International Association of Oil & Gas Producers

REPORT
640

DECEMBER
2022

Guidelines for delivery and use of the Land Survey Data Model

Acknowledgements

This Report was authored by the Geomatics Committee.

Front cover photography used with permission courtesy of
© Ekkasit919/iStockphoto and © noomcpk/Shutterstock

About

Topographic and other features mapped during land surveys in oil and gas exploration and production are currently collected in a variety of CAD, GIS, ASCII and other file types and formats. This leads to difficulties in management of the survey data, including integration of such data within corporate databases and data management systems, and in the external exchange and sharing of the data with partners, regulators, and other parties.

The IOGP Land Survey Data Model was established to define a standard GIS data model for land surveys, addressing the need for a common structure for storing, managing, and visualizing onshore survey data. It provides a consistent approach for spatial visualization, data sharing and integration, through predefined entities and attributes. LSDM is intended to complement the existing IOGP Seabed Survey Data Model (SSDM).

REPORT 640 | DECEMBER 2022

Guidelines for delivery and use of the Land Survey Data Model

Revision history

VERSION	DATE	AMENDMENTS
1.0	December 2022	First release

Contents

Introduction

This guideline is published by the International Association of Oil & Gas Producers (IOGP) Geomatics Committee. Use of this document does not require IOGP Membership and IOGP is not obliged to provide support for the use of this guideline and the associated Land Survey Data Model (LSDM) and is not liable for any consequences that arise from use of the LSDM.

The LSDM is a geodatabase data template that standardizes the structure, attribution and presentation of land survey data. This document describes the LSDM and provides guidance on the structure, delivery and use of the data model for contractors supporting, and oil and gas companies operating onshore exploration licences, production installations and associated infrastructure.

Please visit the IOGP Geomatics Committee page to download the following documents and materials:

- Geodatabase template – a data model template to be used for the storage and exchange of GIS land and topographic survey data deliverables. This is provided as follows:
    a. enterprise architecture project (.eap). Source file for xml, logic and conceptual diagrams, and the LSDM data dictionary
    b. XML schema (.xml). Provided for physical implementation in any ESRI geodatabase
    c. ESRI file geodatabase (.gdb). Provided as an example
- Data Dictionary – detailed definition of data model structure and hierarchy of the LSDM Data Model and provides the details of each feature class and object class, along with the list of associated domains and symbology codes
- Guidelines on delivery and use of the LSDM – basic guidelines on how oil and gas companies and contractors should utilize the LSDM (this document).

Oil and gas companies should use the LSDM to define standard requirements for survey data deliverables. They may extend the data model by adding feature datasets, feature classes, domains and feature attributes for example, to address any company-specific requirements. This guideline is based on the LSDM GIS data model template (developed on the ESRI geodatabase and ArcGIS software) as provided on the IOGP Geomatics Committee web site (Reference 1).

The LSDM provides a core list of symbology codes and associated symbology styles in CAD and GIS format for the LSDM feature classes. End clients may extend the existing symbology codes with additional codes and symbols of their own, and/or define their own cartographic symbols for existing core codes, although the latter is not recommended.

The same technical principles defined herein apply if an oil and gas company uses other GIS database formats and software to implement the LSDM, however detailed methodology on this option is beyond the scope of this document. Industry de facto or vendor-proprietary data formats for the various survey equipment and sensor types are not discussed here, but are assumed to be part of the survey deliverables as specified by the oil and gas company, for example:

- Point clouds, XYZ files, LAS files (e.g., for topography)
- Digital Terrain or Digital Elevation Models (DTM, DEM)
- Satellite and aerial photography imagery, mosaics
- As-built listings

- Sample location listings and results/reports
- Associated maps and charts showing processed data and interpreted results
- SEG-Y, SEG-D and IOGP P-format files
- Other raw, semi-raw and processed data plus calibration, verification results etc.

Survey data and results are often delivered as CAD files for Front End Engineering Design purposes, electronic format map delivery etc. The CAD files should coexist with the GIS data deliverable and should be delivered in an agreed folder structure together with the other deliverables (see section 5). CAD deliverable specifications are beyond the scope of this document.

This data model applies to all oil and gas companies, contractors, and subcontractors (e.g., via installation or environmental consultancy contractors) involved in onshore survey data acquisition and delivery.

Users are encouraged to provide feedback to IOGP (publications@iogp.org) on their use and experience in deploying LSDM within their company, including any issues or gaps and suggestions for improvement and additional functionality. Feedback will be collated and considered for inclusion in future versions of the model.

