument, now on shoe."/>
         <DocFileRef name="StnDgm_15374.jpeg" location="."
            fileType="image" fileFormat="JPEG"/>
      </Feature>
   </Monument>
   <Monument name="SM16043" pntRef="2" type="SM"
   desc="Woodlands Avenue 5/Woodlands Avenue 12(TL 7)">
      <Feature>
         <Property label="Surveyor" value="Ho Kong Chan"/>
         <Property label="SurveyDate" value="2006-02-24T00:00:00"/>
         <DocFileRef name="StnDgm_16043.jpeg" location="."
            fileType="image" fileFormat="JPEG"/>
      </Feature>
   </Monument>
</Monuments>
```

5.7.3 Validation Transfers

Within CSMS there is a need to transfer HCP and VCP information from the CSMS database, to the validation software. This format is intended only for this CSMS internal communications. The format is simplified and then extended.

Validation requires multiple records in a single message, including CSMS administrative data for SG_HorizontalControl attributes : controlStatus, liveDate and deadDate.

We are encoding the control status and dateTime values for the change of status. So the status determines the meaning of the dateTime values.

The LandXML 1.2 `CgPoint` has two `xs:dateTime` attributes, `timeStamp` and `determinedTimeStamp`. These will be used for liveDate and deadDate respectively. The `desc` attribute of `CgPoint` and the `approvalStateType` are reused for the controlStatus.

In the current CSMS data model, controlStatus is either "live" or "dead". We add another value for "processing", to designate a control has been submitted but is not yet approved and "live". The table below shows the status mapping, and how dateTime `CgPoint` attributes are used.

CSMS to LandXML		
controlStatus	**approvalStateType**	**dateTime attribute**
live	activation	timeStamp (date activated)
dead	dead	timestamp,determinedTimeStamp (date activated, date deactivated)
processing (new)	allocation	timeStamp (date submitted for processing)

The following is an example of the encoding for four HCP, showing only the core part of the LandXML.

```
<!--Example of HCP Validation Transfer-->
<CgPoints>
   <CgPoint name="1" desc="activation" timeStamp ="2002-03-12 T00:00:00" code="L01"
            pntSurv="control">41521.731 33946.751</CgPoint>
   <CgPoint name="2" desc="activation" timeStamp ="2010-11-02T00:00:00" code="L01"
            pntSurv="control">38226.645 30717.121</CgPoint>
   <CgPoint name="3" desc="dead" timeStamp ="2010-06-10"
            determinedTimeStamp="2012-07-23 T00:00:00" code="L01"
            pntSurv="control">37918.991 30554.223</CgPoint>
   <CgPoint name="4" desc="allocation" timeStamp ="2012-07-24" code="L01"
            pntSurv="control">38148.206 30225.732</CgPoint>
   <CgPoint name="5" desc="allocation" timeStamp ="2012-07-24" code="L01"
            pntSurv="control">38311.396 30303.307</CgPoint>
</CgPoints>
<Monuments>
   <Monument name="SM18327" pntRef="1" type="SM" />
   <Monument name="SM11652" pntRef="2" type="SM" />
   <Monument name="SM11031" pntRef="3" type="SM" />
   <Monument name="SM80002" pntRef="4" type="SM" />
   <Monument name="SM80003" pntRef="5" type="SM" />
</Monuments>
```

5.8 Vertical Control

Vertical control in LandXML is horizontal control with more information in the `RedVerticalObservation`. HCP and VCP are not so similar in Singapore. The VCP is not just an HCP with a better than average reduced elevation. Of the 15 properties of the HCP structural model, only 7 are used by the VCP, and the VCP has 17 properties not found in the HCP. This means the VCP does not fit into the ICSM model very well, and there is little reason to try to make it either the LandXML or HCP models. The SG protocol uses an alternative model for VCP structural encoding.

5.8.1 Referenced in Survey

Survey submissions are not used to submit new VCP. They reference VCP much as submissions reference HCP, and can use the same model.

```
<!--Example of SG VCP Survey Submission-->
<CgPoints>
   ...
   <CgPoint name="24" ...>32962.452 29316.093 3.557</CgPoint>
</CgPoints>
...
<Monuments>
   ...
   <Monument name="VCP80188" pntRef="24" type="BT" state="found"/>
</Monuments>
```

5.8.2 Detailed VCP Model

The current system allows surveyors to purchase VCP information. The data product is a single data sheet as seen below.

Witness marks are not given their coordinates; they are only located by the station diagram, locality map and the site plan. So we really can't create a `CgPoint` or `RedHorizontalPosition` to hold their properties. We use a `Feature/Property` approach, where the witness marks become properties of features under the `Monuments`. The `Monument` will reference the `Feature` using `featureRef`. The additional image files, the site sketch and the location map, will be mapped to `DocFileRef` elements in the same Feature that holds the witness mark data.

Singapore Land Authority (SLA)

Vertical Control Point (VCP)

VCP No: 80188

Reduced Level (m): 3.557 Mark Type :BOLT

Vertical Accuracy : +/- 5 mm (95% confidence level)

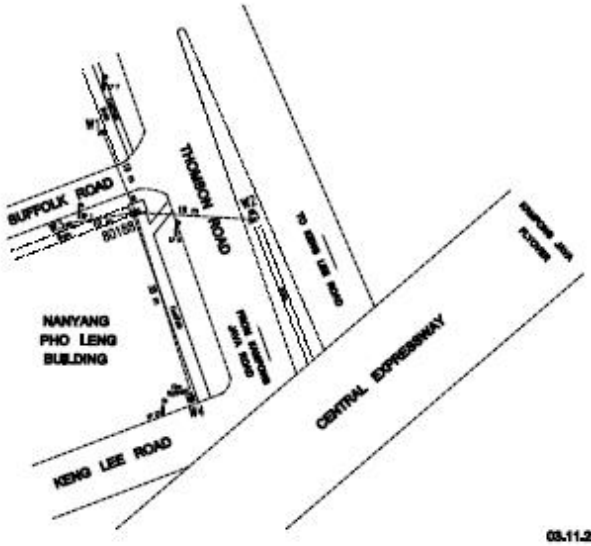
Locality : THOMSON ROAD/SUFFOLK ROAD

SVY21 Coordinates (m) : N 32962.452
: E 29316.093

WGS84 DATUM

Latitude :N 1° 18' 51.75076"
Longitude :E 103° 50' 42.51959"

Witness Mark 1(W1)	Witness Mark 2(W2)	Witness Mark 3(W3)	Witness Mark 4(W4)
Mark Type : BOLT	Mark Type : BOLT	Mark Type : BOLT	Mark Type : BOLT
Height Relative to VCP: -0.701 Reduced Level (m) : 2.856	Height Relative to VCP: -0.193 Reduced Level (m) : 3.364	Height Relative to VCP: -1.032 Reduced Level (m) : 2.525	Height Relative to VCP: 0.412 Reduced Level (m) : 3.969



The coordinates stated are for the purpose of locating the VCP only.
The reduced level is based on the Singapore Survey Department Precise Levelling Datum and measured to the top of the bolt

Datasheet updated on : 01-07-2010

Note: Location Map & Site Plan not to scale

From the data sheet, we take the properties list for the detailed horizontal control model and add any new properties seen on the VCP data sheet. However, where properties are found in both HCP and VCP, they will be encoded identically.

Properties Shared between HCP and VCP		
HCP	**VCP Report**	**Shared**
(h)cp number	vcp number	cp identifier
northing	northing	northing
easting	easting	easting
ellipsoid height	-	
surveyor	-	
authorised assistant	-	
date of survey	-	
location	locality	location
marker type	mark type	marker type
remarks	-	
latitude	WGS84 Latitude	latitude
longitude	WGS84 Longitude	longitude
reduced level	RL (reduced level)	reduced level
station diagram	station diagram	station diagram
	vertical accuracy	
	confidence level	
	location map	
	site plan	
Witness Marks		
	W1 mark type	
	W1 relative height	
	W1 reduced level	
	W2 mark type	
	W2 relative height	
	W2 reduced level	
	W3 mark type	
	W3 relative height	
	W3 reduced level	
	W4 mark type	
	W4 relative height	
	W4 reduced level	

An example of LandXML encoding is shown below. This sample uses the VCP shown on the data sheet. Note that most of the VCP properties are contained under the `Monument`.

```
<CgPoints>
   <CgPoint name="42" desc="final" code="L01" pntSurv="control"
      latitude="1.31437521" longitude="103.8451443"
      ellipsoidHeight="">32962.452 29316.093 3.557</CgPoint>
</CgPoints>
<Monuments>
   ...
   <Monument name="VCP80188" pntRef="42" featureRef="VCP80188"
             type="BT" desc="Thomson Road/Suffolk Road">
   </Monument>
   <Feature name="VCP80188">
      <Feature name="W1">
         <Property label ="MarkType" value="BT"/>
         <Property label ="RelativeHeight" value="-0.701"/>
         <Property label ="ReducedLevel" value="2.856"/>
      </Feature>
      <Feature name="W2">
         <Property label ="MarkType" value="BT"/>
         <Property label ="RelativeHeight" value="-0.193"/>
         <Property label ="ReducedLevel" value="3.364"/>
      </Feature>
      <Feature name="W3">
         <Property label ="MarkType" value="BT"/>
         <Property label ="RelativeHeight" value="-1.032"/>
         <Property label ="ReducedLevel" value="2.525"/>
      </Feature>
      <Feature name="W4">
         <Property label ="MarkType" value="BT"/>
         <Property label ="RelativeHeight" value="0.412"/>
         <Property label ="ReducedLevel" value="3.969"/>
      </Feature>
      <DocFileRef name="StationDiagram_80188.jpg" location="." fileFormat="JPEG"/>
      <DocFileRef name="LocationMap_80188.jpg" location="." fileFormat="JPEG"/>
      <DocFileRef name="SitePlan_80188.jpg" location="." fileFormat="JPEG"/>
   </Feature>
   ...
</Monuments>
```

5.8.3 Validation Transfers

Within CSMS there is a need to transfer HCP and VCP information to support validation of the survey submissions. The same model used for survey submissions will satisfy this requirement. Since this LandXML would not contain any other survey data, we can transfer multiple VCP in one file, which is the requirement. An example is provided below:

