

Cumulative LandXML-1.2 changes since LandXML-1.0

Document date: July 29, 2008
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Proposed LandXML-1.2 changes

The intent for this revision of the LandXML schema is to make corrections and add support for additional data based on real world data exchange by over 50 LandXML supported applications. There will not be any drastic model changes that will cause significant work to update the existing applications. In most cases existing LandXML applications can support LandXML-1.2 by simply changing the LandXML header to reflect the new schema version.

Scope of Proposed Changes for version 1.2

1. Survey data additions.
2. Storm water pipe and structure changes.
3. Enumerations sorting.

Application Implementation Notes

Even though there have been significant additions to the LandXML-1.2 schema, instance data built from previous drafts of LandXML-1.0 and LandXML-1.1 will still validate. Existing LandXML applications can support LandXML-1.2 by simply changing the LandXML header to reflect the new schema version.

LandXML-1.2 <LandXML> header element example:

```
<LandXML xmlns="http://www.landxml.org/schema/LandXML-1.2" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.landxml.org/schema/LandXML-1.2 http://www.landxml.org/schema/LandXML-1.2/LandXML-1.2.xsd" version="1.2" date="2002-07-25" time="10:48:45" readOnly="false" language="English">
```

The Following LandXML schema change notes have been categorized and appear in chronologic order.

LandXML-1.2.xsd Schema Changes since LandXML-1.1.xsd (working draft date July 29, 2008)

Summary of Changes

Minor changes and additions required to provide a smoother workflow for official online cadastral survey submission.

1. Added attributes to <ReducedObservation> for horizontal angle measurements.
2. Changed <Survey>.headOfPower attribute to <Survey>.<HeadOfPower> element allowing for multiple head of power records.

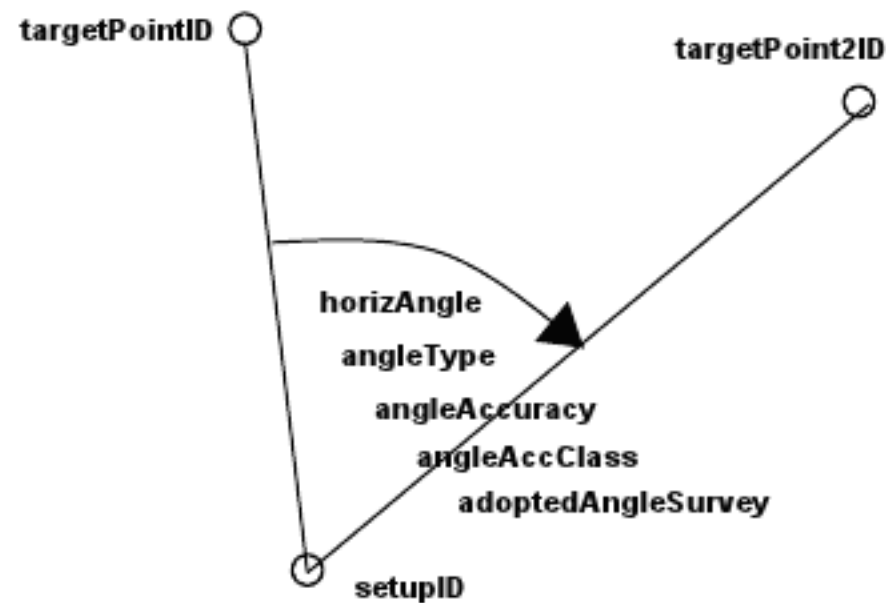
Schema Change Details

Added attributes to <ReducedObservation> for horizontal angle measurements

The current ReducedObservation element contains the horizAngle element but does not have the same metadata elements as does the distance and measurement attributes.

A solution could be to use the metadata elements for azimuth in Reduced Observation and the TargetPoint Element for the from station. This is not optimal because the rest of the setup points refer to Instrument points (as consistent with the rest of the model).

The possible optimum solution would be to change the schema to be consistent for angles and include elements as shown. This would be more logical and provide a more elegant solution.



CSD Element	LandXML1.1 (ReducedObservation)	Proposed Solution
Recordid	Name	Name
locangno		
Locpntno	setupID	Setupid
Locfromlinno	TargetPoint (Element)	targetPointID
Loctolinno	targetSetupID	targetPoint2ID (New)
Angval	horizAngle	horizAngle
Angacc	azimuthAccuracy	angleAccuracy (New)
angderiv	azimuthType	angleType (New)
	adoptedAzimuthSurvey	adoptedAngleSurvey (New)
	azimuthAccClass	angleAccClass (New)

The proposed additions for the ReducedObservation Element would be :

```
<xs:element name="ReducedObservation">
  <xs:annotation>
    <xs:documentation>This has been modified to include new fields such as accuracy, date,
class and adoption. I've added in bearing (azimuth is in terms of true north whereas bearing is the
projection north) </xs:documentation>
    <xs:documentation> - maybe this doesn't matter, may need to discuss</
xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="TargetPoint" minOccurs="0"/>
      <xs:element ref="OffsetVals" minOccurs="0"/>
      <xs:choice minOccurs="0" maxOccurs="unbounded">
        <xs:element ref="FieldNote" minOccurs="0"
maxOccurs="unbounded"/>
        <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
      </xs:choice>
    </xs:sequence>
    <xs:attribute name="purpose" type="purposeType"/>
    <xs:attribute name="setupID" type="xs:IDREF"/>
    <xs:attribute name="targetSetupID" type="xs:IDREF"/>
    <xs:attribute name="targetSetup2ID" type="xs:IDREF"/>
    <xs:attribute name="setID"/>
    <xs:attribute name="targetHeight" type="xs:double"/>
    <xs:attribute name="azimuth" type="direction" use="optional"/>
    <xs:attribute name="horizDistance" type="xs:double" use="optional"/>
    <xs:attribute name="vertDistance" type="xs:double" use="optional"/>
    <xs:attribute name="horizAngle" type="angle" use="optional"/>
    <xs:attribute name="slopeDistance" type="xs:double" use="optional"/>
    <xs:attribute name="zenithAngle" type="zenithAngle" use="optional"/>
    <xs:attribute name="equipmentUsed" type="equipmentType"/>
    <xs:attribute name="azimuthAccuracy" type="xs:double"/>
    <xs:attribute name="distanceAccuracy" type="xs:double"/>
    <xs:attribute name="angleAccuracy" type="xs:double"/>
    <xs:attribute name="date" type="xs:date"/>
    <xs:attribute name="distanceType" type="observationType"/>
    <xs:attribute name="azimuthType" type="observationType"/>
    <xs:attribute name="angleType" type="observationType"/>
    <xs:attribute name="adoptedAzimuthSurvey" type="xs:string"/>
    <xs:attribute name="adoptedDistanceSurvey" type="xs:string"/>
    <xs:attribute name="adoptedAngleSurvey" type="xs:string"/>
    <xs:attribute name="distanceAccClass" type="xs:string"/>
    <xs:attribute name="azimuthAccClass" type="xs:string"/>
    <xs:attribute name="angleAccClass" type="xs:string"/>
  </xs:complexType>
</xs:element>
```



```

<xs:attribute name="azimuthAdoptionFactor" type="xs:double"/>
<xs:attribute name="distanceAdoptionFactor" type="xs:double"/>
<xs:attribute name="coordGeomRefs" type="coordGeomNameRefs"/>
<xs:attribute name="name" type="xs:string"/>
<xs:attribute name="desc" type="xs:string"/>
<xs:attribute name="state" type="stateType"/>
<xs:attribute name="oid" type="xs:string"/>
<xs:attribute name="MSLDistance" type="xs:string"/>
<xs:attribute name="spherDistance" type="xs:string"/>
<!-- coordGeomRefs identifies one or more 'name' values that link to specific
<Line>, <Curve>, <Spiral> or <IrregularLine> in a <CoordGeom> element. This allows linking an
survey observation to specific <Parcel>.<CoordGeom> based geometry. -->
</xs:complexType>
</xs:element>

```

The New elements are shown Highlighted.

Sample Record

A sample record for a measured angle could be

```

< ReducedObservation horizAngle="90.0000" purpose="normal"
setupID="IS-27-SP215054" equipmentUsed="Theodolite EDM"
angleType="Measured" targetSetupID="IS-26-SP215054" targetSetup2ID
="IS-28-SP215054" coordGeomRefs="CG-22-SP215054" name="17"
angleAccuracy="0.0015">

```

Or A sample record for a compiled angle could be

```

< ReducedObservation horizAngle="90.0000" purpose="normal"
setupID="IS-27-SP215054" equipmentUsed="Theodolite EDM"
angleType="Adopted" adoptedAngleSurvey="SP12345" targetSetupID="IS-
26-SP215054" targetSetup2ID="IS-28-SP215054" coordGeomRefs="CG-22-
SP215054" name="17" angleAccuracy="0.0015">

```


Changed <Survey>.headOfPower attribute to <Survey>.<HeadOfPower> element allowing for multiple head of power records

The Head of Power in the original ePlan UML model had a 0..∞ relationship which would have dictated that it became an element rather than an attribute. Also the head of Power is a jurisdictionally defined pick list so will need to be implemented as a type.

```
<!--SurveyHeader Element-->
<xs:element name="SurveyHeader">
  <xs:annotation>
    <xs:documentation>We seemed to have doubled up on the survey purpose here, but the
two are quite different - maybe need a different name</xs:documentation>
  </xs:annotation>
  <xs:complexType mixed="true">
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element ref="Annotation" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="AdministrativeArea" minOccurs="0" maxOccurs="unbounded"/>
    >
      <xs:element ref="AdministrativeDate" minOccurs="0" maxOccurs="unbounded"/>
    >
      <xs:element ref="CoordinateSystem" minOccurs="0"/>
      <xs:element ref="Units" minOccurs="0"/>
      <xs:element ref="MapPoint" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Personnel" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="FieldNote" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="SurveyorCertificate" minOccurs="0" maxOccurs="unbounded"/>
    >
      <xs:element ref="PurposeOfSurvey" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="HeadOfPower" minOccurs="0" maxOccurs="unbounded"/>
    </xs:choice>
    <xs:attribute name="name" type="xs:string" use="required"/>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="purpose" type="purposeType"/>
    <xs:attribute name="startTime" type="xs:dateTime"/>
    <xs:attribute name="endTime" type="xs:dateTime"/>
    <xs:attribute name="surveyor" type="xs:string"/>
    <xs:attribute name="surveyorFirm" type="xs:string"/>
    <xs:attribute name="surveyorReference" type="xs:string"/>
    <xs:attribute name="surveyorRegistration" type="xs:string"/>
    <xs:attribute name="surveyPurpose" type="xs:string"/>
    <xs:attribute name="type" type="surveyType"/>
    <xs:attribute name="class" type="xs:string"/>
  </xs:complexType>
</xs:element>
```

```

    <xs:attribute name="county" type="xs:string"/>
    <xs:attribute name="applyAtmosphericCorrection" type="xs:boolean"/>
    <xs:attribute name="pressure" type="xs:double"/>
    <xs:attribute name="temperature" type="xs:double"/>
    <xs:attribute name="applySeaLevelCorrection" type="xs:boolean"/>
    <xs:attribute name="scaleFactor" type="xs:double"/>
    <xs:attribute name="seaLevelCorrectionFactor" type="xs:double"/>
    <xs:attribute name="combinedFactor" type="xs:double"/>
    <xs:attribute name="jurisdiction" type="jurisdictionType"/>
    <xs:attribute name="submissionDate" type="xs:date"/>
    <xs:attribute name="documentStatus" type="documentStatusType"/>
    <xs:attribute name="surveyFormat" type="surveyFormatType"/>
    <xs:attribute name="surveyStatus" type="surveyStatusType"/>
    <xs:attribute name="communityTitleSchemeNo" type="xs:int"/>
    <xs:attribute name="communityTitleSchemeName" type="xs:string"/>
    <xs:attribute name="fieldNoteFlag" type="xs:boolean"/>
    <xs:attribute name="fieldNoteReference" type="xs:string"/>
    <xs:attribute name="fieldReport" type="xs:string"/>
  </xs:complexType>
</xs:element>

<!--Head Of Power Element-->
<xs:element name="HeadOfPower">
  <xs:complexType>
    <xs:attribute name="name" type="headOfPowerType" use="required"/>
  </xs:complexType>
</xs:element>