1. The Land Survey Data Model

The LSDM provides abstract classes that define behavior, and core classes comprising tables that describe the features of interest to oil and gas companies. The model is designed to track key assets, documents, activities and survey results. For full conformance with the LSDM model, abstract and core classes should be implemented 'as-is'.

The design of the LSDM is based on the feature types acquired during land surveys, rather than on the survey type. This reduces data duplication and redundancy. The model enables the storage of key geospatial and non-geospatial descriptive and feature-specific elements of the following land-based survey activities (see Figure 1):

- Design, engineering and construction surveys of infrastructure and facilities including proposed routes, as-found, as-left, as-installed, and as-built positions; depth of burial; general/detail layout surveys etc. – for company or third-party facilities which may overlap or impact on E&P infrastructure (e.g., those owned or operated by utility companies)
- Land and topographic surveys, including elevation (contours, spot heights, relief shading, terrain modelling, etc.), natural and man-made features, explosive remnants of war (ERW), archaeological sites, and underground services surveys etc.
- Geodetic and survey control network surveys, including coverage, line of sight, monumentation, etc.
- Land survey measurements, survey line plans, and similar documentation for UAV/LiDAR operations or similar (planned and as-executed)
- Vegetation and land use surveys
- Imagery: from satellite, UAV, and crewed survey flights (satellite imagery, LiDAR, aerial photography, etc.)
- Right of Way (ROW) surveys and surveillance (ROW anomalies and observations): pipeline route surveys, pipeline and facility UAV inspection, access road surveys, etc.
- Administrative boundaries and cultural information (roads, railways, rivers, habitation, etc.)
- Geophysical/seismic, exploration and reconnaissance, geohazard, shallow and intermediate geology surveys
- Geotechnical soil investigations
- Environmental baseline and monitoring surveys
- Infrastructure condition and subsidence monitoring surveys

Variable national regulations regarding land survey data (e.g., land grid management) present a primary challenge for the development of a globally acceptable land survey data model. As such, the data model excludes country-specific requirements and focuses on the minimum and common spatial data requirements for land survey.