```
<!--Example of VCP Validation Transfer-->
<CgPoints>
   <CgPoint name="1" ...>32962.452 29931.093 3.557</CgPoint>
   <CgPoint name="2" ...>32576.762 2890e.093 5.573</CgPoint>
   <CgPoint name="3" ...>32188.452 29436.093 10.887</CgPoint>
</CgPoints>
<Monuments>
   <Monument name="VCP80188" pntRef="1" type="BT" state="found" />
   <Monument name="VCP22556" pntRef="2" type="BT" state="found" />
   <Monument name="VCP12345" pntRef="3" type="BT" state="found" />
</Monuments>
```

5.9 Addresses

The LandXML element `LocationAddress`, `ComplexName` and `AddressPoint` elements are the means to encode addresses. It is a rather complicated approach, but we can use it to map

Singapore addresses to the LandXML standard. This table presents a mapping of the CS Directive 4.0 address model to SG LandXML. SGDRM address model mapping is noted in the element descriptions.

The `LocationAddress` itself does not allow a `Feature` child element, and has little customisation facility other than repurposing of existing attributes, which are not adequate for our needs. We therefore use the `AddressPoint`, which may be a child of `LocationAddress`, to serve as a pointer to a `Feature` that contains custom properties, via its `AddressPoint@featureRef` attribute. This is an unfortunate complication, but the best option given the inflexibility of the LandXML `LocationAddress` definition.

Data Item	Type	Description	LandXML Element@attribute	Attribute/Value
House Number	string (10)	the house number (block in CS 3.4)	LocationAddress	numberFirst
Street Name	string (75)	street name	RoadName	roadName
Level Number	string (3)	Level No e.g. 04 or 11 (If Level No is single digit, put a zero in front)	LocationAddress	floorLevelNumber
Unit Number	string (5)	the unit number	LocationAddress	flatNumber
Postal Code	int (6)	Postal Code, if the postal code could not be found in the Singapore Post file (This field is optional)	Feature property, referenced through AddressPoint featureRef.	postalCode
Address Source	sourceType	Address source, for example IRAS	Feature property, referenced through AddressPoint featureRef.	addressSource
Building Name	string (50)	Name of the building	ComplexName	desc
Building Source	sourceType	source of building name, for example IRAS	Feature property, referenced through AddressPoint featureRef.	buildingSource

Please view the `LocationAddress` element attributes for SGDRM address attribute mapping.

The CS Directive address data items Address Source, Building Source and Postal Code are referenced through a child `AddressPoint` to a Feature as shown below:

```
<LocationAddress
```

```
            flatNumber="02"
            floorLevelNumber="05"
            numberFirst="35">
            <ComplexName desc="Wedge Mount Industrial Building"/>
            <RoadName>Jalan Pemimpin</RoadName>
            <AddressPoint pntRef="no"featureRef="addRef1">/>
         </LocationAddress>
         ...
         <Feature name="addRef1">
            <Property label="addressSource" value="IRAS"/>
            <Property label="buildingSource" value="URA"/>
            <Property label="postalcode" value="577176"/>
         </Feature>
```

There were no standard LandXML attributes that could be used for these three data items.

5.10 Associated Documents

Documents related to a particular submission to SLA may be referenced as a number of DocFileRef elements within a Feature under the SurveyHeader. The Feature should have the name “RefDocs”, as shown in the example below.

```
<SurveyHeader name="3443-2006" jurisdiction="Singapore" …>
  <PurposeOfSurvey name="CPLNDONR" />
  <AdministrativeDate adminDateType="Commenced" adminDate="2012-11-17" />
  <AdministrativeDate adminDateType="Completed" adminDate="2013-02-07" />
  <Personnel role="Surveyor" name="SEE SENG GUAN" />
  <Personnel role="Authorised Assistant" name="TAN CHEE HAI" />
  <Feature name="RefDocs">
    <DocFileRef name="somefile.xml"
                location="./somefile.xml">
    </DocFileRef>
    <DocFileRef name="encroachmentresolutions.pdf"
                location="./subfolder/encroachmentresolutions.pdf">
    </DocFileRef>
  </Feature>
</SurveyHeader>
```

5.11 Amendments

The `Amendment` element is used to record changes to a LandXML. Generally, amending a file creates a new version of the file. If the reason for the amendment to the file is held elsewhere, there is no need for these elements. However, a jurisdiction may choose strikeout or erasure methods to apply amendments if they wish a record of change to be embedded in the file.

There is a limit to what the `Amendment` can handle in LandXML. We should limit our tracking of changes in a LandXML file to amendments by SLA to the documents of completed transactions, or to special cases where the land officer alters the file with the consent of the lodging party. Issues of tracking changes between submissions, of whatever type, should be addressed by better solutions designed to versioning.

5.11.1 Strikethrough method

In some jurisdictions, all original information must remain in the file so an amended version of a file will contain both the original and amended content. This method of recording

amendments replicates the system of strikethrough, where original information on a paper plan was struck out but remained readable and new information was added in a style that could be identified as being an amendment to the plan.

Using the strikeout method, an `Amendment` element will contain at least one

`AmendmentItem` element that will have either:

1. In the case of simple deletion, an `oldName` attribute referencing the name of the element that was deleted
2. In the case of a simple addition, a `newName` attribute referencing the name of the added element
3. In the case of an amendment or replacement, an `oldName` attribute referencing the element with the original data and a `newName` attribute referencing the element with the current data.

This clearly requires all data objects to be uniquely identifiable.

Examples:

An amendment where a new element is added to the LandXML:

```
<Parcels>
   <Parcel class="final" name="MK12-12345A" area="2050.7" parcelType=”land”
desc=”CP12345” parcelFormat=”standard”>
      <CoordGeom>
         ...
      </CoordGeom>
   </Parcel>
</Parcels>
<Amendment dealingNumber="CP12345" amendmentDate="2010-02-09"
           comments="Lot MK12-12345A added to plan">
   <AmendmentItem elementName="Parcel" newName="MK12-12345A"/>
</Amendment>
```

Or an amendment where an element is modified.

```
<CgPoints>
   <CgPoint name="1" desc="final" pntSurv="boundary" code="L01">36135.580
22767.794</CgPoint>
</CgPoints>
<Amendment dealingNumber="CP23456" amendmentDate="2010-02-09"
           comments="Correction to Station 1 coordinate">
   <AmendmentItem elementName="CgPoint" oldName="1 " newName="1 "/>
</Amendment>
```

Or an amendment where an element is removed.

```
<Amendment dealingNumber="CP23457" amendmentDate="2010-02-09"
           comments="Remove Station 1 from Plan">
   <AmendmentItem elementName="CgPoint" oldName="1"/>
</Amendment>
```

5.12 Reference Plan Areas

Alienation surveys can record reference plan areas as a listing in the SurveyHeader. These areas can then be compared to the planned or surveyed areas. The structural encoding is as follows:

```
<SurveyHeader>
   <Feature name="referencePlanArea">
```

```
      <Feature>
         <Property label="lotName" value="PLOT1"/>
         <Property label="area" value="1000"/>
      </Feature>
      <Feature>
         <Property label="lotName" value="PLOT2"/>
         <Property label="area" value="1000"/>
      </Feature>
      <Feature>
         <Property label="lotName" value="MK12-12345A"/>
         <Property label="area" value="1000"/>
      </Feature>
      <Feature>
         <Property label="lotName" value="MK12-23456L"/>
         <Property label="area" value="1000"/>
      </Feature>
   </Feature>
</SurveyHeader>
```

This shows the intended areas for four plots in a LandXML file submitted for allocation. For other submission types, the name of the lots must conform to lot name standards.

5.13 Alteration of Survey District boundary (MKTS)

Alteration of survey district boundary surveys can record the intended transfer as a listing in the SurveyHeader. These stipulations can then be compared to the planned (allocation) and surveyed (CP) areas submitted in the SG LandXML files. The structure is as follows:

```
<SurveyHeader>
   <Feature name="surveyDistrictAlteration">
      <Feature>
         <Property label="lotName" value="plot1"/>
         <Property label="fromSD" value="TS28"/>
         <Property label="toSD" value=" TS29"/>
      </Feature>
      <Feature>
         <Property label="lotName" value="plot2"/>
         <Property label="fromSD" value="TS28"/>
         <Property label="toSD" value=" TS29"/>
      </Feature>
      <Feature>
         <Property label="lotName" value="plot3"/>
         <Property label="fromSD" value="TS28"/>
         <Property label="toSD" value=" TS29"/>
      </Feature>
      <Feature>
         <Property label="lotName" value="plot4"/>
         <Property label="fromSD" value="TS28"/>
         <Property label="toSD" value=" TS29"/>
      </Feature>
   </Feature>
</SurveyHeader>
```

This shows the intended alteration for four plots in a LandXML file submitted for allocation that will also transfer these new lots from their parent lot survey district (TS28) to the neighboring TS29 district. The boundaries of these four lots adjacent to balance or final lots still in TS28 will define the new survey district boundary. For other submission types, the name of the lots must conform to lot name standards.

5.14 Elevations

Elevation lists or tables are often used to provide a single source for elevations used by a survey or spatial data set. This is more efficient than including elevations values in every single point, especially where proper 3D geometries are right angle extensions to a 2D geometry (right-volume or extruded are two terms for this shape). In SGLX, elevation lists have a single standard `Feature/Property` construct and can be used in multiple contexts. For instance, a set of elevations for a land survey and a separate set of elevations for a building.

The structure of the `Elevations` construct is as shown below. Elevations are identified by unique strings; they need not be sequentially numbered, nor in a specific order. Elevation values are to be in metres from Singapore Height Datum (SHD) datum. Note that these level elevations may be calculated, as inaccessible boundaries within physical structures. For instance, an elevation halfway between the apparent floor of an upper strata lot and the apparent ceiling of the lower strata lot.