```

Sample

```

    <SurveyHeader name="SP208311" surveyFormat="Standard" surveyPurpose="Subdivision"
desc="Plan of Lot 636 Cancelling Lot 636 on SP158026 [and part of USL being Closed Road]"
type="compiled" surveyStatus="Survey Records Only" fieldNoteFlag="false" submissionDate="2008-05-
29" documentStatus="Captured">
        <CoordinateSystem horizontalDatum="Local" verticalDatum="Arbitrary"/>
        <Personnel name="Twine Surveys Pty Ltd(ACN 109 476 422)" role="Signatory"
regType="Cadastral Surveyor" regNumber="2281"/>
        <Personnel name="Ivan Mervyn Luscombe" role="Surveyed By" regType="Cadastral
Surveyor" regNumber="697"/>
        <SurveyorCertificate name="Form18V2" certificateType="Form18V2"
textCertificate="Twine Surveys Pty Ltd (ACN 109 476 422) hereby certify thatthe corporation, by Ivan
Mervyn Luscombe, cadastral surveyor, for whose work the corporation accepts responsibility, has made this
plan pursuant to the Survey and Mapping Infrastructure Act 2003 and Surveyors Act 2003 and associated
Regulations and Standards and that the plan is accurate, and compiled from&#xD;SP156026,CWL3425 in
the Department of Natural Resources and Mines."/>
        <AdministrativeArea adminAreaType="Local Government Area"
adminAreaName="TABLELANDS REGIONAL" adminAreaCode="6810"/>
        <AdministrativeArea adminAreaType="Locality"
adminAreaName="MILLSTREAM" adminAreaCode="1726"/>
        <AdministrativeArea adminAreaType="County" adminAreaName="CARDWELL"
adminAreaCode="CWL"/>
        <AdministrativeArea adminAreaType="Parish" adminAreaName="WOODLEIGH"
adminAreaCode="5139"/>
        <HeadOfPower name="Surveying and Mapping Infrastructure Act 2003"/>
        <HeadOfPower name="Land Titre Act 1994"/>

    </SurveyHeader>

```

LandXML-1.2.xsd Schema Changes since LandXML-1.1.xsd (working draft date July 8, 2008)

Summary of Changes

A limitation in XML Schema rules results in CgPoint elements unable to contain <Feature> elements directly. This limitation does not allow us to add associated metadata to a <CgPoint>.

3. Added an optional "featureRef" attribute to <CgPoint> that refers to a named Feature element.
4. Added an optional "name" attribute to the <Feature> element.

Schema Change Details

This will effect CgPoint and all other pointType derived elements such as <Monument>, <Start>, <Center>, <End>, <TargetPoint>, <BacksightPoint>, <InstrumentPoint>, and even the surface <P> element.

This reference method works just like the "pntRef" attribute except it points to a <Feature>.name element that contains the free form data associated with the point. This allows an unlimited amount of user attributes to be associated with any LandXML point.

Example:

```
<CgPoints>
  <CgPoint name="S1" code="FP" desc="Fence Post" featureRef="S1">1000.0 1000.0
100.0</CgPoint>
  <CgPoint name="S2" code="FP" desc="Fence Post" featureRef="S2">2000.0 1000.0
200.0</CgPoint>
  <Feature name="S1" code="DTM details">
    <Property label="diameter" value="4.0"/>
    <Property label="height" value="2.54"/>
    <Property label="annotation" value="found wooden fence post"/>
    <Property label="annotation" value="condition poor"/>
  </Feature>
  <Feature name="S2" code="DTM details">
    <Property label="diameter" value="3.0"/>
    <Property label="height" value="3.04"/>
    <Property label="annotation" value="found steel fence post"/>
    <Property label="annotation" value="condition new"/>
  </Feature>
</CgPoints>
```


LandXML-1.2.xsd Schema Changes since LandXML-1.1.xsd (working draft date April 23, 2008)

Summary of Changes

5. TIN face breakline attribute "b" added to <F> element.

Schema Change Details

TIN face breakline attribute "b" added to <F> element

"b" attribute used to indicate the edges of the face that coincide with breakline data.

b=an integer bitmask sum of the sides of the face that had breaklines in the original data.
This gives a valid integer range of 0 to 7 for each TIN face:

1 = side 1
2 = side 2
4 = side 3

For example b="5" has breakline data on TIN face sides 1 and 3.

A practical example use of this is for automatic assignment of appearances to faces, recursively adding faces that do not cross a breakline.

LandXML-1.2.xsd Schema Changes since LandXML-1.1.xsd (working draft date November 19, 2007)

Summary of Changes

6. Added attribute "status" type="observationStatusType" to <InstrumentSetup>, <RawObservation> and <Chain>.
7. Added station and zone attributes to <InstrumentSetup>, <RawObservation> and <Chain>.
8. Added zone attribute to <CgPoint>.
9. Added StadiaFactor attribute to <InstrumentDetails>
10. Added standard error attributes to PointType derived elements, primarily for CGPoint.

Schema Change Details

Added simpleType observationStatusType

The "status" attribute of type "observationStatusType" is used on RawObservations, Chain and InstrumentSetup elements. "Modified" indicates the record is not to be processed and another record appearing later in the file replaces it. "Deleted" indicates a record is not to be processed and there is no replacement record to follow. Note this is analogous to striking out a hand-written record in a paper field book (one never erases in a field book).

```
<xs:simpleType name="observationStatusType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="modified"/>
    <xs:enumeration value="deleted"/>
  </xs:restriction>
</xs:simpleType>
```

Added standard error attributes to PointType derived elements

These attributes have to do with the standard errors of the reported coordinate values themselves. A standard error is the estimate of the error (sigma confidence interval) in the value of a northing, easting or elevation used as control for a least squares adjustment or the results calculated from a least squares adjustment. The attributes northingStdError, eastingStdError, elevationStdError are doubles.

LandXML-1.2.xsd Schema Changes since LandXML-1.1.xsd (working draft date August 1, 2007)

Summary of Changes

1. Added survey level loop and DOT road survey attributes to <RawObservation>, <ReducedObservation> and <ReducedArcObservation>.
2. Created <TestObservation> and added to <InstrumentSetup>.<Corrections>.
3. Renamed <CGPoint> attribute EllipsoidElev attribute to EllipsoidHeight.
4. Added “both” value to enumeration PipeFlowType to indicate invert flow direction for structures.

Schema Change Details

Added survey level loop and DOT road survey attributes to <RawObservation>, <ReducedObservation> and <ReducedArcObservation>

<RawObservation> and the new <TestObservation> element are derived from a new complex base type called <RawObservationType>. In order to support common road survey work the following attributes were added to <RawObservationType> base type.

Added 3-wire level loop attributes:

- “upperStadia” is the upper stadia hair rod reading.
- “rod” is the middle hair rod reading.
- “lowerStadia” is the lower stadia hair rod reading.
- “circlePositionSet” represents the position of the reading circle. This optional attribute (assumed to be “1.0”), unless multiple reading circle positions were present from the same setup record.
- “alignRef” is the name of the alignment.
- “alignStationName” is the station value where the rod reading is taken.
- “alignOffset” is the signed (+/-) distance from the CL of the referenced alignment.

“alignRef”, “alignStationName”, and “alignOffset” attributes have also been added to <ReducedObservation> and <ReducedArcObservation> elements with the same meaning.

Created <TestObservation> and added to <InstrumentSetup>.<Corrections>

The new <TestObservation> element is derived from and extends <RawObservationType>, adding the “setup1RodA”, “setup1RodB”, “setup2RodA” and “setup2RodB” attributes; all defined as numeric double precision rod height readings. This captures calibration data required for high accuracy level loop elevation calculations.

Renamed <CGPoint> attribute EllipsoidElev attribute to EllipsoidHeight

This was improperly named in the LandXML-1.1 schema.


```

<xs:simpleType name="ellipsoidHeightType">
  <xs:annotation>
    <xs:documentation>Represents the National Geodetic Survey ellipsoid height
expressed in the unit height attribute value</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:double"/>
</xs:simpleType>

```

Used by all <PointType> derived elements like <CgPoint>.

```

<xs:complexType name="PointType" mixed="true">
  <xs:simpleContent>
    <xs:extension base="Point3dOpt">
      <xs:attribute name="name" type="xs:string"/>
      <xs:attribute name="desc" type="xs:string"/>
      <xs:attribute name="code" type="xs:string"/>
      <xs:attribute name="state" type="stateType"/>
      <xs:attribute name="pntRef" type="pointNameRef"/>
      <xs:attribute name="pointGeometry" type="pointGeometryType"/>
      <xs:attribute name="DTMAttribute" type="DTMAttributeType"/>
      <xs:attribute name="timeStamp" type="xs:dateTime" use="optional"/>
      <xs:attribute name="role" type="surveyRoleType" use="optional"/>
      <xs:attribute name="determinedTimeStamp" type="xs:dateTime"
use="optional"/>
      <xs:attribute name="ellipsoidHeight" type="ellipsoidHeightType"
use="optional"/>
      <xs:attribute name="latitude" type="latLongAngle" use="optional"/>
      <xs:attribute name="longitude" type="latLongAngle" use="optional"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>

```

Added “both” value to enumeration PipeFlowType to indicate invert flow direction for structures

```

<xs:simpleType name="inOut">
  <xs:restriction base="xs:string">
    <xs:enumeration value="in"/>
    <xs:enumeration value="out"/>
    <xs:enumeration value="both"/>
  </xs:restriction>
</xs:simpleType>

```

Used by <Structure>.<Invert>, flowDir attribute:

```
<xs:element name="Invert">
  <xs:annotation>
    <xs:documentation/>
  </xs:annotation>
  <xs:complexType>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="elev" type="xs:double" use="required"/>
    <xs:attribute name="flowDir" type="inOut" use="required"/>
    <xs:attribute name="refPipe" type="pipeNameRef" use="required"/>
  </xs:complexType>
</xs:element>
```

LandXML-1.1.xsd Schema Changes since March 22, 2006 (working draft date June 11, 2006)

Summary of Changes

1. Fixed <AlignPI> definition for schema validation (does not affect or change instance data structure).
2. Additions to support FAA Airport Surveying-GIS Program (www.airports-gis.faa.gov)
3. survPntType – for consistency with other enumerated values, 'sideShot' renamed to 'sideshot'.
4. Survey/Equipment element is now optional.

Schema Change Details

Fixed <AlignPI> definition for schema validation

Defined sub-elements as global, then referred to in <AlignPI> data structure.

FAA Airport Surveying-GIS Program

1. Added optional <FeatureDictionary> element to main LandXML element to indicate 1 or more feature dictionaries used in file.

Example:

```
<FeatureDictionary name="FAA Airport Survey" version="1.0">
  <DocFileRef name="FAA Airport Survey LandXML Data Exchange"
    location="http://survey.faa.gov/standards/FAA Airport
    Survey LandXML Data Exchange.pdf"/>
</FeatureDictionary>
```

2. Added explicit "elevationUnit" attribute to <Units>.<Metric> and <Units>.<Imperial>
3. Added simple type "latLongAngularType" to <Units>.<Metric> and <Units>.<Imperial> to describe the angular units for new lat/long attribute values.
4. Added "latitude" and "longitude" attributes to base point element <PointType>, allowing all CgPoint, surface points and coordinate geometry locations to have an associated lat/long value. These use the units specified by the <Units>.<latLongAngularType> value.