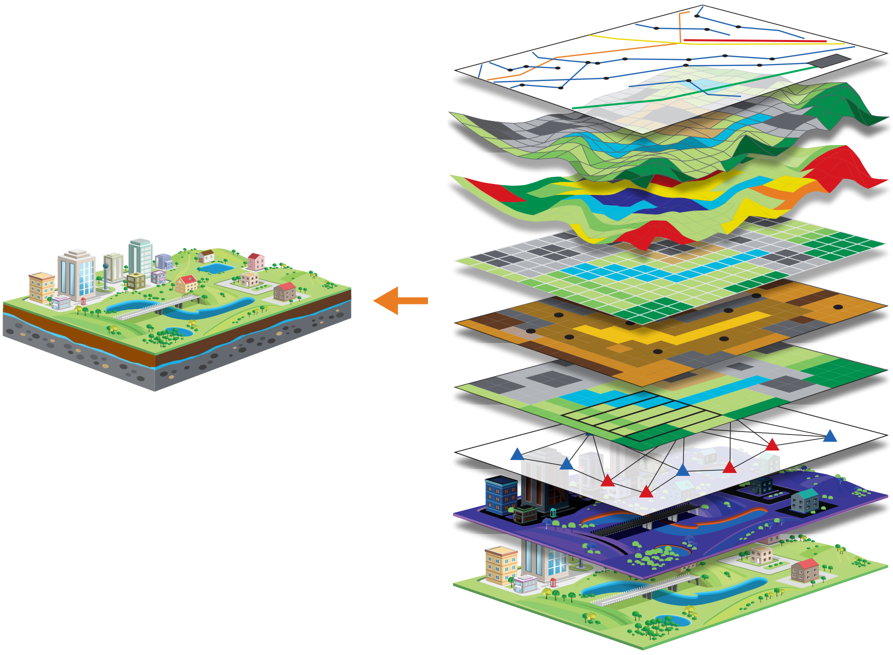

Figure 1: The conceptual framework diagram of the Land Survey Data Model

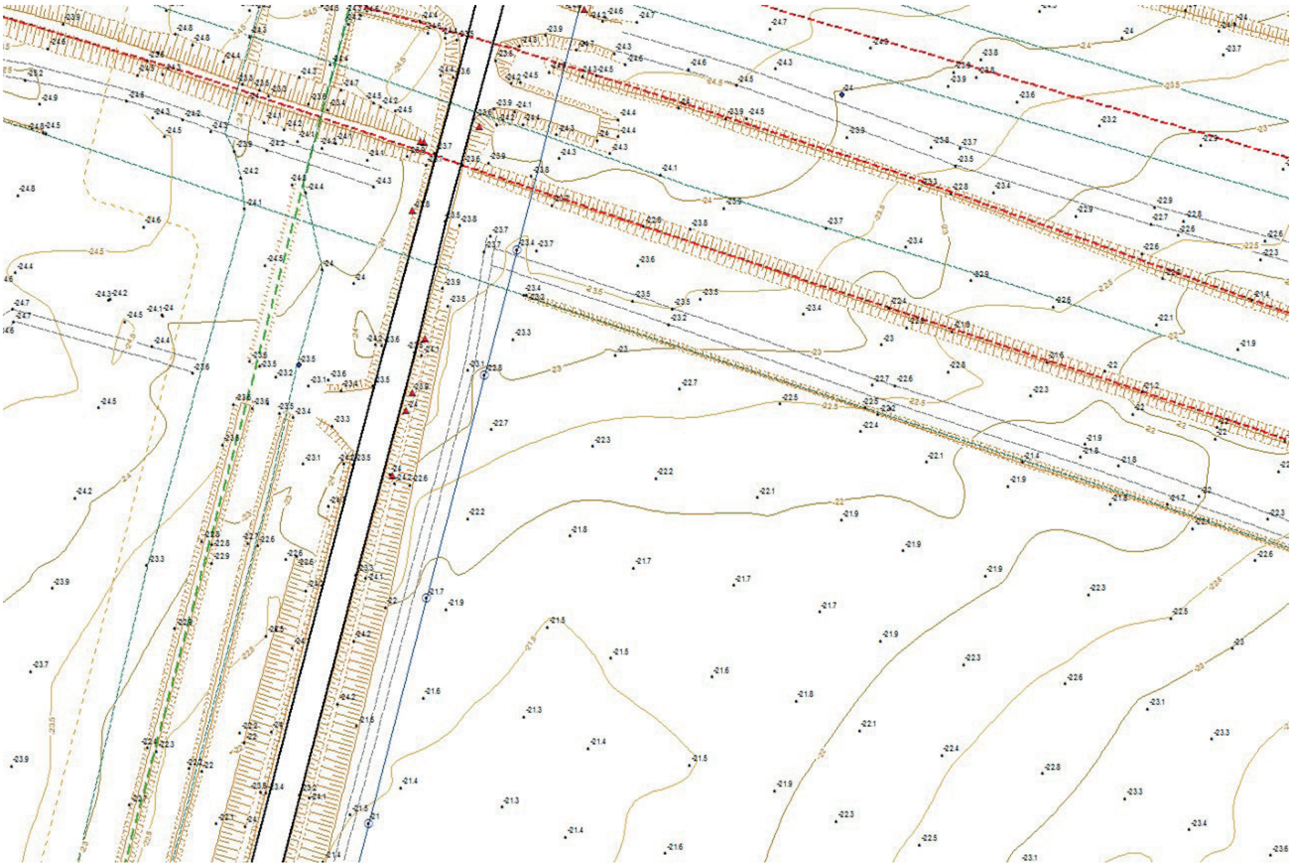

Figure 2: Example of topographic survey data 2D view.

2. Oil and gas company provisions

As part of utilizing the LSDM, the survey contractor should be supplied with:

- The LSDM standard components – template and descriptions – see Introduction for each element
- The survey job particulars – unique survey activity number
- The survey project Coordinate Reference System (CRS): horizontal and vertical, and which includes the defined units of measure, and any Epoch details as may be required for dynamic datums
- Any other relevant existing company data for the area of interest

2.1 The survey job particulars

The oil and gas company should provide a unique survey activity identification number and reference text for the survey job. This is required to allow the SURVEY_ID (number) and SURVEY_ID_REF (text) fields to be attributed within the feature classes inside the LSDM geodatabase. These fields act as relational keys and help define relationships within the geodatabase.