```
<SurveyHeader>
   ...
   <Feature name="Elevations">
      <Property label="level 1" value="9.5"/>
      <Property label="level 2" value="13.5"/>
      <Property label="level 3" value="17.34"/>
      <Property label="level 3 false ceiling" value="19.0"/>
      <Property label="level 4" value="19.34"/>
   </Feature>
</SurveyHeader>
```

For elevations referenced by land surveys, including airspace and subterranean lots, the construct is placed as a child of the `SurveyHeader`, as only one set of level elevations would be necessary in a single survey. Elevations used for defining strata objects, discussed later in this document, will typically require an elevations structure as a child of the Building (a parcel type). Therefore, when multiple buildings are submitted, each building would have its own elevation list.

References to elevations are fundamental to many cadastral features, and the context of the referenced must be correct. Ensure that you scope the reference to the correct elevations list.

Upper and lower elevations are a property of many cadastral objects. Therefore, a construct that contains a pair of elevation references is quite useful, and is shown below. For a `Parcel` element, the `parcelFormat` attribute must be set to indicate the lot is defined as a right-volume (`Parcel@parcelFormat=”extruded”`).

```
<Feature name="ElevRefPair">
   <Property label="lower" value="level 3"/>
   <Property label="upper" value="level 3 false ceiling"/>
</Feature>
```

6 Strata Plan Structures

This section discusses the use of LandXML elements to encode strata title plans, buildings, strata and accessory lots, building outlines, level outlines, typical stories, supporting parcel types, and occupations.

The goal is to create a complete strata data transfer format model which supports efficient encoding of potentially extensive and complex, yet repetitive data. Support for typical storeys allows a single set of objects to represent multiple storeys or levels within the building. Software developed to load data from the XML can instantiate the models or parts of the models as necessary. For instance, if there are 20 storeys derived from a single typical storey, and there is a need to analyse the strata lots for encroachment, then analysis need only be done on the typical storey virtual parcels. So abstraction is more than a data transfer efficiency.

Strata properties and objects:

1. STP metadata.
2. CPST metadata.
3. Buildings.
4. Levels and level outlines.
5. Typical Storey[1].
6. Virtual Parcels.
7. Strata lots.
8. Accessory lots.
9. Common Properties.
10. Voids.
11. Occupations.
12. Provisional strata lots.

Many strata entities are represented by the `Parcel` element. They are associated a specific building and level using the `buildingNo` and `buildingLevelNo` `Parcel` attributes.

6.1 STP Properties

The Strata Title Plan (STP) is required when there are three or more strata lots involved in a new development, or if the existing strata lot has an STP number assigned. The STP number identifies the submissions as part of a strata project. It is encoded in a `Feature` construct under the `SurveyHeader`. The `LandLotNumber` value in the construct lists all land lots used in the Strata Development.

[1] *CS Directive v4.0* uses the term storey where LandXML uses the term level. At times, we adhered to the LandXML term “level”, but more often employ “storey” in descriptions and names. They both mean the same thing.

```
<SurveyHeader>
   ...
   <Feature name="STP">
      <Property label="STPNumber" value="STP1234"/>
      <Property label="LandLotNumber"
                value="MK18-40000A, MK18-40001B,MK18-40002C"/>
   </Feature>
</SurveyHeader>
```

6.2 CPST Properties

At the allocation of Strata lot numbers, it is possible that SLA may not require the surveyor to submit the geometry of planned strata lots. Instead, the surveyor must include the following: the number of strata lot numbers, the number of accessory lot numbers and the number of strata provisional lot numbers. This data is encoded in a separate feature under the `SurveyHeader` as shown below.

The CPST feature is required for all strata surveys to indicate the strata allocation lot count and the land lots used.

```
<SurveyHeader>
   ...
   <Feature name="CPST">
      <Property label="LandLotNumber" value="MK18-40000A"></Property>
      <Property label="StrataLotCount" value="256"></Property>
      <Property label="AccessLotCount" value="120"></Property>
      <Property label="ProvisionalLotCount" value="10"></Property>
   </Feature>
</SurveyHeader>
```

6.3 Use of Parcel Element

The LandXML parcel element is heavily used for modelling strata objects. Firstly, most strata object are geometric polygons. LandXML parcels also have one of the more complete attribution sets of all LandXML elements. Strata parcel types are configured with extensions to the jurisdictional enumerations for parcel attributes.

The `Parcel` element has several attributes and child elements of use in many of the strata plan objects:

1. `name` – depends on role
2. `area` – stated area to 1 square meter, required depending on role
3. `volume` – stated volume, required depending on role
4. `parcelType` – depends on role
5. `class`- depends on role
6. `parcelFormat` = ”extruded”, building is “standard”
7. `buildingNo` = building number
8. `buildingLevelNo` = level number
9. `CoordGeom` – various geometry allowed
10. `LocationAddress` – reduced to `flatNo` for most strata lots

6.4 The Third Dimension

In our SGLX model, strata objects are inherently three dimensional. There are two basic methods by which elevations are conveyed in the SGLX: geometric element content that includes all three components (northing easting elevation), and a data normalization approach. The normalization employs a summary, unique, list of elevations that may then be referenced. In strata, these references return the lower and upper vertical extents of right shapes, which can then be extruded from the 2D parcel geometry. In this strata section, we focus on the second method.

Any of the strata parcel type may have an `ElevRefPair` construct which holds these upper and lower elevations for the right shape (extrusion) of the parcel. This can be used to set the upper and lower elevations of any parcel, thereby overriding the elevations of the Level (see 6.5.4 for discussion.)

Regardless if the elevations references are transferred via the `ElevRefPair` of the level, or an `ElevRefPair` in the parcel itself, the `parcelFormat` should be `extruded`.

SGLX support for fully three dimensional geometry is forthcoming. However, full 3D parcels should coexist with right-volume parcels in the same SGLX submission..

6.5 Building

The building is the top object in the strata model. Yet, there is no specific element in LandXML for the representation of a building, and buildings are not containers of other objects.

Buildings are encoded as a `Parcel` element to represent all building meta-information, including a “greatest extent” (2D) outline. Any number of buildings may be in the submission.

It is probably best to think of the building and level (introduced next) as organizational notions in the SGLX. It is really the lots that are important, and in cadastre in general. Mostly, we use the building number and the level number references on the strata parcels to query, map and analyse the strata data.

6.5.1 Land Lot

A building must rest upon one or more land lots. We use a feature construct to convey the lot name, or names, of the land parcels. Multiple land lots are encoded using comma separated values.

```
<Feature name="LandLot">
   <Property label="name" value="TS30-00385M,TS30-00386X "/>
</Feature>
```

6.5.2 Address

`LocationAddress` is be used to hold the building address in Singapore, following the address scheme described elsewhere in the structural discussions. The `LocationAddress` should be held by the building parcel.

6.5.3 Elevations

Building elevations are encoded as a single `Feature` construct, subsumed within the building parcel element. The `Elevations` structure was first introduced in the discussion of airspace and subterranean surveys and lots. We use the same construction, but within the context of a specific building, as a child of the building parcel.

Specific building elevations may be referenced by other building strata objects by reference to the `Property@label`. Since these references are only to be used within the XML document, the naming convention is arbitrary, however all label values must be unique. See building encoding example.

```
<Feature name="Elevations">
   <Property label="E1" value="9.50"/>
   <Property label="E2" value="13.50"/>
   <Property label="E3" value="17.34"/>
   <Property label="E3a" value="19.00"/>
   <Property label="E4" value="19.34"/>
   <Property label="E5" value="23.24"/>
   <Property label="E6" value="27.14"/>
   <Property label="E7" value="31.04"/>
</Feature>
```

There is no expectation that the elevations listed are in any order, nor that the elevation names have any relation to each other.

6.5.4 Example

An example of a building object encoded as a parcel is shown below. The coordinate geometry is the greatest extent of the building.

```
<Parcel name="300" class="other" parcelFormat="standard" buildingNo="300"
     parcelType="building" buildingLevelNo="outline">
   <CoordGeom>
      ...
   </CoordGeom>
   <LocationAddress numberFirst="631">
      <ComplexName desc="Fawlty Towers"/>
      <RoadName roadName="ANG MO KIO AVENUE 4"/>
      <AddressPoint pntRef="" featureRef="addRef1"/>
   </LocationAddress>
   <Feature name="addRef1">
      <Property label="addressSource" value="IRAS"/>
      <Property label="buildingSource" value="URA"/>
      <Property label="postalCode" value="560631"/>
   </Feature>
   <Feature name="LandLot">
      <Property label="name" value="TS30-00385M "/>
   </Feature>
   <Feature name="Elevations">
      <Property label="E1" value="9.50"/>
      <Property label="E2" value="13.50"/>
      <Property label="E3" value="17.34"/>
      <Property label="E3a" value="19.00"/>
      <Property label="E4" value="19.34"/>
      <Property label="E5" value="23.24"/>
      <Property label="E6" value="27.14"/>
      <Property label="E7" value="31.04"/>
   </Feature>
```