5. CgPoint Changes:

- a. In the standard CgPoint definition <N E Z>, Z = OrthometricElevation (grid elevation).
- b. Added optional ellipsoidElev attribute added to CgPoint and all PointType derived elements of type ellipsoidElevationType = elevation expressed in height unit.
- c. Added optional determinedTimeStamp attribute of type xs:dateTime

LandXML-1.1.xsd Schema Changes since December 23, 2005 (working draft date March 11, 2006)

Summary of Changes

5. Changes to <CoordinateSystem> to support OGC Well Known Coordinate System names.
6. Changes to support electronic Australian cadastral survey system

Schema Change Details

<CoordinateSystem> changes to support OGC Well Known Coordinate System Names

In addition to reusing the extensive coordinate systems dictionary work done by EPSG (European Petroleum Survey Group, <http://www.epsg.org>), the Open Geospatial Consortium (www.opengis.org) also defines well known coordinate systems names.

New <CoordinateSystem>.ogcWktCode attribute represents the Open Geospatial Consortiums Well Known Coordinate System Name. This is a string value where quote characters (") must be in the form of "

Example:

<CoordinateSystem

```
ogcWktCode="PROJCS[&quot;NH83F&quot;,GEOGCS[&quot;LL83&quot;,DATUM[
&quot;NAD83&quot;,SPHEROID[&quot;GRS1980&quot;,6378137.000,298.25722210]
],PRIMEM[&quot;Greenwich&quot;,0],UNIT[&quot;Degree&quot;,0.017453292519943295]
],PROJECTION[&quot;Transverse_Mercator&quot;,],PARAMETER[&quot>false_easting
&quot;,984250.000],PARAMETER[&quot>false_northing&quot;,0.000],PARAMETER[&
quot;scale_factor&quot;,0.9999666666667],PARAMETER[&quot;central_meridian&quot;,-
71.66666666666670],PARAMETER[&quot;latitude_of_origin&quot;,42.50000000000000],UNIT[&qu
ot;Foot_US&quot;,0.30480060960122]]"/>
```

Changes to support electronic Australian cadastral survey system

(Provided by Nevil Cumerford, Bureau of Land Information and Titles, Queensland, Australia)

Enumerations and Types

We have adjusted the schema for those elements where we removed enumerations but our developers suggested that instead of leaving them as strings that we relace them as types (which are strings) so that local enumeration lists can be inserted for these. See how we handled the adminAreaType attribute

where we used an adminAreaType which is a string.

- Increased enumerations survPntType required for interface with Digital cadastral datasets. The following additional enumerations are requested.

```
<xs:enumeration value="boundary"/>
<xs:enumeration value="natural boundary"/>
<xs:enumeration value="traverse"/>
<xs:enumeration value="reference"/>
<xs:enumeration value="administrative"/>
```

- Reduced enumerations for parcel format, many jurisdiction name their parcel formats differently this will allow for greater flexibility

```
<xs:simpleType name="parcelFormat">
  <xs:annotation>
    <xs:documentation>Parcel Format describes how the parcel is described , ie Standard (2D), Volumetric (3D)</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
```

- The following type were included to describe surveyors in the personnel element

```
<xs:simpleType name="registrationType">
  <xs:annotation>
    <xs:documentation>This is a jurisdictionally based list of classes of registration for a surveyor. This allows validation of the surveyors role in the survey for legal traceability.</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="surveyorRoleType">
  <xs:annotation>
    <xs:documentation>This is a jurisdictionally based list of roles that a surveyor can undertake within a survey for example field hand, authorising surveyor, technician.</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
```

- The following Types are used for the additional elements in Survey Header

```
<xs:simpleType name="purpSurvType">
  <xs:annotation>
    <xs:documentation>This is a jurisdictionally based list of purposes of Survey and can be jurisdictionally specific for example Subdivision, Identification (re-peg), Amalgamation (Consolidation) etc</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="exclusType">
  <xs:annotation>
    <xs:documentation>This is a jurisdictionally based list of exclusions for a Title example would be exclusions for Road, Track, Esplanade etc</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
```

- The following types had enumerations in earlier versions of LandXML the enumerations have been removed due to issues with maintainability however in most jurisdictions these values are often defined in Legislation or Regulation. Many jurisdictions would like to define these lists locally. By defining these elements as types (by default a string) a local list could be applied to this attribute. These types include:

```

    <xs:simpleType name="monumentPurpose">
      <xs:annotation>
        <xs:documentation>This is a list of purposes that the monument was used for on this survey. The desired list may be
based on local regulations. </xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string"/>
    </xs:simpleType>
    <xs:simpleType name="monumentState">
      <xs:annotation>
        <xs:documentation>This is a list of states for a monument each jurisdiction may have a list defined by regulation. </
xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string"/>
    </xs:simpleType>
    <xs:simpleType name="parcelClass">
      <xs:annotation>
        <xs:documentation>This is a list of parcel classes which may be jurisdictionally specific defined by regulation and
legislation. </xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string"/>
    </xs:simpleType>
    <xs:simpleType name="monumentType">
      <xs:annotation>
        <xs:documentation>This is a list of allowable monument types that can be used or identified for a survey, ie peg,
spike, pillar etc. Local custom will define this list. </xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string"/>
    </xs:simpleType>
    <xs:simpleType name="observationType">
      <xs:annotation>
        <xs:documentation>This is a list of defined observation types, different jurisdictions may have a list defined by
regulation can be defined by the jurisdiction. </xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string"/>
    </xs:simpleType>
    <xs:simpleType name="equipmentType">
      <xs:annotation>
        <xs:documentation>This gives a list of equipment used for the observation this list of equipment is used to estimate
the accuracy of the observation.. </xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string"/>
    </xs:simpleType>
    <xs:simpleType name="monumentCondition">
      <xs:annotation>
        <xs:documentation>This gives a list of allowable local conditions defined by regulation can be defined by the
jurisdiction. </xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string"/>
    </xs:simpleType>

```

redVerticalPosition and redHorizontalPosition

We also discovered that the redVerticalPosition and redHorizontalPosition elements were duplicated in the schema and they were inconsistent. I have corrected this but please check the Observation Group Element in the attached schema.

For Consistency the redVerticalPosition and redHorizontalPosition should also have subelements of FieldNote and Feature similarly to the ReducedObservation and ReducedArcObservation Elements.

Added lines to the key file for names for RedVerticalPosition and redHorizontalPosition.


```

<xs:key name="RedHorizontalPositionName">
  <xs:selector xpath="/ObservationGroup/RedHorizontalPosition"/>
  <xs:field xpath="@name"/>
</xs:key>
<xs:key name="RedVerticalPositionName">
  <xs:selector xpath="/ObservationGroup/RedVerticalPosition"/>
  <xs:field xpath="@name"/>
</xs:key>

```

Both redHorizontalPosition and redVerticalPosition where missing the attribute to the SetupID as well as the class/order etc in the Vertical Position see below.

```

<!-- RedHorizontalPosition referenced to Observation & HorizontalPosition class in UML datamodel -->
<xs:element name="RedHorizontalPosition">
  <xs:annotation>
    <xs:documentation>This element is used to define the Reduced Horizontal Position. The coordinates given in Geographical
Coordinates may come in variety of means.
    </xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element ref="FieldNote" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    </xs:choice>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="name" type="xs:string" use="required"/>
    <xs:attribute name="state" type="xs:string"/>
    <xs:attribute name="old" type="xs:string"/>
    <xs:attribute name="purpose" type="purposeType"/>
    <xs:attribute name="setupID" type="xs:IDREF"/>
    <xs:attribute name="date" type="xs:date"/>
    <xs:attribute name="equipmentUsed" type="xs:string"/>
    <xs:attribute name="horizontalDatum" type="xs:string"/>
    <xs:attribute name="horizontalAdjustment" type="xs:string"/>
    <xs:attribute name="latitude" type="xs:string"/>
    <xs:attribute name="longitude" type="xs:string"/>
    <xs:attribute name="horizontalFix" type="xs:string"/>
    <xs:attribute name="currencyDate" type="xs:string"/>
    <xs:attribute name="localUncertainty" type="xs:double"/>
    <xs:attribute name="class" type="xs:string"/>
    <xs:attribute name="order" type="xs:string"/>
    <xs:attribute name="positionalUncertainty" type="xs:double"/>
  </xs:complexType>
</xs:element>
<!-- RedVerticalObservation referenced to Observation & verticalPosition class in UML datamodel -->
<xs:element name="RedVerticalObservation">
  <xs:complexType>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element ref="FieldNote" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    </xs:choice>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="name" type="xs:string" use="required"/>
    <xs:attribute name="state" type="xs:string"/>
    <xs:attribute name="old" type="xs:string"/>
    <xs:attribute name="purpose" type="purposeType"/>
    <xs:attribute name="setupID" type="xs:IDREF"/>
    <xs:attribute name="date" type="xs:date"/>
    <xs:attribute name="equipmentUsed" type="xs:string"/>
    <xs:attribute name="height" type="xs:double"/>
    <xs:attribute name="verticalAdjustment" type="xs:string"/>
    <xs:attribute name="verticalFix" type="xs:string"/>
    <xs:attribute name="geosphoid" type="xs:double"/>
    <xs:attribute name="gsDatum" type="xs:string"/>
  </xs:complexType>
</xs:element>

```

```

<xs:attribute name="gsModel" type="xs:string"/>
<xs:attribute name="gsMethod" type="xs:string"/>
<xs:attribute name="originMark" type="xs:string"/>
<xs:attribute name="verticalDatum" type="xs:string"/>
<xs:attribute name="localUncertainty" type="xs:double"/>
<xs:attribute name="class" type="xs:string"/>
<xs:attribute name="order" type="xs:string"/>
<xs:attribute name="positionalUncertainty" type="xs:double"/>
</xs:complexType>
</xs:element>

```

For structural consistency I have also moved the elements to the Observation Group area they were out of place where they were.

Parcel Element

We have also found that in the schema the top level can have many Parcels Elements which can contain many parcel elements. This then in turn can call another parcels element but in the current schema this can only call a single Parcels element. We require that the Parcel element can contain many parcels elements. This construct allows us to manage parcel allocations for titling purposes as well as parcels in parts and other nice things. Please refer the Parcel element in the attached schema.

In the Parcel element we introduced an attribute for exclusionArea, this was so that an area can be excluded from a parcel (ie a road reservation). In the ePlan model it was identified that more than one exclusion could be present in a parcel and hence an additional element called Exclusions to enable this to occur.

Additional attributes of lotEntitlements and liabilityApportionment are requested to enable allocation of voting rights within community title schemes (Condominiums etc)

The original schema asked for an element for VolumeGeom which was embedded in the schema we have moved it to be consist with the rest of the schema format.

```

<xs:element name="Parcel">
  <xs:annotation>
    <xs:documentation>Modified to include parcel class and an official ID</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="Center" minOccurs="0"/>
      <xs:element ref="CoordGeom" minOccurs="0"/>
      <xs:element ref="VolumeGeom" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Parcels" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Title" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Exclusions" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="LocationAddress" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="name" type="xs:string" use="required"/>
    <xs:attribute name="oldID" type="xs:string"/>
    <xs:attribute name="area" type="xs:double"/>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="dirClosure" type="direction"/>
    <xs:attribute name="distClosure" type="xs:double"/>
    <xs:attribute name="owner" type="xs:string"/>
    <xs:attribute name="parcelType" type="xs:string"/>
  </xs:complexType>
</xs:element>