It is recommended that the oil and gas company pre-fill the following information in the geodatabase template, or supply the particulars for the survey project to the survey contractor, to be populated into the survey geodatabase:

- the "T_Survey_JobDetails" table with values for SURVEY_ID or SURVEY_ID_REF, project description, survey name, scope of work link, assurance plan link, client name, etc.
- the "Survey_Keysheet" feature class with a proposed survey extent and populate the SURVEY_ID or SURVEY_ID_REF, survey name, and survey type fields.
- the "Proposed_Survey_Run_Lines" feature class with the proposed survey design, unless the survey is designed by the contractor.
- if applicable, the proposed environmental and/or geotechnical sampling/coring and/or borehole locations are pre-filled in the "Geotechnical_Sample_Pnt" feature class, unless the locations are designed by the contractor.

2.2 The survey project Coordinate Reference Systems (CRS)

All coordinates should reference a single 3D or horizontal 2D CRS, or a compound CRS which includes horizontal 2D and vertical (1D) components, and if the CRS is dynamic, one coordinate epoch.

The CRS (and the coordinate epoch where relevant) is recorded in the *CRS and Coordinate Epoch* table. CRS information is defined either directly by using Well-Known Text (WKT) or indirectly by using a (geodetic) authority code or full OGC URI string that references the full CRS description.

The data model includes provision to record the sequence of coordinate operations applied in the process from raw survey data recording to final coordinate delivery. This allows verification of all coordinate operations performed on the dataset coordinates.

Appendix A contains a number of real-world examples that demonstrate how the CRS tables should be populated for different static and dynamic CRS scenarios.

Note: GIS software and applications implement varying support for 3D. The example CRS audit trails provided in Appendix A and specifically the indicated 'Is Current' CRS may not be relevant to all implementations of the data model. GIS software and application support for fully 3D CRS types is beyond the scope of this document.

Refer to the data dictionary for a detailed description of the data model schema.

The example template ESRI ArcGIS Geodatabase provided by the IOGP is referenced to the WGS 84 geographic 2D CRS (EPSG:4326) and the EGM2008 vertical CRS (EPSG:3855). Users may modify the CRS of the feature datasets within the Geodatabase using tools in ESRI ArcGIS software. Alternatively, users with access to the Enterprise Architect software application can choose to modify the CRS of the data model project file provided by IOGP and re-export ESRI XML for import into an empty geodatabase. It is recommended that the CRS set-up of the geodatabase is verified by a Geodetic/Survey specialist.

CRS and Coordinate Epoch

The *CRS and Coordinate Epoch* table is for recording:

1. The CRS to which coordinates within the dataset are referenced
2. The coordinate epoch to which coordinates within the dataset are referenced (where applicable)
3. The CRS(s) and coordinate epoch(s) to which coordinates within the dataset were previously referenced (where applicable)

Strictly, coordinate epoch is an attribute of coordinate data, not an attribute of the CRS. However, as all coordinates in the dataset should reference the same CRS and coordinate epoch, for convenience the CRS and coordinate epoch are placed in a single table in the data model. This table should record the survey acquisition CRS and, if the CRS is dynamic, the coordinate epoch together with all subsequent CRS and coordinate epochs which the dataset has referenced (the sequence of CRSs and the coordinate operations between these CRSs). For coordinates referenced to a dynamic CRS[1] it is mandatory to populate the *Coordinate Epoch* attribute field.

A compound CRS may be defined by populating either *CRS Authority Code* or *CRS WKT* attribute fields, or both. If the compound CRS cannot be defined by these methods, populate the table with separate horizontal and vertical component CRS and populate the *Compound CRS Horizontal Component* and *Compound CRS Vertical Component* attribute fields for the compound CRS. See examples 3a and 3b in Appendix A.

[1] In a dynamic CRS such as WGS 84, coordinates of a fixed point on the surface of the Earth change slowly with time. See the IOGP video at https://youtu.be/IKM-bR6SwVs and IOGP Guidance Note 373-25, "Dynamic versus static CRSs and use of the ITRF".

Except for a compound CRS, populate either the *CRS Authority Code* or the *CRS WKT* attribute fields or both. If both *CRS Authority Code* and *CRS WKT* attribute fields are populated but in conflict, the object full description *CRS WKT* should prevail over the *CRS Authority Code* reference.

The *CRS Authority Code* attribute field expects a character string that describes the CRS through a reference to its definition in a registry of geodetic definitions such as the EPSG Dataset. The character string may be a Compact URI (Uniform Resource Identifier), or 'CURIE', for which the format is "authority:code" or a full URI using the syntax below. Other definitions may be described using these strings but with the code value substituted.