```
</Parcel>
```

Note: `parcelFormat` is set as "`standard`" rather than "`extruded`" as there are no elevations set for the building itself.

Note: `buildingNo` will be used to group other LandXML elements to this building.

Note: `buildingLevelNo` is alphanumeric.

6.6 Level

Conceptually, a level is an organizational category of strata objects in a building. Yet, like the building, it is not a container of these objects, and there is no composite relationship. Rather, the level holds information and relationships that are common to the cadastral objects that are associated to the level by their own properties.

A level is encoded as a `Parcel` element; whose geometry represents the exterior extent of the level. Strata lots, accessory lots, common properties, void spaces, and void areas associate with one and only one Level by their `buildingLevelNo` attribute. The level does NOT have a `Parcels` element referencing the lots. Levels may also contain references to occupations which represent physical features.

6.6.1 Attributes

Levels and level outlines are modelled as a `Parcel` in the LandXML file.

Set:

1. `name` = ”any name” (unique building level name)
2. `parcelType` = ”level”
3. `class` = ”other”
4. `parcelFormat` = ”extruded” (has ElevRefPair)
5. `buildingNo` = building number
6. `buildingLevelNo` = level number

A level Parcel element is identified by `parcelType=”level”`. A level must be unique in the building, that is, only one level in a building may have the same `buildingLevelNo`, which must be unique within the building. However, the `buildingLevelNo` is a string value, and the levels are not required to indicate any ordering.

6.6.2 Name

Parcels may follow any naming scheme. The `buildingNo` and `buildingLevelNo` values provide a combined unique identifier for processing. Therefore, the name may be used for presentation and cartographic purposes.

6.6.3 Coordinate Geometry

Level geometry encoding is not constrained to the degree of land parcels, at least in the near future. `IrregularLine` geometry using `PntList2D` is expected to be common, but any supported `CoordGeom` is allowed.

6.6.4 Elevation References

Each level must be associated with building elevations corresponding to its lower and upper vertical extent. These are encoded as `ElevRefPair` constructs.

```
<Feature name="ElevRefPair">
   <Property label="lower" value="E3"/>
   <Property label="upper" value="E3a"/>
</Feature>
```

The elevation references have several purposes, and work in combination with elevations set at the parcel level.

For levels that have consistent lower and upper profiles, the level references are simply the lower and upper elevations of all the associated cadastral parcels on that level.

For more complex situations, some or all of the associated parcels may have their own `ElevRefPair` which then overrides the elevations indicated in the Level parcel. This is an important refinement in the strata model, allowing more adaptive modelling.

For example, some levels are not level. A section of the storey may step down a half meter, and yet maintain the upper elevation, or the opposite, or both may vary independently. Perhaps a topmost level has a consistent lower elevation, but a completely irregular upper elevation. As long as these changes occur at lot boundaries, the override functionality can model them.

Also, this functionality provides an approach for a more complex vertical hierarchy of lots within lots. For example, accessory lots or voids which do not occupy the full level height.

So, where needed, the override in affected parcels can deal with a greater variety of building designs, and still provide the simplicity of centralized elevation collections. In essence, we have the flexibility to model simple buildings simply, and then move along a gradient of more complex situations by applying lot elevations directly only where needed.

This approach is also able to integrate with parcels that are defined by more complex full 3D volume geometries.

6.6.5 Occupation References

Levels can reference occupations by two methods, by reference to the occupation name or to the occupation group.

References are established using a feature construct, where the property label is the reference type and the value is the reference value. The astute reader will realize that this can be used to reference occupations created for a specific level, or for the generalized case of the typical storey.

This example shows the feature-property used to reference occupations (not shown).

```
<Parcel name="L5" class="other" parcelFormat="standard" buildingNo="500"
        parcelType="level" buildingLevelNo="5">
   <CoordGeom>
      ...
   </CoordGeom>
   <Feature name="details">
      <Property label="group" value="UpperFloorOuterWalls"/>

      <Property label="occName" value="SouthElevatorWall"/>
```

```
        <Property label="occName" value="SouthStairwellWall"/>
    </Feature>
</Parcel>
```

6.7 Typical Storey

A typical storey represents the composition, relationships and geometry of a repeated level design. This abstraction can then be used to create a complete model of all building levels when needed, for instance certain presentations. It can also be a useful tool in analysis.

The typical storey is modelled as a parcel identified by `parcelType="typicalStorey".` There may be more than one typical storey in a building.

The typical storey itself does not represent a particular level, it is only used in the construction of actual building levels. However, the `buildingLevelNo` is used to indicate the physical building storey from which the generalized information was derived.

A Typical Storey parcel will have several child element and feature-property constructs.

1. A `Parcels` element which, via `pclRef`, represents a collection of virtual parcels.
2. A list of the levels, and their elevations, to be constructed from the typical storey.
3. A construct that provides the actual lot names and flat numbers and other information to be used in the construction of real strata lots from the typical storey.
4. A construct that references occupation details associated with the typical storey.

6.7.1 Attributes

A typical storey is modelled as a `Parcel` in the LandXML file.

Set:

1. `name` = ”any name” (unique to typical stories in file)
2. `parcelType` = ”typicalStorey”
3. `class` = ”other”
4. `parcelFormat` = ”standard” (geometry is level outline, but no elevations)
5. `buildingNo` = building number
6. `buildingLevelNo` = the building level from which the typical level was derived

6.7.2 Virtual Parcels

The typical storey parcel has a `Parcels` child element which references all related virtual parcels that define the composite geometry of the typical storey. Virtual parcels each define a particular geometry of each “template” parcel of the storey. When creating real levels from the typical storey, the virtual parcels are copied and assigned valid lot names, or parcel names for non-lots as described in following sections. Thus, the real model of the building may be “built-out” within the reading software after data transfer.

Virtual Parcels are identified by the `parcelType` of "`virtual`". The different virtual parcels within a building are identified by name convention. Name convention templates are a capitalized character followed by a monotonically increasing serial number starting with 1. In the list below, "x" is the number.

- "Ux" virtual strata lots
- "Ax" virtual accessory lots
- "Cx" virtual common properties (realised parcels will be "CAx")
- "Vx" virtual void areas (realised parcels will be "VAx")

When realised, all parcels will have their `parcelType` set to the appropriate enumeration item, and the `name` set to a true name for lots, and by some convention for non-lot parcels.

In effect, non-lot parcels would not need to be realised. Since all island-type enclosed parcels are referenced in the Parcels element of a lot, with the individual Parcels referenced by `pclRef`, there is no need for more than one copy of a non-lot parcel in a realised level. This is the discretion of any reading software.

Occupations are referenced, and can be referenced by any realised level. As with non-lot parcels, occupations could be copied to realised levels if necessary.

6.7.3 Level Values

To build-out levels from a typical storey, we need the names of the levels to create, and their elevation references. The `LevelValues` construct is used to provide this information.

```
<Feature name="LevelValues">
   <Feature name="300-L3">
      <Feature name="ElevRefPair">
         <Property label="lower" value="E3"/>
         <Property label="upper" value="E4"/>
      </Feature>
   </Feature>
   <Feature name="300-L4">
      <Feature name="ElevRefPair">
         <Property label="lower" value="E4"/>
         <Property label="upper" value="E5"/>
      </Feature>
   </Feature>
   ...
</Feature>
```

The hierarchical structure can be easily extended if additional level property information is needed.

6.7.4 Parcel Values

When we create a level from a typical storey, we need to copy virtual parcels and update their properties with specific lot data. We use a hierarchical Feature construct to encode the attributes needed to instantiate the lots. Some properties are in the virtual lot itself; geometry, area, and any other property that is common between the levels. The key properties to transfer to the created lot are the lot name and flat number. An accessory lot will also require lot names needed to establish the “appurtenant to” relationship.

This is an example of the `ParcelValues` structure for a single level.

```
<!-- Lot names and flat numbers for level 3-->
<Feature name="ParcelValues">
   <Feature name="300-L3">
      <Feature name="U1">
         <Property label="lotName" value="MK18-U300001A"/>
         <Property label="flatNo" value="301"/>
      </Feature>
      <Feature name="U2">
         <Property label="lotName" value="MK18-U300002F"/>
         <Property label="flatNo" value="302"/>
      </Feature>
      <Feature name="U3">
         <Property label="lotName" value="MK18-U300003L"/>
         <Property label="flatNo" value="303"/>
      </Feature>
      <Feature name="U4">
         <Property label="lotName" value="MK18-U300004J"/>
         <Property label="flatNo" value="304"/>
      </Feature>
      <Feature name="U5">
         <Property label="lotName" value="MK18-U300005T"/>
         <Property label="flatNo" value="305"/>
      </Feature>
      <Feature name="A1">
         <Property label="lotName" value="MK18-A3001N"/>
         <Property label="appTo" value="MK18-U300005T"/>
         <Property label="flatNo" value="S-305"/>
      </Feature>
      <Feature name="C1">
         <Property label="lotName" value="CA1"/>
      </Feature>
   </Feature>
</Feature>
```

This example holds data for five strata lots, one accessory lot, and a common property for the 300-L3 level. This hierarchical structure can be easily extended if additional properties are needed.

Note that the accessory lot is appurtenant to the strata lot created from virtual lot U5.

6.7.5 Typical Lot

Any virtual parcel can be denoted as a typical lot. A typical strata lot is used to show the general characteristics and properties of a commonly occurring strata lot within the building. There may be many virtual parcels within a building that are similar to a typical strata lot, with the exception that the geometry is transposed. For instance, there may be 10 lots of the same type along the south side of a building level, arranged from the west side to the east. This same arrangement of typical lot may be repeated on the north side of the floor, and across many floors.

The typical lot has little value in the SGLX transfer specification, but it may have value as an encapsulation of the standard properties of a type of repeated strata lot. In this sense. It is a generalisation. There may be several typical lots, and so their names should be unique. Any virtual parcel can be flagged as a typical lot by the inclusion of the following feature-property. The `Feature` name must be "`TypicalLot`", with a unique name as the property value.

```
<Feature name="TypicalLot">
   <Property label="typicalName" value="DoubleDelux"/>
</Feature>
```

6.7.6 Example of a Typical Storey

This is a truncated example of typical storey. Note the value of the parcel type, and that no `buildingLevelNo` is given.