```

```

    <xs:attribute name="setbackFront" type="xs:double"/>
    <xs:attribute name="setbackRear" type="xs:double"/>
    <xs:attribute name="setbackSide" type="xs:double"/>
    <xs:attribute name="state" type="parcelStateType"/>
    <xs:attribute name="taxId" type="xs:string"/>
    <xs:attribute name="class" type="parcelClass"/>
    <xs:attribute name="exclusionArea" type="xs:double"/>
    <xs:attribute name="useOfParcel" type="useOfParcelType"/>
    <xs:attribute name="parcelFormat" type="parcelFormat"/>
    <xs:attribute name="buildingNo" type="xs:string"/>
    <xs:attribute name="buildingLevelNo" type="xs:string"/>
    <xs:attribute name="volume" type="xs:string"/>
    <xs:attribute name="pclRef" type="parcelNameRefs"/>
    <xs:attribute name="lotEntitlements" type="xs:string"/>
    <xs:attribute name="liabilityApportionment" type="xs:string"/>
  </xs:complexType>
</xs:element>
<xs:element name="VolumeGeom" minOccurs="0" maxOccurs="unbounded">
  <xs:annotation>
    <xs:documentation>Defines the properties of 3D coordinate Geometry Collection</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:choice minOccurs="4" maxOccurs="unbounded">
      <xs:element ref="CoordGeom"/>
    </xs:choice>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="name" type="xs:string" use="required"/>
    <xs:attribute name="state" type="stateType"/>
    <xs:attribute name="old" type="xs:string"/>
  </xs:complexType>
</xs:element>
<xs:element name="Title">
  <xs:annotation>
    <xs:documentation>This may be expanded, but the LandXML schema is not really aimed at providing title information so I
think name is sufficient</xs:documentation>
  </xs:annotation>
  <xs:complexType mixed="true">
    <xs:attribute name="name" type="xs:string" use="required"/>
    <xs:attribute name="titleType" type="xs:anySimpleType"/>
  </xs:complexType>
</xs:element>
<xs:element name="Exclusions">
  <xs:annotation>
    <xs:documentation>An Exclusion is an area which has been reserved from a tenure for a specific purpose but may have
no defined spatial extent for example 10ha for road. A single parcel could have more than one exclusion for different purposes.</
xs:documentation>
  </xs:annotation>
  <xs:complexType mixed="true">
    <xs:attribute name="exclusionType" type="exclusType" use="required"/>
    <xs:attribute name="area" type="xs:double" use="required"/>
  </xs:complexType>
</xs:element>
<xs:element name="LocationAddress">
  <xs:annotation>
    <xs:documentation>This element is used to define the location or positional address of a parcel. The address record is
not designed to be a postal address (ie it has not postcode or zipcode etc) The element also needs to be able to handle both primary
addresses and aliases if required.</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="ComplexName" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="RoadName" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="AdministrativeArea" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="AddressPoint" minOccurs="0" maxOccurs="unbounded"/>
      <xs:any namespace="##any" processContents="skip" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>

```



```

<xs:attribute name="addressType" type="addressTypeType"/>
<xs:attribute name="flatType" type="flatTypeType"/>
<xs:attribute name="flatNumber" type="xs:string"/>
<xs:attribute name="floorLevelType" type="floorLevelTypeType"/>
<xs:attribute name="floorLevelNumber" type="xs:string"/>
<xs:attribute name="numberFirst" type="xs:int"/>
<xs:attribute name="numberSuffixFirst" type="xs:string"/>
<xs:attribute name="numberLast" type="xs:int"/>
<xs:attribute name="numberSuffixLast" type="xs:string"/>
</xs:complexType>
</xs:element>
<xs:element name="ComplexName">
  <xs:complexType>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="priority" type="xs:int"/>
  </xs:complexType>
</xs:element>
<xs:element name="RoadName">
  <xs:complexType>
    <xs:attribute name="roadNameType" type="roadNameTypeType"/>
    <xs:attribute name="roadName" type="xs:string"/>
    <xs:attribute name="roadNameSuffix" type="roadNameSuffixType"/>
    <xs:attribute name="roadType" type="roadTypeType"/>
    <xs:attribute name="pclRef" type="parcelNameRefs"/>
  </xs:complexType>
</xs:element>
<xs:element name="AddressPoint">
  <xs:annotation>
    <xs:documentation>Represents a 2D or 3D Address Point. The Address Point is the geocoded point with which to
reference an address</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="PointType">
        <xs:attribute name="addressPointType" type="addressPointTypeType"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

```

CgPoint Element

In the CG Point Type you refer to the survey order. FIG is moving to Positional and Local Uncertainty to describe precision and accuracy of points

```

<xs:element name="CgPoint">
  <xs:annotation>
    <xs:documentation>Represents a COordinate GeOMetry Point. The Point is identified by the "name" attr and the data
value will be a sequence of space delimited, two or three double numeric values: (Northing Easting) or (Northing Easting
Elevation).</xs:documentation>
  </xs:annotation>
  <xs:complexType mixed="true">
    <xs:simpleContent>
      <xs:extension base="PointType">
        <xs:attribute name="oid" type="xs:string"/>
        <xs:attribute name="surveyOrder" type="xs:string"/>
        <xs:attribute name="pntSurv" type="survPntType"/>
        <xs:attribute name="zoneNumber" type="zoneNumberType"/>
        <xs:attribute name="surveyHorizontalOrder" type="xs:string"/>
        <xs:attribute name="surveyVerticalOrder" type="xs:string"/>
        <xs:attribute name="localUncertainty" type="xs:double"/>
        <xs:attribute name="positionalUncertainty" type="xs:double"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>

```

```

        </xs:extension>
    </xs:simpleContent>
</xs:complexType>
</xs:element>

```

Addressing

One of the areas that the ICSM wanted to see included in the schema was the address data for data transfer of street addressing information this is captured into our National Street Address File. Hence I have added some suggestions to the schema. As per earlier notes we could have added a ##any field but this did not give us the ability to provide cross validated data as would the schema. We have added both a ##any field under a locationAddress element as well as specific elements as per the schema.

The following Type were required

```

<xs:simpleType name="addressTypeType">
  <xs:annotation>
    <xs:documentation>This Type is to define a jurisdictional specific list of address types such a primary address, alias,
secondary, historical etc.</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="flatTypeType">
  <xs:annotation>
    <xs:documentation>To define a Jurisdictional specific list of address living unit types for addressing</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="roadNameSuffixType">
  <xs:annotation>
    <xs:documentation>to Allow a list of specific road suffixes to be specified, ie east, upper etc (ie Fred Street East)</
xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="roadTypeType">
  <xs:annotation>
    <xs:documentation>To define if the road is a public or private road.</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="roadNameTypeType">
  <xs:annotation>
    <xs:documentation>to define a jurisdictionally specific list of Road name types such a street, road, avenue etc.</
xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="floorLevelTypeType">
  <xs:annotation>
    <xs:documentation>To define a jurisdictionally specific list of floo level types for example, Lower Ground Floor</
xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="addressPointTypeType">
  <xs:annotation>
    <xs:documentation>This is a string to define the type of Geocode that the address point is for example centroid of parcel,
Access Point etc. This will be a jurisdictionally based list.</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string"/>

```

```
</xs:simpleType>
```

Survey Header

In Survey Header Element the attribute SurveyPurpose is designed to show the purpose of the survey, ie a subdivision, amalgamation, a lease etc. The ePlan model shows a multiplicity for this element which cannot be supported in the current structure so an additional element PurposeOfSurvey is required to support this model.

```
<xs:element name="SurveyHeader">
  <xs:annotation>
    <xs:documentation>We seemed to have doubled up on the survey purpose here, but the two are quite different - maybe
need a different name</xs:documentation>
  </xs:annotation>
  <xs:complexType mixed="true">
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element ref="Annotation" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="AdministrativeArea" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="AdministrativeDate" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="CoordinateSystem" minOccurs="0"/>
      <xs:element ref="Units" minOccurs="0"/>
      <xs:element ref="MapPoint" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Personnel" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="FieldNote" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="SurveyorCertificate" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="PurposeOfSurvey" minOccurs="0" maxOccurs="unbounded"/>
    </xs:choice>
  </xs:complexType>
</xs:element>
```

!--Purpose Of Survey Element-->

```
<xs:element name="PurposeOfSurvey">
  <xs:complexType>
    <xs:attribute name="name" type="purpSurvType" use="required"/>
  </xs:complexType>
</xs:element>
```

CoordinateSystem

Because of the large areas in Australia and limited surveying infrastructure many surveys are done on a local coordinate system aligned to the adjoining survey or additional work is required to define the local conditions. The working group felt that this could be best achieved by including a FieldNote element as a subelement to the CoordinateSystem element, this is consistent with treatment in other areas of the model.

CoordinateSystem element -->

```
<xs:element name="CoordinateSystem">
  <xs:annotation>
    <xs:documentation>
      Simplified coordinate systems definitions to reuse work done by
      EPSG (European Petroleum Survey Group)
      EPSG Code: EPSG has reserved the integer range 0 to 32767 for use as codes for coordinate systems.
      Example: Represents Australian Map Grid Zone 52
      name="AGD66 - AMG Zone 52" , epsgCode="20252"

      Example: Represents Colorado CS27 South Zone
      name="NAD27-Colorado South" , epsgCode="26755"
    </xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="FieldNote" minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
```

```

    </xs:documentation>
</xs:annotation>
<xs:complexType>
  <xs:sequence>
    <xs:element ref="Start" minOccurs="0"/>
    <xs:element ref="FieldNote" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    <xs:any namespace="##other" processContents="skip" minOccurs="0"/>
  </xs:sequence>
  <xs:attribute name="desc" type="xs:string"/>
  <xs:attribute name="name" type="xs:string"/>
  <xs:attribute name="fileLocation" type="xs:anyURI"/>
  <xs:attribute name="epsgCode" type="xs:string"/>
  <xs:attribute name="rotationAngle" type="angle"/>
  <xs:attribute name="datum" type="xs:string"/>
  <xs:attribute name="horizontalDatum" type="xs:string"/>
  <xs:attribute name="verticalDatum" type="xs:string"/>
  <xs:attribute name="ellipsoidName" type="xs:string"/>
  <xs:attribute name="fittedCoordinateSystemName" type="xs:string"/>
  <xs:attribute name="horizontalCoordinateSystemName" type="xs:string"/>
  <xs:attribute name="compoundCoordinateSystemName" type="xs:string"/>
  <xs:attribute name="localCoordinateSystemName" type="xs:string"/>
  <xs:attribute name="geographicCoordinateSystemName" type="xs:string"/>
  <xs:attribute name="projectedCoordinateSystemName" type="xs:string"/>
  <xs:attribute name="geocentricCoordinateSystemName" type="xs:string"/>
  <xs:attribute name="verticalCoordinateSystemName" type="xs:string"/>
  <!-- should obit these, never used -->
  <!-- ***** -->
</xs:complexType>

```

Personnel Element

The role of the personnel and the type of registration are important enumerations that are jurisdictionally based and are required for legaling tracking those doing the work and authorising the work. The Personnel element has been changed to include some types.

```

<xs:element name="Personnel">
  <xs:complexType>
    <xs:attribute name="name" type="xs:string"/>
    <xs:attribute name="role" type="surveyorRoleType"/>
    <xs:attribute name="regType" type="registrationType"/>
    <xs:attribute name="regNumber" type="xs:string"/>
  </xs:complexType>
</xs:element>

```


LandXML-1.1.xsd Schema Changes since October 5, 2005 (working draft date December 23, 2005)

Summary of Changes

Added breakline enumerations and defined <Breakline>.brkType attribute.
Expanded definitions for numeric values.
Changes to 3D Road Model <DesignCrossSect>.

Schema Change Details

Added breakline enumerations and defined <Breakline>.brkType attribute

Previously the brkType attribute was required, but undefined – making it completely ambiguous. The brkType attribute is now optional with a well defined set of known values.

```
<xs:simpleType name="breakLineType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="standard"/>
    <xs:enumeration value="wall"/>
    <xs:enumeration value="proximity"/>
    <xs:enumeration value="nondestructive"/>
  </xs:restriction>
</xs:simpleType>

<xs:element name="Breakline">
  <xs:complexType>
    <xs:sequence>
      <xs:choice>
        <xs:element ref="PntList2D"/>
        <xs:element ref="PntList3D"/>
      </xs:choice>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="brkType" type="breakLineType"/>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="name" type="xs:string"/>
    <xs:attribute name="state" type="stateType"/>
  </xs:complexType>
</xs:element>
```

Expanded definitions for numeric values

Where applicable, the following defined numeric types are used throughout the schema instead of the very generic `xs:double`. All of the following `simpleTypes` are derived from `xs:double`.

<xs:simpleType name="station">

Represents the actual measured distance along the geometry in numeric decimal form expressed in linear units. Also known as the internal station value where no station equations are applied.