	CRS Authority Code character string	Description
1	EPSG:23031	Shortened ('CURIE') form of the full OGC URI (see 6 below).
2	https://epsg.org/crs_23031/ED50-UTM-zone-31N.html	Returns the definition of EPSG CRS code 23031 in an HTML web page from the EPSG Georepository GUI.
3a	https://api.epsg.org/def/crs/epsg/0/23031/wkt	Returns the definition of EPSG CRS 23031 in Well-Known Text (WKT). It provides WKT indirectly through the *CRS_AUTH_CODE* attribute field rather explicitly in the *CRS_WKT* attribute field.
	or	
3b	https://epsg.org/crs/wkt/id/23031	
4a	https://api.epsg.org/def/crs/epsg/0/23031/gml	Returns the definition of EPSG CRS 23031 in resolvable Geographic Mark-up Language (GML). The GML for the CRS includes links to URI definitions of components of the CRS such as datum, map projection and coordinate system which need to be 'resolved' to create a GML document of the full CRS definition.
	or	
4b	https://epsg.org/crs/gml/id/23031	
5	https://api.epsg.org/def/crs/epsg/0/23031	Without any /wkt or /gml element the URI defaults to resolvable GML as (4a) above.
6	https://www.opengis.net/def/crs/EPSG/0/23031	This is a standard OGC syntax which is forwarded from OGC to the EPSG repository as the URI for resolvable GML as (4) above.

For coordinates referenced to a dynamic CRS, the coordinate epoch must be populated with the point in time to which the coordinates are referenced. The coordinate epoch should be cited as a decimal year in the Gregorian calendar, rounded to two decimal places. For example: "2017.45".

When a dynamic CRS is used and the coordinate epoch is not given and cannot be recovered, it is recommended that the missing information is recorded by populating this field with the value -9999.

Coordinate Operation

Coordinate operations include coordinate transformations and/or conversions from one CRS to another CRS. For dynamic CRSs, the *Coordinate Operation* table should also be used for recording point motion operations.

The *Coordinate Operation* table is for recording an auditable trail of coordinate operations that have been historically applied to coordinates within the dataset. The audit trail enables a user to return to the original or any intermediate dataset by undoing or reversing operations previously applied.

All coordinates within a dataset shall have the same unique coordinate operation audit trail.

For all coordinate operations, populate either *Coordinate Operation Authority Code* or *Coordinate Operation WKT* attribute fields, or both. If both *Coordinate Operation Authority Code* and *Coordinate Operation WKT* attribute fields are populated but in conflict, the object full description *Coordinate Operation WKT* should prevail over the *Coordinate Operation Authority Code* reference.

The *Coordinate Operation Authority* attribute field expects a character string that describes the coordinate operation through a reference to its definition in a registry of geodetic definitions such as the EPSG Dataset. The character string may be a Compact URI, or 'CURIE', for which the format is "authority:code" or a full URI using the syntax below. Other definitions may be described using these strings but with the code value substituted.

	COORD_OP_AUTH_CODE string	Description
1	EPSG:1311	Shortened ('CURIE') form of the full OGC URI (see 6 below).
2	https://epsg.org/transformation_1311/ED50-to-WGS-84-18.html	Returns the definition of EPSG transformation code 1311 in an HTML web page from the EPSG Georepository GUI.
3a	https://api.epsg.org/def/coordinateOperation/epsg/0/1311/wkt or	Returns the definition of EPSG coordinate operation code 1311 in Well-Known Text (WKT). It provides WKT indirectly through the *COORD_OP_AUTH_CODE* field rather than explicitly in the *COORD_OP_WKT* field.
3b	https://epsg.org/transformation/wkt/id/1311	
4a	https://api.epsg.org/def/coordinateOperation/epsg/0/1311/gml or	Returns the definition of EPSG transformation code 1311 in resolvable Geographic Mark-up Language (GML).
4b	https://epsg.org/transformation/gml/id/1311	
5	https://api.epsg.org/def/coordinateOperation/epsg/0/1311	Without any /wkt or /gml element the URI defaults to resolvable GML as (4a) above.
6	https://www.opengis.net/def/coordinateOperation/EPSG/0/1311	This is a standard OGC syntax which is forwarded from OGC to the EPSG repository as the URI for resolvable GML as (4) above.

2.3 Existing Company Data

Where applicable, the oil and gas company should provide the survey contractor with relevant pre-existing data for the survey area, either in native format or in LSDM format, if available. This includes, but is not limited to, any of the items listed in Section 2 above.