```
<Parcel name="TypicalLowerStorey" class="other"
   parcelFormat="standard" buildingNo="300" parcelType="typicalStorey">
   <!-- Geometry of virtual level outline -->
   <CoordGeom>
      ...
   </CoordGeom>
   <Parcels ...="">
      <!-- References to virtual parcels -->
      <Parcel name="U1" pclRef="U1" />
      <Parcel name="U2" pclRef="U2" />
      <Parcel name="U3" pclRef="U3" />
      <Parcel name="U4" pclRef="U4" />
      <Parcel name="U5" pclRef="U5" />
      <Parcel name="A1" pclRef="A1" />
      <Parcel name="C1" pclRef="C1" />
   </Parcels>
   <!—Level values for levels 3 and 4-->
   Feature name="LevelValues">
     <Feature name="300-L3">
        <Feature name="ElevRefPair">
           <Property label="lower" value="E3"/>
           <Property label="upper" value="E4"/>
        </Feature>
     </Feature>
     <Feature name="300-L4">
        <Feature name="ElevRefPair">
           <Property label="lower" value="E4"/>
           <Property label="upper" value="E5"/>
        </Feature>
     </Feature>
   ...
   </Feature>
   <!-- Lot names and flat numbers for level 3-->
   <Feature name="ParcelValues">
      <Feature name="300-L3">
         <Feature name="U1">
            <Property label="lotName" value="MK18-U300001A"/>
            <Property label="flatNo" value="301"/>
         </Feature>
         <Feature name="U2">
            <Property label="lotName" value="MK18-U300002F"/>
            <Property label="flatNo" value="302"/>
         </Feature>
         <Feature name="U3">
            <Property label="lotName" value="MK18-U300003L"/>
            <Property label="flatNo" value="303"/>
         </Feature>
         <Feature name="U4">
            <Property label="lotName" value="MK18-U300004J"/>
            <Property label="flatNo" value="304"/>
         </Feature>
         <Feature name="U5">
```

```
            <Property label="lotName" value="MK18-U300005T"/>
            <Property label="flatNo" value="305"/>
         </Feature>
         <Feature name="A1">
            <Property label="lotName" value="MK18-A3001N"/>
            <Property label="appTo" value="MK18-U300005T"/>
            <Property label="flatNo" value="S-305"/>
         </Feature>
         <Feature name="C1">
            <Property label="lotName" value="CA1"/>
         </Feature>
      </Feature>
   </Feature>
```

6.8 Strata Lots

Strata lots are SLA numbered lots, so the lot name is to be encoded in the `name` attribute of the `Parcel`. Most SG specific parcel attributes defined for land lots also apply to strata lots. They should have `parcelFormat`, `parcelClass`, `parcelType` and other appropriate attributes complete.

Some attributes are specific to strata lots and other building objects. Strata lots are identified to a particular building number and level (floor) by use of standard LandXML `Parcel` attributes: `buildingNo` and `buildingLevelNo`.

6.8.1 Attributes

Strata lots are modelled as `Parcel` in the LandXML file.

Set:

7. `name` = ”MK18-U123456A” (example, see below)
8. `parcelType` = ”strata”
9. `class` = ”final” (or other stage)
10. `parcelFormat` = ”extruded”
11. `buildingNo` = building number
12. `buildingLevelNo` = the level where located

6.8.2 Name Convention

Strata lots are managed similarly to land lots, with registration and standard name convention. Just as with land lots, strata lots are a composition of the survey district and lot number. The strata lot numbers begin with the prefix ”U” followed by six digits and a check digit (that is actually an alpha). For example ”U123456X”. A full name example is ”MK18-U123456A”.

6.8.3 Area and Volume

Strata lot area and volume can be recorded directly to the `area` and `volume` attributes. These should be the values stated by the surveyor. Strata lot areas are to the nearest square meter. The area recorded in the area attribute should be the reported area for the parcel.

Total Strata Lot Area must also be recorded. This area accounts for part lot areas, void areas and common properties. This is encoded in a feature-property under the `Parcel` element for the strata lot. All strata lots must report the computed area and volume using properties in a `Feature name="Total"` construction.

In the first case, normal strata lots, only two properties are required, as shown here:

```
<Feature name="Total">
   <Property label="area" value="100"></Property>
   <Property label="volume" value="300"></Property>
</Feature>
```

In the case of part lots in the strata unit definitions, an area tabulation of all part lot areas is required. This requires three additional properties to be used in the `Feature name="Total"` construct, and a second construct `Feature@name="SubTotal"` for subtotals. The two features below should be used to encode these areas.

```
<Feature name="SubTotal">
   <Property label="strataArea" value="100"></Property>
</Feature>

<Feature name="Total">
   <Property label="floorArea" value="100"></Property>
   <Property label="voidArea" value="100"></Property>
   <Property label="strataArea" value="200"></Property>
</Feature>
```

6.8.4 Coordinate Geometry

It is assumed that the geometry will not reference stations, as in a land survey, at least in the near term. `PntList2D` geometry is expected, but any supported `CoordGeom` is allowed. `PntList2D` is the expected general case.

6.8.5 Strata Lot Addresses

Each strata lot Parcel has a reference to the building via the `buildingNo` attribute, and therefore can be linked to the building address. The unit can be identified to level using the `buildingLevelNo` attribute, but there is no LandXML attribute for a unit number as a Parcel attribute. The `flatNumber` attribute of `LocationAddress` is used for that purpose. To reduce duplication, we use a `LocationAddress` for strata lots that contains only the `flatNumber`. The full address can be created on loading the transfer file.

6.8.6 Measured Dimensions

Onsite measurement for the total length and breadth of a strata lot and the measured height from the physical floor and ceiling, instead of the boundary floor and ceiling from elevations, can be encode in a feature as shown below.

```
<Feature name="Measurements">
   <Property label="Length" value=" 30.55"></Property>
   <Property label="Breadth" value="15.20"></Property>
   <Property label="UnitHeight" value="2.85"></Property>
</Feature>
```

6.8.7 Relationships to Other Parcels

A single strata lot parcel may have complex relationships to other parcels. Given the many to many relationships between strata lots and accessory lots, the relation is encoded only in the accessory lot, not in the strata lot. See that section for more discussion and instructions.

A strata lot may enclose void areas, common properties, or even another strata lot. Spatial relationships of this kind are encoded much the same as island parcels in land parcels. The strata parcel may have a nested `Parcels` element containing one or more `Parcel` elements thus establishing the relationship. These nested `Parcel` elements do not include full attribution and geometry, but use `pclRef` to point to the full Parcel encoding at the same hierarchical level as the strata lot.

6.8.8 Example

This example of a strata lot shows the most common attributes and properties. Note that location address is compiled from the `flatNumber` and the `buildingLevelNo`; the rest of the address is linked via `buildingNo`.

```
<Parcel name="MK18-U123456A" desc="ST12345" area="314"
        class="final" parcelFormat="extruded" parcelType="strata"
        buildingNo="300" buildingLevelNo="9">
   <CoordGeom>
      ...
   </CoordGeom>
   <LocationAddress flatNumber="906"/>
   <Feature name="Measurements">
      <Property label="Length" value=" 30.55"></Property>
      <Property label="Breadth" value="15.20"></Property>
      <Property label="UnitHeight" value="2.85"></Property>
   </Feature>   </Parcel>
```

6.9 Accessory Lots

Accessory lots are lots (spatial units) contained within buildings, appurtenant to a strata lot, and are encoded as LandXML `Parcel` elements.

6.9.1 Attributes

Accessory lots are modelled as `Parcels` in the LandXML file.

Set:

1. `name` = ” MK18-A1234N”, for example (see below)
2. `parcelType` = ”accessory”
3. `class` = ”final” (or other stage)
4. `parcelFormat` = ” extruded”
5. `buildingNo` = building number
6. `buildingLevelNo` = the level where located

6.9.2 Name Convention

Accessory lots are managed similarly to land lots, with registration and standard name convention. Just as with land lots, accessory lots are a composition of the survey district and lot number. The accessory lot numbers begin with the prefix ”A” followed by four digits

and a check digit (that is actually an alpha). For example, ”A1234X”, and a full name example, ”MK18-A1234N”.

6.9.3 Area and Volume

Accessory lot area and volume can be recorded directly to the `area` and `volume` attributes. These should be the values stated by the surveyor.

6.9.4 Coordinate Geometry

It is assumed that the geometry will not reference stations, as in a land survey, at least in the near term. Point2D geometry is expected, but any supported `CoordGeom` is allowed. `PntList2D` is the expected general case.

6.9.5 Relationship to Strata Lot(s)

There is an additional aggregation relationship to one or more accessory lots. That is, a strata lot may have one or more associated accessory lots. The accessory lots are appurtenant to the strata lot, and cannot be sold, transferred or modified independently. They are most often parking or storage spaces. An accessory lot can be apportioned between strata lots. In addition, an accessory lot may have more than one associated strata lot.

A many-to-many relationship exists between strata lots and accessory lots.

This means that use of the `pclRef` attribute of the Parcel element is not sufficient for encoding this relationship. It has the type `parcelNameRef` which is to be a single parcel name reference.

We use Feature/Property encoding in all cases. To simplify, we can:

1. Encode relationship only in the accessory lot.
2. Use multiple instances of Property for each owner parcel of an accessory lot.
3. Feature@name=“AppurtenantTo”
4. Property@label=”pclRef”
5. Property@value=”the pclRef value”
6. On loading all accessory lots, the many-to-many relationships can be established in the reading software.

The feature-property structure is within the accessory lot `Parcel` element. The example shows an accessory lot owned by two strata lots.

6.9.6 Example

This example shows an accessory lot with typical values, but two strata lot references.