Represents the geometric volume (area * height) of a closed boundary numeric decimal form expressed in volume units.

<xs:simpleType name="area">

Represents the geometric area of a closed boundary in numeric decimal form expressed in area units

<xs:simpleType name="crossSectSurfaceVolume">

Represents the cross section surface volume from the previous station to the current station in numeric decimal form expressed in volume units.

<xs:simpleType name="crossSectSurfaceArea">

Represents the cross sectional surface area in numeric decimal form expressed in area units.

<xs:simpleType name="angle">

Represents a normalized angular value in the specified Angular units. Assume 0 degrees = east.

<xs:simpleType name="zenithAngle">

Represents zenith angles with the 0 origin as straight up and measured in a clockwise direction in the specified Angular units.

<xs:simpleType name="direction">

Represents a normalized angular value that indicates a horizontal direction, expressed in the specified Direction units. Assume 0 degrees = north.

<xs:simpleType name="offsetDistance">

Represents a linear offset distance. When associated with horizontal (planimetric) road or coordinate geometry, the offset is a 2D distance measured perpendicular to the road centerline or coordinate geometry used as the origin. When used in cross sections of long section (profile) the offset is a 2d linear measurement from the origin of the cross section or long section. In all cases a positive value indicates an offset to the RIGHT of the origin and negative values indicate an offset to the LEFT of the origin. The value is in decimal form expressed in linear units.

<xs:simpleType name="offsetElevation">

Represents a vertical offset distance or elevational shift. In all cases a positive value indicates a vertical elevational shift above the origin and negative values indicate a vertical elevational shift below the origin. The value is in decimal form expressed in linear units.

<xs:simpleType name="crossSlope">

Difference in elevation between two points as measure perpendicular to the horizontal alignment of a roadway, negative when the shoulder has a lower elevation than the centerline. The unit of measure for this item is PERCENT %.

<xs:simpleType name="slope">

Difference in elevation between two points. Unit of measure for this item is PERCENT %.

Changes to 3D Road Model <DesignCrossSect>

The design cross data model has been simplified. The CrossSectSurf (for sampled ground surface data) and the DesignCrossSectSurf (representing a designed surface) are now peers. The previous method of grouping <DesignCrossSectSurf> into left and right side collections is overly complicated.

```
<xs:element name="CrossSect">
  <xs:complexType>
    <xs:choice>
      <xs:element ref="CrossSectSurf" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="DesignCrossSectSurf" minOccurs="0"
maxOccurs="unbounded"/>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    </xs:choice>
    <xs:attribute name="sta" type="xs:double" use="required"/>
    <xs:attribute name="name" type="xs:string"/>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="angleSkew" type="angle"/>
    <xs:attribute name="areaCut" type="crossSectSurfaceArea"/>
    <xs:attribute name="areaFill" type="crossSectSurfaceArea"/>
    <xs:attribute name="centroidCut" type="xs:double"/>
    <xs:attribute name="centroidFill" type="xs:double"/>
    <xs:attribute name="sectType" type="xs:string"/>
    <xs:attribute name="volumeCut" type="crossSectSurfaceVolume"/>
    <xs:attribute name="volumeFill" type="crossSectSurfaceVolume"/>
  </xs:complexType>
</xs:element>
```

Also, the area and volume related attributes are now clearly defined.

Each <DesignCrossSectSurf> now has an optional side attribute, indicating the side of the road.

```
<xs:element name="DesignCrossSectSurf">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="CrossSectPnt" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="name" type="xs:string"/>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="state" type="stateType"/>
    <xs:attribute name="side" type="sideofRoadType"/>
    <xs:attribute name="material" type="xs:string"/>
    <xs:attribute name="closedArea" type="xs:boolean"/>
    <xs:attribute name="typicalThickness" type="xs:double"/>
    <xs:attribute name="typicalWidth" type="xs:double"/>
    <xs:attribute name="area" type="crossSectSurfaceArea"/>
    <xs:attribute name="volume" type="crossSectSurfaceVolume"/>
  </xs:complexType>
</xs:element>
```

A <DesignCrossSectSurf> is made up of <CrossSectPnt>s that can reference additional geometry to describe the geometric transition between two or more sections. Three types of geometry may be referenced Alignments, Parcel and PlanFeature. The accompanying *Refstation attribute specifies the station along the referenced geometry that the point lies on.

```
<xs:element name="CrossSectPnt">
  <xs:complexType mixed="true">
    <xs:simpleContent>
      <xs:extension base="PointType">
        <xs:attribute name="dataFormat" type="dataFormatType" default="Offset
Elevation"/>
        <xs:attribute name="alignRef" type="alignmentNameRef"/>
        <xs:attribute name="alignRefStation" type="station"/>
        <xs:attribute name="planFeatureRef" type="planFeatureNameRef"/>
        <xs:attribute name="planFeatureRefStation" type="station"/>
        <xs:attribute name="parcelRef" type="parcelNameRef"/>
        <xs:attribute name="parcelRefStation" type="station"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>
```

The dataFormat attribute is now optional and if not present defaults to offset distance, offset elevation format. Offset as measured from the centerline or profile grade line.

Two attributes were removed designLocation and connectionType because the information can be derived from the point data in cross section surfaces.

LandXML-1.1.xsd Schema Changes since May 17, 2005 (working draft date October 5, 2005)

Summary of Changes

Renamed design cross section surface "closedVolume" to "closedArea".

Removed enumerations (changed to xs:string).

Clarified the difference between angle and a direction.

Changes to <Roadway>.

Schema Change Details

Renamed design cross section surface "closedVolume" to "closedArea".

Removed enumerations (changed to xs:string)

EquipmentType

MonumentCondition

MonumentPurpose (an enumerated List)

MonumentState

MonumentType

ParcelClass

ObservationType

Clarified the difference between angle and a direction

All angular and direction values default to radians unless otherwise noted. Angular values, expressed in the specified Units.angleUnit are measured counter-clockwise from east=0. Horizontal directions, expressed in the specified Units.directionUnit are measured counter-clockwise from 0 degrees = north.

Changes to <Roadway>

Added optional <PlanFeatures> element for feature lines.

Added optional surfaceRefs attribute (space delimited surface names).

LandXML-1.1.xsd Schema Changes since April 27, 2005 (working draft date May 17, 2005)

Summary of Changes

1. Added new spiral types to enumerated spiraltype.

Schema Change Details

Added the following spiral types to spiralType enumeration.

- sineHalfWave
- biquadraticParabola
- cubicParabola
- japaneseCubic
- radioid
- weinerBogen

No additional parameters or attributes are required on the <Spiral> element to support these new types.

LandXML-1.1.xsd Schema Changes since April 19, 2005 (working draft date April 27, 2005)

Summary of Changes

2. Added optional "staIncrement" attribute to the <StaEquation> element.
3. Added optional "n" and "i" attribute to <F> element.

Schema Change Details

Added "staIncrement" attribute to the <StaEquation> element.

The optional "staIncrement" attribute indicates whether or not the station values increase or decrease after the station equation. A value of "decreasing" indicates the station values are decrementing.

Added optional "n" and "i" attribute to <F> element.

Attribute "i" is optional, where a value of "1" indicates the face is part of the triangulation but is invisible.

Attribute "n" is optional, containing 3 to 4 space delimited face index values indicating the adjacent face index for each face edge. A value of "0" (an invalid face index value) indicates the edge has NO neighboring face. The face index value is implied and defined from 1 to n number of F elements in a single Faces collection.

Example:

```
<Faces>
  <F>5 10 20</F> Implied face index = 1
  <F>5 10 20</F> Implied face index = 2
  <F>5 10 20</F> Implied face index = 3
  <F n="2 0 3" i="1">10 20 30</F> Implied face index = 4
  ...
</Faces>
```

Where **n="2 0 3"**, 2 is the neighboring face index for the edge 10 to 20, 0 means no neighbor between 20 and 30 and 3 is the neighbor index for 30 to 10.

LandXML-1.1.xsd Schema Changes since March 4, 2005 (working draft date April 19, 2005)

Summary of Changes

1. Added <DesignCrossSectSurf> to <Alignment>.<CrossSects>.<CrossSect> creating a complete multi-surface 3D road model.
2. Changes and corrections to data structure supporting electronic Australian cadastral survey system.
3. Pipe network changes.

Schema Change Details

1. Added <DesignCrossSectSurf> to <Alignment>.<CrossSects>.<CrossSect>

Road design cross section definitions have been added to the existing cross section data structure. The intent is to model the finished road design cross sections that would be included on design plan documents. There is NO intent to model the rules used to produce the design, just the finished cross section. Given that roads vary from simple single lane driveway access to elevated multi-lane highways, this data structure allows modeling of both in a very clear and understandable fashion.

Why not just use the existing <GradeModel>? The lack of wide spread adoption of the <GradeModel> suggests that deficiencies exist in that modeling concept. All vendors that support the <GradeModel> either produce or reduce it to cross section format for processing. The <GradeModel> is not being removed from LandXML-1.1 so existing applications will continue to work with the new version.

Will this affect the required IHSDM road model data? When used with the existing <Roadway> data structure, the new model will support the current and future versions of the US FHWA IHSDM software that analyze multi-lane highways.

Why not try to fix the GradeModel? We all use road design cross sections. They are a required part of the road engineering process and design plan documentation. Even software that does not explicitly use a cross section based road design methodology must still produce the design sections for plan documentation. Since software support is widely available it will be very straight forward for software developers to add. In the end the new road model is very straight forward to understand for end users and software vendors matching the way roads are designed and built all around the world.

The new 3D road model represented in this design cross section form will support the following (where the GradeModel partially does or does not):

- Complete 3D road model including all sub-surfaces and datum surface.
- Non-linear, compound geometric transitions between specified cross section points (for example, allowing for any form of lane widening/narrowing).
- Closed volumetric surfaces suitable for accurate material quantities takeoff calculations.
- Clear transition points between sub-surfaces.
- Support complex multi-lane highway designs, including elevated and depressed.
- Support bridge cross section component modeling.

In each cross section <CrossSect> there are two collections of design cross sections, Left and Right of the center line or profile grade line.

Road design cross section schema definition added to existing <Alignment>.<CrossSects>.<CrossSect> structure (bold text indicates new additions):

```
<xs:element name="CrossSect">
  <xs:complexType>
    <xs:choice>
      <xs:element ref="CrossSectSurf" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="DesignCrossSectSurfs" minOccurs="0" maxOccurs="2"/>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    </xs:choice>
    <xs:attribute name="sta" type="xs:double" use="required"/>
    <xs:attribute name="name" type="xs:string"/>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="angleSkew" type="angle"/>
    <xs:attribute name="areaCut" type="xs:double"/>
    <xs:attribute name="areaFill" type="xs:double"/>
    <xs:attribute name="centroidCut" type="xs:double"/>
    <xs:attribute name="centroidFill" type="xs:double"/>
    <xs:attribute name="sectType"/>
    <xs:attribute name="volumeCut" type="xs:double"/>
    <xs:attribute name="volumeFill" type="xs:double"/>
  </xs:complexType>
</xs:element>
```

```
<xs:element name="DesignCrossSectSurfs">
  <xs:complexType>
    <xs:choice maxOccurs="unbounded">
      <xs:element ref="DesignCrossSectSurf" maxOccurs="unbounded"/>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    </xs:choice>
    <xs:attribute name="side" type="sideofRoadType" use="required"/>
    <xs:attribute name="desc" type="xs:string"/>
    <xs:attribute name="name" type="xs:string"/>
    <xs:attribute name="state" type="stateType"/>
  </xs:complexType>
</xs:element>
```

```
<xs:element name="DesignCrossSectSurf">
  <xs:annotation>
    <xs:documentation></xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="CrossSectPnt" minOccurs="0" maxOccurs="unbounded"/>
```

```

    <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="name" type="xs:string"/>
  <xs:attribute name="desc" type="xs:string"/>
  <xs:attribute name="state" type="stateType"/>
  <xs:attribute name="material" type="xs:string"/>
  <xs:attribute name="closedVolume" type="xs:boolean"/>
  <xs:attribute name="typicalThickness" type="xs:double"/>
  <xs:attribute name="typicalWidth" type="xs:double"/>
  <xs:attribute name="area" type="xs:double"/>
  <xs:attribute name="volume" type="xs:double"/>
</xs:complexType>
</xs:element>

<xs:element name="CrossSectPnt">
  <xs:annotation>
    <xs:documentation></xs:documentation>
  </xs:annotation>
  <xs:complexType mixed="true">
    <xs:simpleContent>
      <xs:extension base="PointType">
        <xs:attribute name="dataFormat" type="dataFormatType"/>
        <xs:attribute name="designLocation" type="designLocationType"/>
        <xs:attribute name="connectionType" type="connectionType"/>
        <xs:attribute name="transCoordGeomRef" type="coordGeomNameRef"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

```

Design Cross Section Element / Attribute definitions

<DesignCrossSectSurfs> is a collection of **<DesignCrossSectSurf>** elements. At least one is required and a maximum of two may be defined (for right and left side of PGL).