The oil and gas company and survey contractor should provide capable geo-information/geospatial management/survey specialists who can liaise with each other on LSDM deliverable requirements. Ensuring there is good engagement between company and survey contractor is fundamental to a positive outcome, particularly to ensure company-specific requirements are met.

3. The use of the LSDM template

The LSDM template typically should be used in the following manner:

1. The oil and gas company implements the core LSDM template and customizes the template where necessary, to include additional company-specific attributes, topology rules, and relationship classes. The oil and gas company then issues the template to their survey or installation contractor/s (for on-pass as required to their survey subcontractor/s) for a particular survey or installation project.

   The template should be embedded in company deliverable specifications, for example as part of a survey or installation contractor framework agreement, so that it can be used routinely, and LSDM becomes a standard deliverable for any relevant land survey work conducted on behalf of the oil and gas company.
2. The survey contractor/subcontractor first renames the template for the survey project, and populates the LSDM geodatabase either directly, or by data loading from other charting tools (e.g., CAD), and then completes the attribute entries. This is usually done by a Geospatial/GIS/CAD Specialist. The geodatabase file is then submitted to the oil and gas company, together with other external files and data types, such as CAD drawings, XYZ point clouds and LAS files, DTM/DEMs, images (e.g., TIFFS), unprocessed satellite data files, mosaics, as-built listings, SEG-Y, SEG-D, IOGP P-format, associated maps, charts, reports and data.
3. The same process is repeated for each survey project.
4. Within the oil and gas company, as well as for specific survey projects, the LSDM can act as a template for implementation of a corporate GIS database, such as the ArcSDE geodatabase.

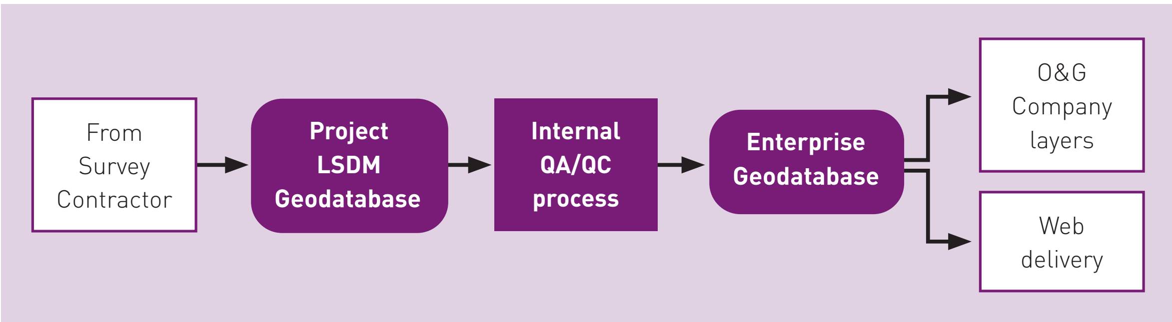

Figure 3: The IOGP LSDM workflow from survey contractor/installation contractor/survey subcontractor to oil and gas company of the delivery and management of relevant land survey data.

4. GIS data delivery requirements

4.1 LSDM Geodatabase

The LSDM geodatabase is the primary component of the GIS deliverable. This deliverable should be based on the LSDM template that is provided as part of this data model, and its general structure is shown in Figure 4. The schema contains 54 objects, organized into five feature data sets. The geodatabase template provided to the survey contractor should contain all of the feature data sets and feature classes, however, not all of these may be relevant for each survey type. For example, a topographic survey (for which an example output is depicted in Figure 2), does not involve the use of high-resolution seismic equipment (subsurface data is not acquired in this type of survey), and hence interpreted features would not be loaded to the Shallow Intermediate Geology features class. A general guideline indicating which land features belong to which LSDM geodatabase feature classes is provided in Appendix B.

Survey contractors are only expected to populate the relevant feature classes. This includes completing the attribute tables for each feature class that has been utilized. Note that an area of interest may be surveyed on multiple occasions using different techniques (topographic, environmental or geotechnical sampling, shallow seismic etc.), which would gradually build up the full dataset, filling out different feature classes with the results from the different surveys.

It is mandatory for the *survey keysheet* and *survey equipment limits* feature classes to be populated and attributed, as this provides important feature level metadata and survey information to the geodatabase user.