```
<Parcel name="TS12-A4356Y" desc="ST12345" area="8"
        class="final" parcelFormat="extruded" parcelType="accessory"
        buildingNo="300" buildingLevelNo="-3">
   <CoordGeom>
      ...
   </CoordGeom>
   <Feature name="AppurtenantTo">
      <Property label="pclRef" value="TS12-U543223F"></Property>
      <Property label="pclRef" value="TS12-U543212A"></Property>
```

```
    </Feature>
</Parcel>
```

6.10 Common Properties

Common properties are not registered or tracked by SLA as lots, yet are an important concept for building representation and are shown on plan drawings. They serve as important adjacency and continuity checks to the layouts of a building level during digital validations. Common properties are encoded as `Parcels`.

6.10.1 Attributes

Common properties are modelled as `Parcels` in the LandXML file. Common properties are not registered or tracked by SLA, so they do not need to follow the rules of registered lots.

Set:

1. `name` = ” CAxxxx” (see below)
2. `parcelType` = ”common”
3. `class` = ”reference”
4. `parcelFormat` = ”extruded”
5. `buildingNo` = building number
6. `buildingLevelNo` = the level where located

6.10.2 Name Convention

Preparation of the submission must follow a naming convention that CSMS software can use to correctly identify these areas. The convention is ”CAxxxx” where the x values are a number series assigned by the surveyor and unique to the submission file. There is no survey district part in the name. The `buildingNo`, `buildingLevelNo` are to be used to locate the common area to the correct building and floor.

6.10.3 Area and Volume

Area of common property is needed only when the common property is used for amalgamation in the Get Lot Number submission as the common property is yet to assign a lot number to it. Area can be recorded directly to the `area` attribute. It should be the value stated by the surveyor. Volume is not needed.

6.10.4 Coordinate Geometry

It is assumed that the geometry will not reference stations or `CgPoints`, as in a land survey, at least in the near term. Point2D geometry is expected, but any supported `CoordGeom` is allowed. `PntList2D` is the expected general case.

6.10.5 Example

This example of a common property parcel shows the most typical attributes and child elements.

```
<Parcel name="CA22" desc="ST12345"
        class="reference" parcelFormat="extruded" parcelType="common"
        buildingNo="300" buildingLevelNo="9">
   <CoordGeom>
```

```
      ...
    </CoordGeom>
    <LocationAddress flatNumber="P376"/>
  </Parcel>
```

6.11 Void Areas and Spaces

Voids in strata are different from the voids described in the section 5.2 discussion. Strata voids are defined areas and volumes within strata lots. Void areas and void spaces are the two types of strata voids, and they are treated differently in strata lot area calculations.

Voids are modelled as `Parcels` in the LandXML file. Void areas and spaces are not registered or tracked by SLA, and therefore have a special naming convention, with numbering at the discretion of the surveyor, as long as they are unique to the file.

6.11.1 Attributes

Voids are modelled as `Parcels` in the LandXML file. Void areas are tracked by SLA, but no lot number is assigned.

Set:

1. `name` = ” VAxx” (see below)
2. `parcelType` = ”voidArea” (or ”voidSpace”)
3. `class` = ”reference”
4. `parcelFormat` = ”extruded”
5. `buildingNo` = building number
6. `buildingLevelNo` = the level where located

6.11.2 Name Convention

A submission must follow a naming convention that CSMS software can use to correctly identify void areas. These names are not generated by SLA, nor are they registered.

The naming convention is ”VAxxxx” where the x values are a number series assigned by the surveyor and unique to the submission file. There is no survey district identifier as part of the name. The `buildingNo`, `buildingLevelNo` are to be used to locate the void area or space to the correct building and floor.

6.11.3 Coordinate Geometry

It is assumed that the geometry will not reference stations, as in a land survey, at least in the near term. Point2D geometry is expected, but any supported `CoordGeom` is allowed. `PntList2D` is the expected general case.

6.11.4 Example

This example of a void area parcel shows the most typical attributes and properties.

```
<Parcel name="VA03" desc="ST12345" area="25"
        class="reference" parcelFormat="extruded" parcelType="empty"
        buildingNo="300" buildingLevelNo="2">
  <CoordGeom>
    ...
  </CoordGeom>
```