"side" is an enumeration of type="sideofRoadType" (right, left, both) and is required.

"desc" is a text description for the element.

"name" is a text name for the element.

"state" is an enumeration of type stateType (proposed, existing, destroyed,...)

<DesignCrossSectSurf> is a collection of **<CrossSectPnt>** elements. At least one is required and there is no maximum limit. These points or slope/distances define either a closed volume surface or a series of linear segments of any complexity.

"closedVolume" is a Boolean (true, false) value indicating whether this cross section surface has a closed geometry.

"desc" is a text description for the element.

"name" is a text name for the element.

"state" is an enumeration of type stateType (proposed, existing, destroyed,...)

"material" is a text value for the construction material to be used for the surface.

"typicalThickness" is a double numeric value indicating the average top to bottom thickness of the closed volume surface.

"typicalWidth" is a numeric value indicating the typical or average left to right width of the closed volume surface.

"area" is a numeric value for the geometric cross sectional area of the closed volume surface.

"volume" is a numeric value for the geometric cross sectional volume of the closed volume surface between the current station and the next station.

typicalThickness, typicalWidth, area and volume attributes are not required and are intended for the convenience of XSLT type reports. These values can be computer directly from the given geometry of the closed volume surfaces.

<CrossSectPnt>

"dataFormat" indicates how the numeric location values are interpreted, either offset and elevation or slope and distance.

"designLocation" indicates where the point lies, on the top most or final surface, the datum or lowest most surface or an intermediate point not in either surface.

"connectionType" indicates if the point is an inner or outer connection point for the previous or next cross section surface.

"transCoordGeomRef" contains the name of a <CoordGeom> element that defines the non-linear geometric transition path for the point between the current station and the next station. The <CoordGeom> element may define a simple circular curve or complex line-line, line-curve or spiral compound geometries.

Example LandXML data

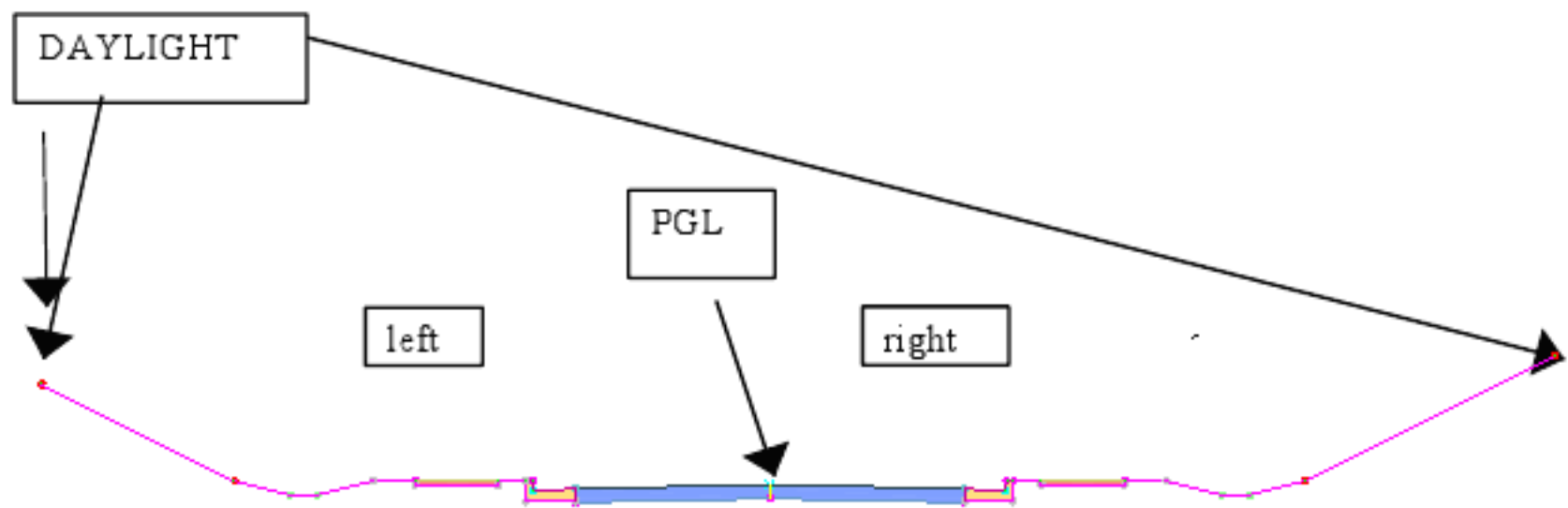
```
<Alignment name="Centerline (1)" length="1729.04857333" staStart="0.0" desc="">
  <CoordGeom>
    <Line dir="21.59584224" length="549.51699471">
      <Start>3805.44179327 4002.01523403</Start>
      <End>4007.69541432 4512.9578925</End>
    </Line>
    <Curve rot="ccw" chord="756.99488886" crvType="arc" delta="33.85386001" dirEnd="415.44970225" dirStart="381.59584224"
external="58.87056226" length="768.11971809" midOrd="56.32010366" radius="1299.9999999" tangent="395.63771933">
      <Start>4007.69541432 4512.9578925</Start>
      <Center>5216.4395703 4034.48368722</Center>
      <End>4479.17123711 5105.20092562</End>
      <PI>4153.31267843 4880.82310878</PI>
    </Curve>
    <Line dir="55.44970225" length="411.41186053">
      <Start>4479.17123711 5105.20092562</Start>
      <End>4818.02183032 5338.52472309</End>
    </Line>
  </CoordGeom>
  <CrossSects>
    <CrossSect sta="0.00" name="0+00">
      <DesignCrossSectSurfs side="right">
        <DesignCrossSectSurf name="lane" closedVolume="true" material="asphalt" typicalThickness="1.0" typicalWidth="14.0"
desc="right travel lane">
          <CrossSectPnt connectionType="inner" designLocation="Final Surface" dataFormat="Offset Elevation">0.00 627.717</
CrossSectPnt>
          <CrossSectPnt connectionType="outer" designLocation="Final Surface" dataFormat="Offset Elevation">14.00 627.437</
CrossSectPnt>
          <CrossSectPnt designLocation="Datum" dataFormat="Offset Elevation">14.00 626.437</CrossSectPnt>
          <CrossSectPnt designLocation="Datum" dataFormat="Offset Elevation">0.00 626.717</CrossSectPnt>
        </DesignCrossSectSurf>
        <DesignCrossSectSurf name="curb and gutter" closedVolume="true" material="concrete" desc="curb and gutter">
          <CrossSectPnt connectionType="inner" dataFormat="Offset Elevation" designLocation="Final Surface">14.00 627.437</
CrossSectPnt>
          <CrossSectPnt dataFormat="Offset Elevation" designLocation="Final Surface">17.00 627.257</CrossSectPnt>
          <CrossSectPnt dataFormat="Offset Elevation" designLocation="Final Surface">17.04 628.000</CrossSectPnt>
          <CrossSectPnt connectionType="outer" dataFormat="Offset Elevation" designLocation="Final Surface">17.54 628.000</
CrossSectPnt>
          <CrossSectPnt dataFormat="Offset Elevation" designLocation="Datum">17.54 626.51</CrossSectPnt>
          <CrossSectPnt dataFormat="Offset Elevation" designLocation="Datum">14.00 626.51</CrossSectPnt>
        </DesignCrossSectSurf>
        <DesignCrossSectSurf name="inner buffer" material="grass" closedVolume="false" typicalWidth="2.00">
          <CrossSectPnt dataFormat="Slope Distance" connectionType="outer" designLocation="Final Surface">0.00 2.00</
CrossSectPnt>
        </DesignCrossSectSurf>
        <DesignCrossSectSurf name="sidewalk" closedVolume="true" material="concrete" typicalThickness="0.44"
typicalWidth="4.0" desc="right sidewalk">
          <CrossSectPnt connectionType="inner" designLocation="Final Surface" dataFormat="Offset Elevation">19.54 628.00</
CrossSectPnt>
          <CrossSectPnt connectionType="outer" designLocation="Final Surface" dataFormat="Offset Elevation">25.54 628.00</
CrossSectPnt>
```