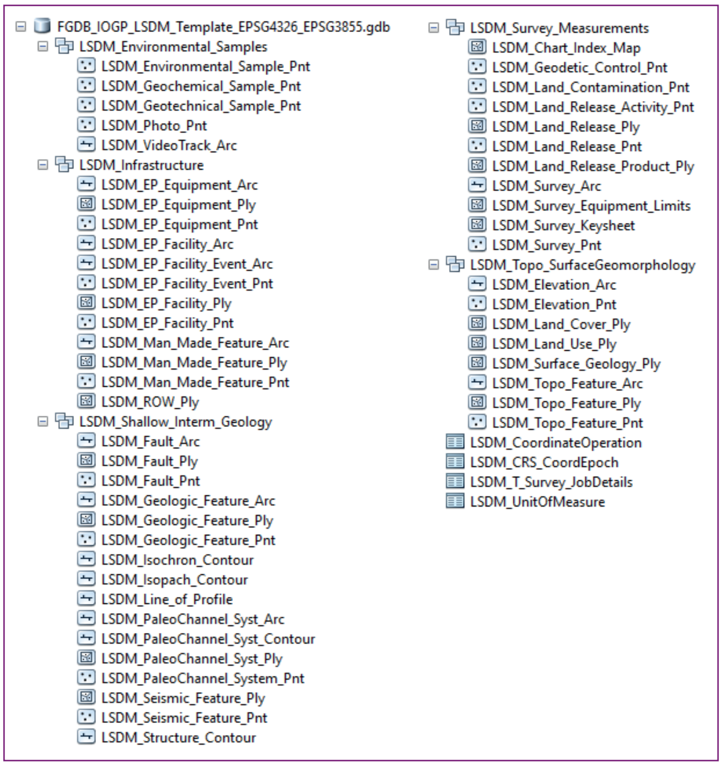

Figure 4: The LSDM geodatabase

4.1.1 Infrastructure

The infrastructure dataset aims to capture primarily the oil and gas company infrastructure assets, for example production facilities, control buildings, transmission pipeline systems and pipe/engineering features and events, safety and emergency systems and facilities, onsite company offices and accommodation etc.

General, non-company infrastructure data also should be captured in this dataset. This includes 'cultural' features that are not related to oil and gas company activity, for example public transport and utilities routes and systems – roads, railways and public rights of way, electric, fiber and domestic water lines etc.

4.1.2 Survey Measurements

Survey measurements is a class related to survey project management, data acquisition, charting, and processed data acquired from survey instrumentation. This class also captures International Mine Action Standards (IMAS) Land Release features (refer to Technical Note 07.11/01-2016 Land Release Symbology) – Reference 2.

4.1.3 Topography and Surface Geomorphology

Topographic characterization of the land area is an important element through an oil and gas facility life cycle, including access, planning, engineering, development, operations and decommissioning. Topography refers to the elevation, land terrain, geographical characterization, and surface geomorphology of area. This dataset also captures land cover and land use areas.

4.1.4 Environmental Samples

Environmental characterization of an onshore area (via baseline, impact assessment and monitoring processes, etc.) is an important aspect of oil and gas facilities management, from front end engineering and design through field development, operations, and maintenance to final decommissioning and retirement. This class includes physical, biological and chemical properties of the environment (soil, water, air, fauna, flora, etc.).

4.1.5 Shallow Intermediate Geology

Shallow and intermediate geology features may also be referred to as geohazard features. One of the most important objectives of a land shallow seismic or geohazard survey is the identification of shallow subsurface features that may be hazardous to drilling operations and / or the placement of infrastructure and facilities, for example the identification of shallow gas or liquids, unconsolidated soils or cavities, shallow faulting or other unconformities, bedrock, boulders etc.

4.1.6 Units of Measure

The LSDM includes a centralized reference table for units of measure ('UnitOfMeasure') for all of the objects in LSDM.

The measurements units in 'UnitOfMeasure' table should reference the Energistics Unit of Measure Standard

'UnitOfMeasure' can be joined to any table in the LSDM to examine units alongside the measurements.

The 'UnitOfMeasure' table is scalable to store multiple units for a specific field, differentiated by unique survey job numbers (Survey_ID or Survey_ID_Ref).

4.1.7 Hyperlinking Feature classes to Survey reports and survey data

Each respective feature class in the LSDM geodatabase may require a hyperlink to a data set, chart, or report, via a hyperlink attribute field. For example, the *survey keysheet* feature class contains a REPORT_URL field that enables the file path to be added to the survey report.

Similar fields exist for the:

- *Chart index map* (DRAWING_URL) – to populate the file path to the CAD or PDF file for maps or charts produced by the survey contractor.
- *Geotechnical sample* (DATA_URL and REPORT_URL) – to populate the file path to the geotechnical report and/or core logs.
- *Line of profile* (CHART_URL) – to populate the file path to a cross-section chart/diagram.