```
</Parcel>
```

7 Enumerations

The following appendix outlines all the LandXML type definitions used by the ePlan Protocol in SG implementation. This includes the enumerated types.

7.1 Primitive Data Types

The following are primitive data type definitions. They are defined by the XML standard (see http://www.w3.org/TR/xmlschema-0/#CreatDt).

Type	Description
anySimpleType	Highest level of simple type. Can store any simple type.
anyURI	Uniform Resource Identifier
boolean	True of False
date	ISO8601 date format (e.g. YYYY-MM-DD)
double	A double precision floating point number
IDREF	A reference to the ID of another element
int	An integer
positiveInteger	A positive integer value
string	An extended sequence of characters
time	ISO8601 time format (e.g. hh:mm:ss)

7.2 LandXML Enumerated Types

The following types are defined in LandXML with an enumerated list of valid values. This list contains only the LandXML types used by SG. Items in the enumeration not used by SG are indicated with “(NA)”. This is not an alteration of the enumeration, just showing the functional subset in the CSMS system.
See LandXML1.2 schema for full list http://www.landxml.org/schema/LandXML-1.2/LandXML-1.2.xsd

The attributes are listed under the element to which they belong and are listed in the order in which the elements appear in this document.

Attribute	Type	Description	Enumerations
Metric			
directionUnit	angularType	Angular values expressed in `"decimal dd.mm.ss"` units have the numeric format e.g.	Set to `"decimal dd.mm.ss"`

Attribute	Type	Description	Enumerations
		"45.3025" representing 45 degrees 30 minutes and 25 seconds. Both the minutes and seconds must be two characters with a numeric range between 00 and 60	
areaUnit	metArea	Valid metric units of measure for area.	Set to `"squareMeter"`
linearUnit	metLinear	Valid metric units of measure for length	Set to `"meter"`
pressureUnit	metPressure	Valid metric units of measure for pressure	Set to `"milliBars"`
temperatureUnit	metTemperature	Valid metric units of measure for temperature.	Set to `"celsius"`
volumeUnit	metVolume	Valid metric units of measure for area volume.	Set to `"cubicMeter"`
Curve			
rot	clockwise	The direction of the curve either clockwise (cc) or counter clockwise (ccw)	▪ cw ▪ ccw
ReducedObservation			
purpose	purposeType	enumeration of purpose in survey Note: use “normal” for SG OBS, observation or demarcation. Values not used in SG are labelled Not Applicable (NA).	normal check backsight foresight traverse sideshot resection (NA) levelLoop (NA) digitalLevel (NA) remoteElevation(NA) recipricalObs (NA) topo (NA) cutSheets (NA)

Attribute	Type	Description	Enumerations
			asBuilt (NA)
CgPoint			
pntSurv	survPntType	The function the point serves in the survey.	traverse reference administrative control boundary monument (NA) sideshot (NA) natural boundary (NA)

7.3 ICSM Jurisdiction Based Enumerated Types

The following types are defined as types in LandXML for the purpose of being extended with jurisdictionally defined enumeration lists. Source files are available from ICSM. Types not used by SG have been removed.

Type	Description
adminDateTypeType	This is the name of the admin date type for the Survey
annotationType	An Annotation will be a specific type within a jurisdiction.
equipmentType	This gives a list of equipment used for the observation this list of equipment is used to estimate the accuracy of the observation.
jurisdictionType	This is the name of the jurisdiction in which the Survey lies (i.e. which state)
monumentState	This is a list of states for a monument each jurisdiction may have a list defined by regulation.
monumentType	This is a list of allowable monument types that can be used or identified for a survey, i.e. peg, spike, pillar etc. Local custom will define this list.
observationType	This is a list of defined observation types, different jurisdictions may have a list defined by regulation can be defined by the jurisdiction.
parcelClass	This is a list of parcel classes which may be jurisdictionally specific defined by regulation and legislation.
parcelFormat	Parcel Format describes how the parcel is described , i.e. Standard (2D), Volumetric (3D)
purpSurvType	This is a jurisdictionally based list of purposes of Survey and can be jurisdictionally specific for example Subdivision, Amalgamation (Consolidation) etc
survPntType	To define the role of the point in the survey.

7.4 SG Enumerated Types

The following types are defined as types in LandXML for the purpose of being extended with jurisdictionally defined enumeration lists. The attributes are listed under the element to which they belong and are listed in the order in which the elements appear in this document.

Coordinate System				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
datum	surveyDatumType	Datum of the survey	CASSINI SVY21	0 in CGS 1 in CGS
horizontalDatum	horizDatumType	Horizontal Datum	SVY21	
verticalDatum	vertDatumType	Vertical datum for Singapore	SHD	

CgPoint				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
desc	approvalStateType	The SLA class related to official status of the point.	allocation activation RT final dead	allocation activation Registration of Title final dead – historic.

code	methodType	A combined methods categorisation. L – land H – high water mark F – foreshore S – strata V – void A – area 01 – surveyed, and demarcated under SVY21 datum. 02 – refined, points that are refined but not surveyed and demarcated under SVY21 datum. 03 – unknown, unrefined and surveyed under Cassini datum.	L01 L02 L03 H01 H02 H03 F01 F02 F03 S01 S02 S03 V01 V02 V03 A01 A02 A03	

Monument				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
type	monumentType	This is a survey mark	CM SP NL SM MK PP OT UM TM BT	Concrete Marker Spike Nail ISN Marker Cut Mark Pipe Others Not Marked Temp mark, peg Bolt
state	monumentState	state of physical monument	unmarked found refixed new compiled	no mark P.O. marks original lost, replaced new mark placed from records

Parcel				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
parcelFormat	parcelFormat	format of geometry description	standard surface multisurface extruded volume	2D land or 2D strata surface in 3D patches in 3D 2D with lower and upper elevations 3D Volume
parcelType	parcelTypeType	parcel type	land airspace subterranean empty strata accessory stateReserve foreshore reclaimed strataProvisional surveyDistrict building level common typicalStorey virtual voidSpace voidArea	standard land lot above ground 3D below ground 3D void within building related to strata restriction abutting coast land reclaimed from sea or other water bodies proposed strata lot survey district a building a building level common use areas typical storey virtual parcel referenced by a typical storey strata void space strata void area
class	parcelClass	state or role in the survey	parent interim final reference provisional other	parent of final lots temporary lot submitted new lot lot not in lineage or physical parent, but necessary for analysis Approved provisional lot to be used for analysis. Not a lot

useOfParcel	useOfParcelType	use of the parcel.	vacant	eponymous
Feature@name = “SurveyType”	surveyTypeType		resurvey substandard modern	resurveyed substandard survey modern survey

LocationAddress				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
addressSource, buildingSource	sourceType	Source of the address and building information.	URA IRAS	Urban Redevelopment Authority Inland Revenue Authority of Singapore

SurveyHeader				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
jurisdiction	jurisdictionType	This is the name of the jurisdiction in which the Survey lies.	Singapore	eponymous

AdministrativeArea				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
adminAreaType	adminAreaTypeType	Type of Admin Area	MK TS	Mukim Township Subdivision

AdministrativeDate				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
adminDateType	adminDateTypeType	The administrative	Commenced Completed Generated Amended	date of start of survey date of end of survey date generated date of amendment

		purpose of the date		

Personnel				
Attribute	**Type**	**Description**	**Enumeration**	**Definition**
role	surveyorRoleType	Role of person	Surveyor Authorised Assistant	Surveyor Authorised Assistant

Annotation				
Attribute	**Type**	**Description**	**Enumeration**	**Definition**
type	annotationType	Notation of Annotation	RoadLabel Disclaimer PlanNote ParcelNote AbuttalLine AbuttalLot HouseNumber AmendmentNote HWNNote OccupationNote	A road label Statement Note Note Abuttal line Abuttal lot number label House number label Amendment note High water mark label Occupation label

CertificateType				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
certificateType	certificateTypeType	Type of Surveyor Certificate	CP FD CPST	Certification of Survey Documents and Plans Certification of Field Book Certification of Strata Certified Plan (other than for subdivided

			STP CS	building) Certification of Strata Title Plan Certification of Chief Surveyor

DocFileRef				
Attribute	**Type**	**Description**	**Enumerations**	**Definition**
fileType	fileTypeType	This is for stating the type of file attached as supporting document.	ReferencePlan	Reference plan

PurposeOfSurvey				
Attribute	**Type**	**Description**	**Enumeration**	**Definition**
name	purpSurvType	See Appendix B	See Appendix B	See Appendix B

Occupations and Encroachments				
Attribute	**Type**	**Description**	**Items**	**Definition**
code	occCodeType	This is a jurisdictional list of the classes of occupations.	party-wall	A polygon representing a wall between parcels shared and spanning the boundary.
			outer-wall	A line defining the outer extent of a wall.
			inner-wall	A line defining the inner extent of a wall.
			fence	A line representing a fence.
			inner-drain	A line representing an edge of a concrete drain nearest the parcel boundary.
			outer-drain	A line representing an edge of a concrete drain away from the parcel boundary.
			eave	A line or polygon representing an eave.
			kerb	A line representing the edge of a road kerb.
			building	A line or polygon representing a building outline.
			flower-box	A line or polygon representing a flower box.
			footpath	A line representing an edge of footpath or walkway
			column	A polygon representing a column.
			other	A line, polygon or point representing a detail not in the enumeration above.
geometry	geomType	SG jurisdiction list of the geometry classes used to define occupations and encroachments.	polygon	A closed non intersecting series of lines. Curve segments are allowed.
			line	CoordGeom representing a single segment or multiple segments. Curve segments are allowed.
			point	Location defined by northing and easting, and optionally elevation.

8 Appendix A – Non-CSMS Ancillary Files

In the pre-CSMS system, there are many data files that are part of a normal submission. Most of these are small files, which contain only a few records each of specific administrative information. There are also Sketches (SK), Field Details (FD) and plans, all of which are submitted as scanned images. The long term goal is to move the information contained in these various files into the SG LandXML to facilitate a better automation of the cadastral transaction processes. Some of this data will be readily amendable to inclusion in the XML, other bits, not so easily.

In particular, the Sketches, Field Details and Plans record information in drawings which can be difficult to transition to digital data records. Most jurisdictions have taken several years in the move from paper (and scanned images are just paper in this context) to all digital cadastre. In many cadastres, document images are still a part of the submission, even when it duplicates data submitted as digital records.

It is our plan to merge these disparate data files into the SG LandXML as deemed appropriate and tractable. This will follow the first LandXML modelling for the survey data. In addition to the modelling of the data in LandXML, the effects on existing systems, not planned to be a part of the new CSMS will need to be considered. Perhaps the administrative data can be channeled through the new portal being constructed, to the necessary systems. The notion of consolidating Sketches, Field Details and Plans requires a more involved analysis. This would present difficulties in that it would change the surveying practices as well as make further demands on the software used for submission of jobs. It would also alter the legal definition of documents.