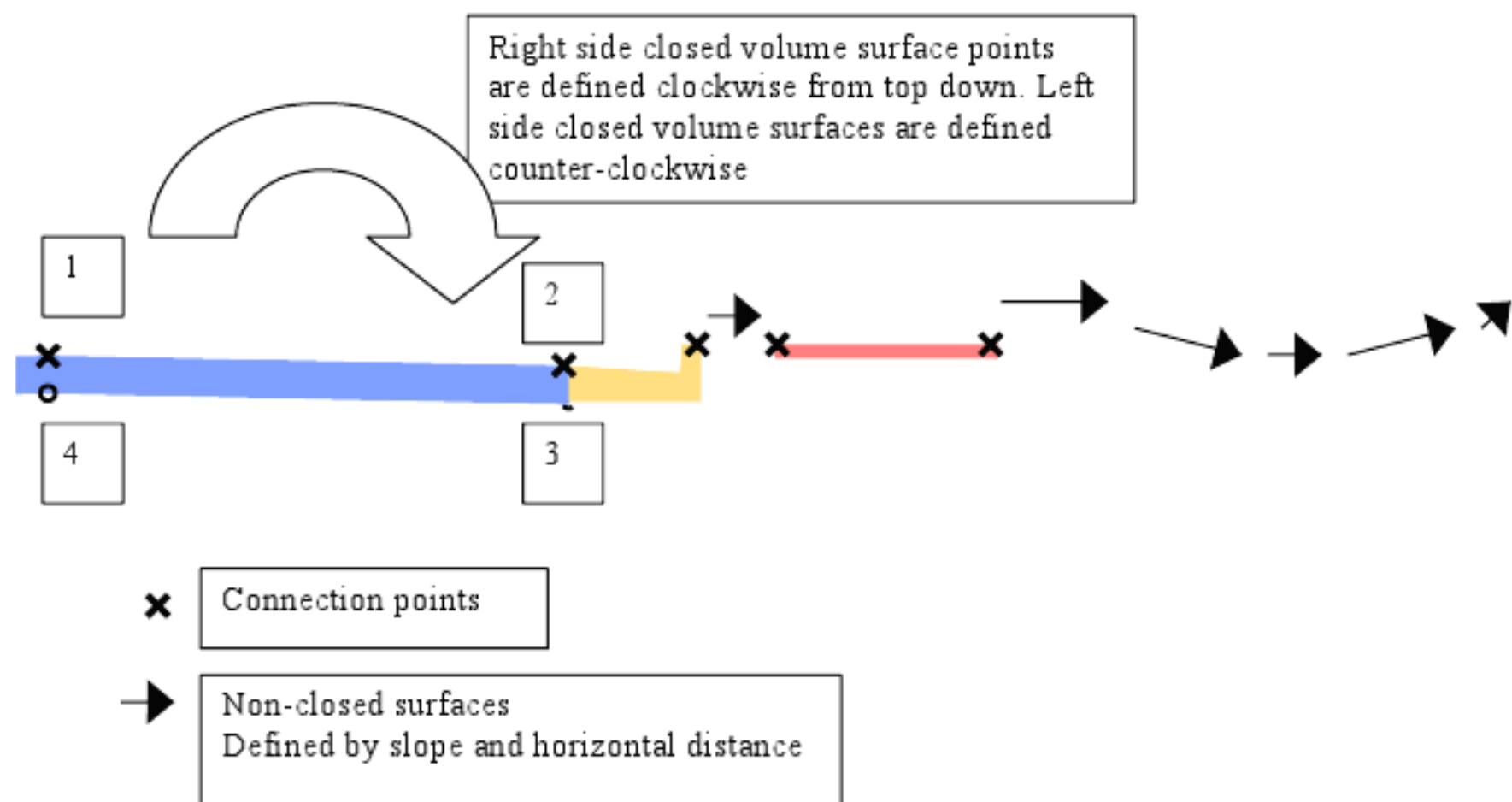
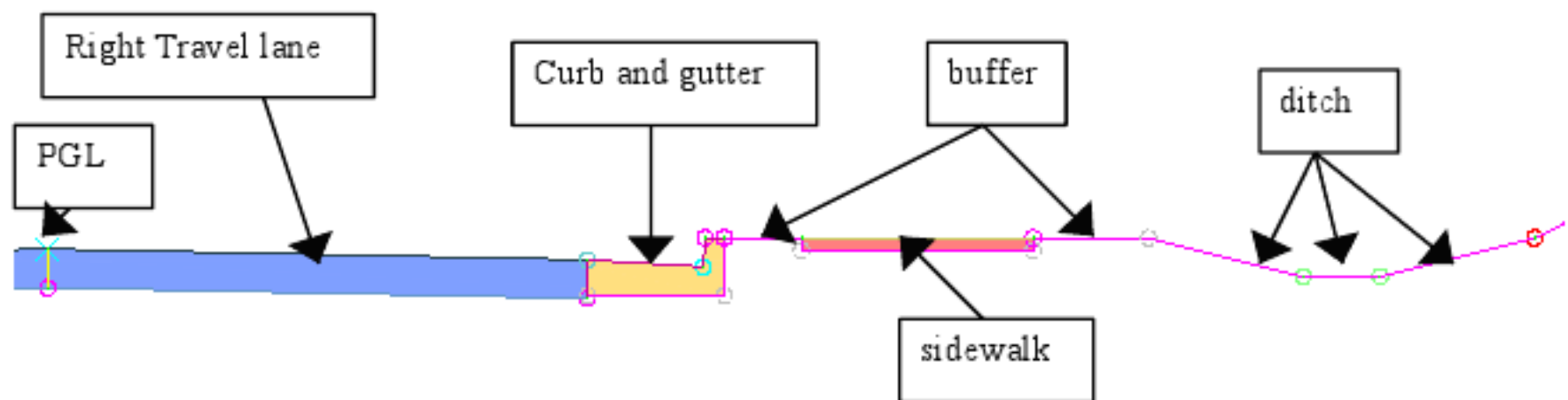
```

        <CrossSectPnt designLocation="Datum" dataFormat="Offset Elevation">25.54 627.66 </CrossSectPnt>
        <CrossSectPnt designLocation="Datum" dataFormat="Offset Elevation">19.54 627.66 </CrossSectPnt>
    </DesignCrossSectSurf>
    <DesignCrossSectSurf name="outer buffer" material="grass" closedVolume="false" typicalWidth="3.00">
        <CrossSectPnt dataFormat="Slope Distance" connectionType="outer" designLocation="Final Surface">0.00 3.00 </
CrossSectPnt>
    </DesignCrossSectSurf>
    <DesignCrossSectSurf name="right ditch" material="grass" closedVolume="false" typicalWidth="4.00">
        <CrossSectPnt dataFormat="Slope Distance" designLocation="Final Surface">-25.00 4.00 </CrossSectPnt>
        <CrossSectPnt desc="ditch bottom" dataFormat="Slope Distance" designLocation="Final Surface">0.00 2.00 </
CrossSectPnt>
        <CrossSectPnt dataFormat="Slope Distance" designLocation="Final Surface">25.00 4.00 </CrossSectPnt>
        <CrossSectPnt dataFormat="Slope Distance" connectionType="dayLight" designLocation="Final Surface">50.00 19.21 </
CrossSectPnt>
    </DesignCrossSectSurf>
    </DesignCrossSectSurfs>
    <DesignCrossSectSurfs side="left">
        <DesignCrossSectSurf name="lane" closedVolume="true" material="asphalt" typicalThickness="1.0" typicalWidth="14.0"
desc="right travel lane">
            <CrossSectPnt connectionType="inner" designLocation="Final Surface" dataFormat="Offset Elevation">0.00 627.717 </
CrossSectPnt>
            <CrossSectPnt connectionType="outer" designLocation="Final Surface" dataFormat="Offset Elevation">-14.00
627.437 </CrossSectPnt>
            <CrossSectPnt designLocation="Datum" dataFormat="Offset Elevation">-14.00 626.437 </CrossSectPnt>
            <CrossSectPnt designLocation="Datum" dataFormat="Offset Elevation">0.00 626.717 </CrossSectPnt>
        </DesignCrossSectSurf>
        <DesignCrossSectSurf name="curb and gutter" closedVolume="true" material="concrete" desc="curb and gutter">
            <CrossSectPnt connectionType="inner" dataFormat="Offset Elevation" designLocation="Final Surface">-14.00
627.437 </CrossSectPnt>
            <CrossSectPnt dataFormat="Offset Elevation" designLocation="Final Surface">-17.00 627.257 </CrossSectPnt>
            <CrossSectPnt dataFormat="Offset Elevation" designLocation="Final Surface">-17.04 628.000 </CrossSectPnt>
            <CrossSectPnt connectionType="outer" dataFormat="Offset Elevation" designLocation="Final Surface">-17.54
628.000 </CrossSectPnt>
            <CrossSectPnt dataFormat="Offset Elevation" designLocation="Datum">-17.54 626.51 </CrossSectPnt>
            <CrossSectPnt dataFormat="Offset Elevation" designLocation="Datum">-14.00 626.51 </CrossSectPnt>
        </DesignCrossSectSurf>
        <DesignCrossSectSurf name="inner buffer" material="grass" closedVolume="false" typicalWidth="2.00">
            <CrossSectPnt dataFormat="Slope Distance" connectionType="outer" designLocation="Final Surface">0.00 -2.00 </
CrossSectPnt>
    </DesignCrossSectSurf>
    <DesignCrossSectSurf name="sidewalk" closedVolume="true" material="concrete" typicalThickness="0.44"
typicalWidth="4.0" desc="right sidewalk">
        <CrossSectPnt connectionType="inner" designLocation="Final Surface" dataFormat="Offset Elevation">-19.54 628.00 </
CrossSectPnt>
        <CrossSectPnt connectionType="outer" designLocation="Final Surface" dataFormat="Offset Elevation">-25.54 628.00 </
CrossSectPnt>
        <CrossSectPnt designLocation="Datum" dataFormat="Offset Elevation">-25.54 627.66 </CrossSectPnt>
        <CrossSectPnt designLocation="Datum" dataFormat="Offset Elevation">-19.54 627.66 </CrossSectPnt>
    </DesignCrossSectSurf>
    <DesignCrossSectSurf name="outer buffer" material="grass" closedVolume="false" typicalWidth="3.00">
        <CrossSectPnt dataFormat="Slope Distance" connectionType="outer" designLocation="Final Surface">0.00 -3.00 </
CrossSectPnt>
    </DesignCrossSectSurf>
    <DesignCrossSectSurf name="right ditch" material="grass" closedVolume="false" typicalWidth="4.00">
        <CrossSectPnt dataFormat="Slope Distance" designLocation="Final Surface">-25.00 -4.00 </CrossSectPnt>
        <CrossSectPnt desc="ditch bottom" dataFormat="Slope Distance" designLocation="Final Surface">0.00 -2.00 </
CrossSectPnt>
        <CrossSectPnt dataFormat="Slope Distance" designLocation="Final Surface">25.00 -4.00 </CrossSectPnt>
        <CrossSectPnt dataFormat="Slope Distance" connectionType="dayLight" designLocation="Final Surface">50.00 -14.56 </
CrossSectPnt>
    </DesignCrossSectSurf>
    </DesignCrossSectSurfs>
</CrossSect>
</CrossSects>
</Alignment>

```


Example: Two lane road design cross section





Road design cross section conventions:

- All offset values are measured from the PGL and are horizontal measurements.
- + offsets to the right, - to the left of and way from the PGL.
- + slopes increase from PGL, - slopes decrease.
- Right side closed volume surface point are defined clockwise from the top most point down.
- Left side closed volume surface point are defined counter-clockwise from the top most point down.
- Inner connection points begin from PGL, the previous closed volume surface outer connection point or after a simple slope/offset point.

Changes to Pipes**Added <Center> element:**

The Center point of the Pipe is the “point of center” on the curved pipe arc. If this optional element is specified, then the pipe starts at refStart, passes through the <Center> point, and end at refEnd.

Added <EggPipe>:

Same attributes as elliptical pipe, but represents an egg shaped pipe cross section.

LandXML-1.1.xsd Schema Changes since October 22, 2004 (working draft date March 4, 2005)

Summary of Changes

4. Changed <CoordinateSystem> to support common EPSG coordinate system names shared by OpenGIS and GML schemas. Attribute "fileLocation" is no longer required.
5. Allow duplicate "name" attributes across collections of same element type.
6. Added railway cant (superelevation) data to <Alignment>.
7. Added additional data structure to support electronic Australian cadastral survey system.

Schema Change Details

1. <CoordinateSystem> changes to support EPSG coordinate system

Rather than define our own global coordinate system dictionary, it is proposed that we use the most comprehensive dictionary available and actively maintained. This simplifies LandXML coordinate systems to reuse the extensive coordinate systems dictionary work done by EPSG (European Petroleum Survey Group, <http://www.epsg.org>). See <http://www.ihsenergy.com/epsg/epsg21.html> for EPSG coordinate systems details. LandXML can reference a simple numeric EPSC code to refer to specific and complex coordinate system details of all know types (2D, 3D, projected, etc...).

New <CoordinateSystem>.epsgCode attribute represents the EPSG numeric code for a specific coordinate system. EPSG has reserved the integer range 0 to 32767 for use as codes for coordinate systems.

Example: Represents Australian Map Grid Zone 52

name="AGD66 - AMG Zone 52" , epsgCode="20252"

Example: Represents Colorado CS27 South Zone

name="NAD27-Colorado South" , epsgCode="26755"

For software developers a complete Microsoft Access .mdb database and SQL script for creating the database tables for the coordinate systems is provided by EPSG.

2. Allow duplicate “name” attributes across collections of same element type

LandXML-1.0 specified that all elements of the same type must have a unique “name” attribute across the entire data file. This uniqueness spanned multiple collections of the element.

The net result of this change will enforce unique element names within the same element collection (Parcels, CgPoints, Structs, Pipes, etc...), while allowing references or separate definitions to occur in another collection of the same element type. This reduces the scope of unique names to collections of the same element type.

For example

```
<CgPoints name="Set Points">
  <CgPoint name="1" code="PCOR">1145.99755444 -626.27773323 0.000000</CgPoint>
  <CgPoint name="2" code="PCOR">1759.50228244 -493.99972666 0.000000</CgPoint>
</CgPoints>
<CgPoints name="Property Corners">
  <CgPoint name="1" pntRef="1"/>
  <CgPoint name="2" pntRef="2"/>
</CgPoints>
```

Having the same COGO point appear in multiple point collections or groups is not allowed in LandXML-1.0. The intent of this example is to reuse points 1 and 2 in a separate point group to refer to the original coordinate value.

```
<Parcels name="Block A">
  <Parcel name="1" />
  <Parcel name="2" />
</Parcels>
<Parcels name="Block B">
  <Parcel name="1"/>
  <Parcel name="2" pclRef="2"/>
</Parcels>
```

In the above <Parcel> example, Block B parcel “1” is it’s own definition, separate from Block A parcel “1”. Block B parcel “2” references Block A parcel “2” by using the new pclRef attribute.

3. Railway cant (superelevation)

(Provided by Richard Bradshaw, Bentley Systems)

The following represents a formal implementation for cant within the LandXML schema.

<Alignment>.<Cant>

The following schema fragment:

```
<xs:element name="Cant">
  <xs:annotation>
    <xs:documentation>The "Cant" element will typically represent a proposed railway cant
/ superelevation alignment.</xs:documentation>
```



```

    <xs:documentation>It is defined by a sequential series of any combination of the cant
stations and speed-only stations.</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence>
      <xs:choice maxOccurs="unbounded">
        <xs:element ref="CantStation" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="SpeedStation" minOccurs="0" maxOccurs="unbounded"/>
      </xs:choice>
      <xs:element ref="Feature" minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="name" type="xs:string" use="required"/>
    <xs:attribute name="desc" type="xs:string" use="optional"/>
    <xs:attribute name="state" type="stateType" use="optional"/>
    <xs:attribute name="equilibriumConstant" type="xs:double" use="optional"/>
    <xs:attribute name="appliedCantConstant" type="xs:double" use="optional"/>
    <xs:attribute name="gauge" type="xs:double" use="required"/>
    <xs:attribute name="rotationPoint" type="xs:string" use="optional"/>
  </xs:complexType>
</xs:element>

```

- The “name”, “desc” and “state” attributes are typical LandXML “alignment” attributes.
- The “equilibriumConstant” is a unitless optional double that is used as the equilibrium constant in the cant equilibrium equation ($\text{cant} = \text{constant} * \text{speed} * \text{speed} / \text{radius}$).
- The “appliedCantConstant” is a unitless optional double that is used as the applied cant constant in the cant equilibrium equation ($\text{cant} = \text{constant} * \text{speed} * \text{speed} / \text{radius}$).
- The “gauge” is a required double that is the rail to rail distance. This value is expressed in meters or feet depending upon the units.
- The “rotationPoint” is an optional string that defines the rotation point. Valid values are “insideRail”, “outsideRail”, “center”, “leftRail” and “rightRail”.

<Alignment>.<Cant>.<CantStation>

The following schema fragment:

```
<xs:element name="CantStation">
  <xs:annotation>
    <xs:documentation>A cant station.</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:attribute name="station" type="xs:double" use="required"/>
    <xs:attribute name="equilibriumCant" type="xs:double" use="optional"/>
    <xs:attribute name="appliedCant" type="xs:double" use="required"/>
    <xs:attribute name="cantDeficiency" type="xs:double" use="optional"/>
    <xs:attribute name="cantExcess" type="xs:double" use="optional"/>

    <xs:attribute name="rateOfChangeOfAppliedCantOverTime" type="xs:double" use="optional"/>
    <xs:attribute name="rateOfChangeOfAppliedCantOverLength" type="xs:double" use="optional"/>
    <xs:attribute name="rateOfChangeOfCantDeficiencyOverTime" type="xs:double" use="optional"/>
    <xs:attribute name="cantGradient" type="xs:double" use="optional"/>
    <xs:attribute name="speed" type="xs:double" use="optional"/>
    <xs:attribute name="transitionType" type="spiralType" use="optional"/>
    <xs:attribute name="curvature" type="clockwise" use="required"/>
    <xs:attribute name="adverse" type="xs:boolean" use="optional"/>
  </xs:complexType>
</xs:element>
```

- The “station” is a required double that is internal station value.
- The “equilibriumCant” is an optional double that is the equilibrium cant. This value is expressed in millimeters or inches depending upon the units
- The “appliedCant” is a required double that is the applied cant. This value is expressed in millimeters or inches depending upon the units.
- The “deficiencyCant” is an optional double that is the cant deficiency. This value is expressed in millimeters or inches depending upon the units.
- The “cantExcess” is an optional double that is the cant excess. This value is expressed in millimeters or inches upon the units.
- The “rateOfChangeOfAppliedCantOverTime” is an optional double that is the rate of change of applied cant as a function of time. This value is in millimeters /seconds or inches/seconds depending upon the units.
- The “rateOfChangeOfAppliedCantOverLength” is an optional double that is the rate of change of applied cant as a function of length. This value is in millimeters /meters or inches/feet depending upon the units.
- The “rateOfChangeOfCantDeficiencyOverTime” is an optional double that is the rate of change of cant deficiency as a function of time. This value is in millimeters /seconds or inches/seconds depending upon the units.
- The “cantGradient” is an optional double that is the cant gradient. This value is unitless.
- The “speed” is an optional double that is the design speed. This value is in kmph or mph depending upon the units.
- The “transitionType” is an optional enumerated type.
- The “curvature” is a required enumerated type.
- The “adverse” is an optional Boolean that indicates whether the cant is adverse.

<Alignment>.<Cant>.<SpeedStation>

The following schema fragment:

```
<xs:element name="SpeedStation">
  <xs:annotation>
    <xs:documentation>A cant speed-only station.</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:attribute name="station" type="xs:double" use="required"/>
    <xs:attribute name="speed" type="xs:double" use="required"/>
  </xs:complexType>
</xs:element>
```

The “station” is a required double that is internal station value. The “speed” is an optional double that is the design speed. This value is in kmph or mph depending upon the units.

4. Changes to support electronic Australian cadastral survey system

(Provided by Nevil Cumerford, Bureau of Land Information and Titles, Queensland, Australia)

New Elements

<AdministrativeArea> – this element allows us to add geocode areas such as localities, town, county, local government this would enable the current schema to fit into almost any jurisdiction.

<Annotation> – this element allows the user to make legal annotation within the file in a format that can be easily verified and allow the operation of business rules.

<SurveyCertificate> – the element gives the user the ability to make certifications in relationship to accuracy and compliance with regulations etc required for the legal processing of the survey.

<Amendment> – this element allows us to have an explicit audit trail of changes within the file to allow for legal traceability of changes.

<AmendmentItem> – this element is used in conjunction with the Amendment element

<RedHozizontalPosition> – this element allows the user to transfer data related directly to the reference frame rather than the survey itself, for example a VRS Point Position on a control mark.

<RedVerticalPosition> – this is to allow for the direct publishing of heights etc.

<Coord3DGeom> – this element allows us to represent 3 dimensional or volumetric parcels.

The following elements have been extended:

Parcel – Required additions to enable the definition of 3D parcels. This included the attributes of Parcel Format, Use of Parcel, Volume, Building and floor number. We have also added an attribute of pclRef which uses the defined type of parcelNameRefs to enable us to explicitly create relationships between created parcels and existing parcels.

Survey Header – Addition of several attributes mainly related to jurisdictional processing, ie what state is it in, what legislation are we performing the survey under etc.

ReducedObservation and ReducedArcObservation have been extended to include a couple more distance types, ie the inclusion of spheriodial Distances and Mean Sea Level Distances.

Increased Enumerations

We have added a couple of enumerations in various locations.

- Observation Type
 - Deduced – this is different to scaled, scaled has the connotation of some rigour
 - Balance – this is the subtraction of a measured distance from an adopted measurement ie it has the same characteristics as an adopted line but different.
- Parcel Class has had several enumerations added primarily for 3D Cadastre.
- Monument Type has been expanded
- Monument Condition has been expanded

Most of the new attributes added have been given a specific type so that each jurisdiction can add their own variations. These appear in the XSD as types but with no enumerations, examples of Queensland's Enumerations are given in the Model CIF Document.

We have included “name” in most of the new elements and added it to some existing elements where it was missing, this is so that we can track amendments to these elements for legal audit purposes.

We have also set the “name” attributes of the new elements as unique within the schema, we also found some original elements where the “name” attribute was used but uniqueness was not enforced.

LandXML-1.1.xsd Schema Changes since July 17, 2002

The intent for this revision of the LandXML schema is to make corrections and add support for additional data based on real world data exchange by over 40 LandXML supported applications. There will not be any drastic model changes that will cause significant work to update the existing applications.

Summary of Changes

1. Clarify what is meant by “zenithAngle” in the survey data.

2. Add support for PI based alignment definitions.

Schema Change Details

1. New zenithAngle simple type definition

To clarify the angular measurement for zenithAngle, a new angle type called zenithAngle has been created:

```
<xs:simpleType name="zenithAngle">
  <xs:annotation>
    <xs:documentation>Represents zenith angles with the 0 origin as
    straight up and measured in a clockwise direction in the specified
    Angular units.</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:double"/>
</xs:simpleType>
```

This new angle type replaces type 'ang' in <Survey>..< RawObservation>.zenithAngle, <Survey>..< ReducedObservation>.zenithAngle and <Survey>..< PointResults>.meanzenithAngle as the type.

Prior definition example:

```
<xs:attribute name="zenithAngle" type="ang" use="optional"/>
```

Current definition example:

```
<xs:attribute name="zenithAngle" type="zenithAngle" use="optional"/>
```

2. PI based Alignment element changes and additions

Added new alignment geometry type to support PI based alignments.

Instead of just a <CoordGeom> element, there is now a choice between <CoordGeom> and <AlignPIs>.

```
<xs:element name="Alignment">
  <xs:annotation>
    <xs:documentation>geometric horizontal alignment, PGL or chain typically representing
    a road design center line</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:choice maxOccurs="unbounded">
      <xs:choice>
        <xs:element ref="Start" minOccurs="0"/>
```



```

        <xs:element ref="CoordGeom"/>
        <xs:element ref="AlignPIs" minOccurs="0" maxOccurs="1"/>
    </xs:choice>
    ....
</xs:element>

```

The definition for the new <AlignPIs> added as follows:

```

<xs:element name="AlignPI">
    <xs:annotation>
        <xs:documentation>A Single Alignment PI Definition</xs:documentation>
    </xs:annotation>
    <xs:complexType>
        <xs:all>
            <xs:element name="Station" type="xs:double">
                <xs:annotation>
                    <xs:documentation>Station Name</xs:documentation>
                </xs:annotation>
            </xs:element>
            <xs:element ref="PI"/>
            <xs:element name="InSpiral" minOccurs="0">
                <xs:annotation>
                    <xs:documentation>In Spiral Definition</xs:documentation>
                </xs:annotation>
            <xs:complexType>
                <xs:all>
                    <xs:element ref="Spiral"/>
                </xs:all>
            </xs:complexType>
        </xs:element>
        <xs:element name="Curve1" minOccurs="0">
            <xs:annotation>
                <xs:documentation>First Curve Definition</xs:documentation>
            </xs:annotation>
            <xs:complexType>
                <xs:all>
                    <xs:element ref="Curve"/>
                </xs:all>
            </xs:complexType>
        </xs:element>
        <xs:element name="ConnSpiral" minOccurs="0">
            <xs:annotation>
                <xs:documentation>Connecting Spiral Definition</xs:documentation>
            </xs:annotation>
            <xs:complexType>
                <xs:all>

```

```

        <xs:element ref="Spiral"/>
      </xs:all>
    </xs:complexType>
  </xs:element>
  <xs:element name="Curve2" minOccurs="0">
    <xs:annotation>
      <xs:documentation>Second Curve Definition</xs:documentation>
    </xs:annotation>
    <xs:complexType>
      <xs:all>
        <xs:element ref="Curve"/>
      </xs:all>
    </xs:complexType>
  </xs:element>
  <xs:element name="OutSpiral" minOccurs="0">
    <xs:annotation>
      <xs:documentation>Out Spiral Definition</xs:documentation>
    </xs:annotation>
    <xs:complexType>
      <xs:all>
        <xs:element ref="Spiral"/>
      </xs:all>
    </xs:complexType>
  </xs:element>
</xs:all>
</xs:complexType>
</xs:element>

<xs:element name="AlignPIs">
  <xs:annotation>
    <xs:documentation>A sequential list of Alignment PI Definitions</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence minOccurs="2" maxOccurs="unbounded">
      <xs:element ref="AlignPI"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>

```