Several submission files are digital scans of legal documents, so it is likely that some digital images will be a part of the submission into the future. These could, however be referenced by name in the SG LandXML to create a fully automated submission. Such an approach that considers a packet submission approach has been used elsewhere.

Therefore, no expectation of the complete digital data submission in SG LandXML is presently tenable. Additional analysis and planning will be forthcoming, and this document maintains its focus on the survey data in existing data files. We should consider the SG LandXML to be developed in three phases:

1. The currently planned inclusion of survey data from JOB/SVY files, and the extension to cover 3D survey data for airspace, subterranean and strata plans.
2. The assimilation of administrative and sundry data in other submission files.
3. The transformation of image files containing sketches, drawings and legal communications. Some of which will likely remain in image format.

8.1 Permits Permission and Addresses

The project must coordinate requests and communications with other government agencies, for permits permissions and other planning activities.

These files include:

1. IRAS_House No.pdf – House addresses and diagram from the Inland Revenue Authority of Singapore. Addresses are covered in SG LandXML, and present in SVY.
2. Grant of Written Permission.pdf – planning approval.

In some cases, these documents contain information found in the SG LandXML. However, there may be a need to have the original documents presented along with the job.

8.2 Files Produced During Submission Processing

Several files, usually Microsoft Excel files, are generated by SLA after the surveyor has completed forms in the submission process. The current agreed position is that any such information should be stored in SLA databases, and not included in the submitted SG LandXML through any editing process. That is, the SG LandXML file submitted by the surveyor should be 'read only'.

These files include:

1. CALCULATION_OF_SURVEY_FEES.XLS - This is entitled *Calculation of Survey Fees Payable to Chief Surveyor.* It contains fees by lot.
2. COMPARISON_OF_AREAS.XLS – a spread sheet comparing parent and child areas
3. ES_SUBMISSION.XML – a record of the submission including reference to all files.
4. PROJECT-PROFILE.XML Project and Member profiles for the project/job.
5. ES(job number).log – record of submission success or failure.
6. SUBMISSION.XML - similar to ES_SUBMISSION.XML , but different element names. References generated by a different system.
7. AUTHORISATION_FOR_DEDUCTION_OF_SURVEY_FEES.doc – A form that authorizes SLA to deduct the survey fees from the surveyor's GIRO account.
8. SURVEY_REPORT.DOC - A summary report for the survey job done.
9. CERTIFICATE_IN_RELATION_TO_ENCROACHMENT.DOC - A document form to declare if any encroachment found has been resolved.

These files contain information found in SG LandXML and can be used for calculation of survey fees and generation of summary report. A declaration form can be submitted and stored directly to database through the RS portal. Some of these file that are system generated would not be needed in the new system.

8.3 Surveyor Prepared Files

Many submission files are a direct result to the survey efforts in the field and office. These include the survey data in various forms.

These files are"

1. JOB – contains field and equipment data already covered by SG LandXML sections.
2. SVY – contains adjusted survey data already covered by SG LandXML sections.
3. CP*.dwf – certified plan drawings in Autodesk Design Web Format.
4. SK*.tiff – sketches (drawings) scanned into raster image files (Tagged Information File Format).
5. PDF – contains scanned sketches (drawings) and physical documents.

8.4 Sketches

There are different sketches required for different type of submissions.

These sketches are required for CP:

1. Traverse Sketch
2. Demarcation Sketch
3. Details Sketch
4. Party-wall Sketch

These sketches are required for CPST:

1. Site Plan
2. Elevation Sketch
3. Storey Plan

The above listed sketches will no longer be needed when the information is stored in the SG LandXML.

9 Appendix B – PurposeOfSurvey Enumeration Encoding

The purpSurvType code is a concatenation of three separate codes. Each enumeration item is a specific meaningful permutation (order matters) of the three codes, and not all permutations are allowed. The format is a two-letter code followed by two three-letter codes. The first code relates to the process, of "phase" of the project that requires approval, and therefore a specific submission. The second code relates to the general lot or land type. This is not the parcelType, but it is close. The third is the "survey" type, which categorizes a survey approach for specific purposes.

Purpose of Survey *Compilation and Description of* ***purpSurvType***				
purpSurvType	Codes	Process	Lot Type	Job Type
LNLNDLAM	LN,LND,LAM	Get Lot Number	Land Lot	Land Allocation for Ministries
LNLNDONR	LN,LND,ONR	Get Lot Number	Land Lot	Owner's requests
LNLNDBUS	LN,LND,BUS	Get Lot Number	Land Lot	Blocking up survey
LNLNDVFS	LN,LND,VFS	Get Lot Number	Land Lot	Verification survey
LNLNDALN	LN,LND,ALN	Get Lot Number	Land Lot	Alienation
LNLNDAPP	LN,LND,APP	Get Lot Number	Land Lot	Approved plan
LNLNDAOB	LN,LND,AOB	Get Lot Number	Land Lot	Alteration of MK/TS Boundary
LNLNDPOL	LN,LND,POL	Get Lot Number	Land Lot	Proclamation of Land
LNLNDRDC	LN,LND,RDC	Get Lot Number	Land Lot	Road Declaration
LNLNDAQN	LN,LND,AQN	Get Lot Number	Land Lot	Acquisition
LNLNDRLM	LN,LND,RLM	Get Lot Number	Land Lot	Return of Land from Ministries
SNPTERSD	SN,PTE,RSD	Get Lot Number	Strata Private	Residential Development
SNPTEIDS	SN,PTE,IDS	Get Lot Number	Strata Private	Industrial
SNPTEMDM	SN,PTE,MDM	Get Lot Number	Strata Private	Mixed Development
SNPTECMC	SN,PTE,CMC	Get Lot Number	Strata Private	Commercial
SNPTECHS	SN,PTE,CHS	Get Lot Number	Strata Private	Cluster Housing
SNPTESTL	SN,PTE,STL	Get Lot Number	Strata Private	Strata Lease
SNPTESDV	SN,PTE,SDV	Get Lot Number	Strata Private	Subdivision existing strata lots
SNPTEAML	SN,PTE,AML	Get Lot Number	Strata Private	Amalgamation existing strata lots
SNPTERSV	SN,PTE,RSV	Get Lot Number	Strata Private	Resurvey existing strata lots
SNPTEPDV	SN,PTE,PDV	Get Lot Number	Strata Private	Phase Development
SNHDBNHD	SN,HDB,NHD	Get Lot Number	Strata HDB	HDB Development
SNHDBRSV	SN,HDB,RSV	Get Lot Number	Strata HDB	Resurvey of HDB strata lots
SNHDBRCA	SN,HDB,RCA	Get Lot Number	Strata HDB	Recess area
SNHDBAML	SN,HDB,AML	Get Lot Number	Strata HDB	Amalgamation of Adjoining lots
SNHDBSAI	SN,HDB,SAI	Get Lot Number	Strata HDB	Space Adding Item
SNHDBHUD	SN,HDB,HUD	Get Lot Number	Strata HDB	Privatization of HUDC
SNHDBSDV	SN,HDB,SDV	Get Lot Number	Strata HDB	Subdivision of existing HDB block
ACLNDLAM	AC,LND,LAM	Activation	Land Lot	Land Allocation for Ministries
ACLNDONR	AC,LND,ONR	Activation	Land Lot	Owner's requests
ACLNDBUS	AC,LND,BUS	Activation	Land Lot	Blocking up survey

ACLNDVFS	AC,LND,VFS	Activation	Land Lot	Verification survey
ACLNDALN	AC,LND,ALN	Activation	Land Lot	Alienation
ACLNDAPP	AC,LND,APP	Activation	Land Lot	Approved plan
ACLNDAOB	AC,LND,AOB	Activation	Land Lot	Alteration of MK/TS Boundary
ACLNDPOL	AC,LND,POL	Activation	Land Lot	Proclamation of Land
ACLNDRDC	AC,LND,RDC	Activation	Land Lot	Road Declaration
ACLNDAQN	AC,LND,AQN	Activation	Land Lot	Acquisition
ACLNDRLM	AC,LND,RLM	Activation	Land Lot	Return of Land from Ministries
SAPTERSD	SA,PTE,RSD	Activation	Strata Private	Residential Development
SAPTEIDS	SA,PTE,IDS	Activation	Strata Private	Industrial
SAPTEMDM	SA,PTE,MDM	Activation	Strata Private	Mixed Development
SAPTECMC	SA,PTE,CMC	Activation	Strata Private	Commercial
SAPTECHS	SA,PTE,CHS	Activation	Strata Private	Cluster Housing
SAPTESTL	SA,PTE,STL	Activation	Strata Private	Strata Lease
SAPTESDV	SA,PTE,SDV	Activation	Strata Private	Subdivision existing strata lots
SAPTEAML	SA,PTE,AML	Activation	Strata Private	Amalgamation existing strata lots
SAPTERSV	SA,PTE,RSV	Activation	Strata Private	Resurvey existing strata lots
SAPTEPDV	SA,PTE,PDV	Activation	Strata Private	Phase Development
SAHDBNHD	SA,HDB,NHD	Activation	Strata HDB	New HDB Development
SAHDBRSV	SA,HDB,RSV	Activation	Strata HDB	Resurvey of HDB strata lots
SAHDBRCA	SA,HDB,RCA	Activation	Strata HDB	Recess area
SAHDBAML	SA,HDB,AML	Activation	Strata HDB	Amalgamation of Adjoining lots
SAHDBSAI	SA,HDB,SAI	Activation	Strata HDB	Space Adding Item
SAHDBHUD	SA,HDB,HUD	Activation	Strata HDB	Privatization of HUDC
SAHDBSDV	SA,HDB,SDV	Activation	Strata HDB	Subdivision of existing HDB block
RTLNDPOL	RT,LND,POL	Registration of Tile Plan	Land Lot	Proclamation of Land
RTLNDALN	RT,LND,ALN	Registration of Tile Plan	Land Lot	Alienation
CPLNDLAM	CP,LND,LAM	Certified Plan	Land Lot	Land Allocation for Ministries
CPLNDONR	CP,LND,ONR	Certified Plan	Land Lot	Owner's requests
CPLNDBUS	CP,LND,BUS	Certified Plan	Land Lot	Blocking up survey
CPLNDVFS	CP,LND,VFS	Certified Plan	Land Lot	Verification survey
CPLNDALN	CP,LND,ALN	Certified Plan	Land Lot	Alienation
CPLNDAPP	CP,LND,APP	Certified Plan	Land Lot	Approved plan
CPLNDAOB	CP,LND,AOB	Certified Plan	Land Lot	Alteration of MK/TS Boundary
CPLNDPOL	CP,LND,POL	Certified Plan	Land Lot	Proclamation of Land
CPLNDRDC	CP,LND,RDC	Certified Plan	Land Lot	Road Declaration
CPLNDAQN	CP,LND,AQN	Certified Plan	Land Lot	Acquisition
CPLNDRLM	CP,LND,RLM	Certified Plan	Land Lot	Return of Land from Ministries
STPTERSD	ST,PTE,RSD	Strata Certified Plan	Strata Private	Residential Development
STPTEIDS	ST,PTE,IDS	Strata Certified Plan	Strata Private	Industrial
STPTEMDM	ST,PTE,MDM	Strata Certified Plan	Strata Private	Mixed Development
STPTECMC	ST,PTE,CMC	Strata Certified Plan	Strata Private	Commercial

STPTECHS	ST,PTE,CHS	Strata Certified Plan	Strata Private	Cluster Housing
STPTESTL	ST,PTE,STL	Strata Certified Plan	Strata Private	Strata Lease
STPTESDV	ST,PTE,SDV	Strata Certified Plan	Strata Private	Subdivision existing strata lots
STPTEAML	ST,PTE,AML	Strata Certified Plan	Strata Private	Amalgamation existing strata lots
STPTERSV	ST,PTE,RSV	Strata Certified Plan	Strata Private	Resurvey existing strata lots
STPTEPDV	ST,PTE,PDV	Strata Certified Plan	Strata Private	Phase Development
STHDBNHD	ST,HDB,NHD	Strata Certified Plan	Strata HDB	New HDB Development
STHDBRSV	ST,HDB,RSV	Strata Certified Plan	Strata HDB	Resurvey of HDB strata lots
STHDBRCA	ST,HDB,RCA	Strata Certified Plan	Strata HDB	Recess area
STHDBAML	ST,HDB,AML	Strata Certified Plan	Strata HDB	Amalgamation of Adjoining lots
STHDBSAI	ST,HDB,SAI	Strata Certified Plan	Strata HDB	Space Adding Item
STHDBHUD	ST,HDB,HUD	Strata Certified Plan	Strata HDB	Privatization of HUDC
STHDBSDV	ST,HDB,SDV	Strata Certified Plan	Strata HDB	Subdivision of existing HDB block
LCPTEMDM	LC,PTE,MDM	Strata Certified Plan (LCP)	Strata Private	Subdivision of existing HDB block
RFLNDFDM	RF,LND,FDM	Refinement	Land Lot	Refinement of Land lot found marks.
GSCPSHCP	GS,CPS,HCP	GNSS Observations	Control Point	Horizontal Control Point
GSCPSVCP	GS,CPS,VCP	GNSS Observations	Control Point	Vertical Control Point

Contributing Aspect Encoding *purpSurvType*	
Code	Description
LN	Get Lot Number (Land)
SN	Get Lot Number (Strata)
AC	Activation of Caveat Lot Numbers (Land)
SA	Activation of Caveat Lot Numbers (Strata)
RT	Registrar of Title Plan
CP	Certified Plan
ST	Strata Certified Plan
LC	Strata Certified Plan (LCP)
RF	Refinement
LND	Land
PTE	Private Strata
HDB	HDB Strata
LAM	Land Allocation for Ministries
ONR	Owner's requests
BUS	Blocking up survey
VFS	Verification survey
ALN	Alienation
APP	Approved plan
AOB	Alteration of MK/TS Boundary
POL	Proclamation of Land
RDC	Road Declaration
AQN	Acquisition
RLM	Return of Land from Ministries
NHD	New HDB Development
RCA	Recess area
SAI	Space Adding Item
HUD	Privatization of HUDC
RSD	Residential Development
IDS	Industrial
MDM	Mixed Development
CMC	Commercial
CHS	Cluster Housing
STL	Strata Lease
SDV	Subdivision existing strata lots
AML	Amalgamation existing strata lots
RSV	Resurvey existing strata lots
PDV	Phase Development
CPS	Control Point Submission
HCP	Horizontal Control Point
VCP	Vertical Control Point
FDM	Found Marks

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