This enables users of the GIS project to locate the data, identify specific features and access associated information and files relating to the feature of interest, provided that the necessary data/document viewers are available. In essence, it allows users to conduct map-based searches for reports, charts, data, etc., that are associated with the survey project.

During data loading by the survey contractor (outside the oil and gas company's system environment), relative path names are required to define the location of any linked documents and data. During data loading to company data and information stores, it should be the responsibility of the oil and gas company to update these paths to absolute path names or hyperlink values, or to provide others means to relate or link the data and reports with the GIS project data.

4.1.8 Feature class metadata requirements

All feature classes utilized as part of the survey deliverable should be accompanied by suitable metadata statements. The metadata should detail, as a minimum, the feature class description, credits, acquisition and processing methodology (where relevant), any interpretation methodology used to produce the product, as well as quality and accuracy statements.

This metadata statement may be embedded into the geodatabase (as ISO 19139 style sheet) or as an external XML file, compiled with ISO 19139 XML implementation schema for ISO 19115 metadata standard – Reference 4.

The oil and gas company should specify their preferred metadata standard. ISO 19139 stylesheet or ArcGIS metadata stylesheet are acceptable metadata standards used by oil and gas companies. Where a standard is not specified, the ISO 19139 stylesheet is the recommended option as it improves compatibility with other software applications, especially when the survey results are part of an OGC cataloguing service.

The LSDM material available on the IOGP Geomatics Committee web site contains some basic metadata templates that may be used.

It should be noted that the attributes defined in the LSDM provide feature-level metadata within the feature classes. For example, the *survey keysheet* and *survey equipment limits* provide all the necessary information for a survey, e.g., survey dates, equipment used, equipment coverage, links to survey reports etc. The oil & gas company may extend the feature level metadata to meet their own requirements.

4.1.9 Renaming the LSDM geodatabase

The LSDM geodatabase template, as downloaded from the IOGP Geomatics Committee web site, has the following naming convention:

<Source>_<CRS>_<LSDM Version Number>_<Date>_<ArcGIS Version><file extension>

Example: IOGP_LSDM_Template_EPSG4326_EPSG3855_V1_01072020_10.mdb

for the delivery of a particular survey job, the recommended file naming convention is:

<SURVEY_ID_REF>_<CRS>_<LSDM Version Number>_<Date>_<ArcGIS Version>.<file extension>, where:

- SURVEY_ID_REF
  - This represents the oil and gas company's survey project naming convention, e.g., BR0034, BT21052012, PROJECT25 etc.
- Horizontal CRS Name*
  - Recommend use of the Horizontal CRS EPSG code
- Vertical CRS Name*
  - Recommend use of the Vertical CRS EPSG code
- ArcGIS Version
  - Should match the ArcGIS version being used to compile the geodatabase.
- File Extension
  - ESRI File Geodatabase (.gdb).

* If the CRS is 3D, then the single EPSG code should be used.

The oil and gas company should specify the preferred Geodatabase format to be used (and Application release version, where relevant). For large surveys where raster data (e.g., DEM, DTM) are being loaded to the geodatabase, care should be taken to ensure storage and application capability is sufficient for large files.

4.2 Raster data sets

As part of a land survey project, there will be some data sets that are best delivered in raster format, for example aerial photo mosaics and LiDAR imagery, terrain models, hill shade topography images, picked seismic horizons, etc. It is recommended that these are loaded as ESRI Raster/Mosaic data sets or as Terrain data sets. Alternatively, these raster files can be stored in the 'Images' folder as described in the deliverable folder structure discussed in section 5.

The recommended naming convention for raster data sets is:

<SURVEY_ID_REF>_<DataType>_<Subtype>, where:

- SURVEY_ID_REF
  - This represents the oil and gas company's survey project naming convention e.g. 05072020, BRO034, BTO21052012, PROJECT25 etc.
- DataType
  - LIDAR – DEM
  - UAV - Orthomosaic
- Subtype (optional)
  - Further description of raster data, e.g., HiRes, Smoothed, Raw etc.

By default, feature class metadata requirements are also applicable to raster data sets.

4.3 Layer Files and Symbology

Layer files can be set up once and re-used for subsequent survey projects. The LSDM geodatabase feature class contains the symbology code value in the SYMBOLOGY_CODE field which is in the following format:

IOGPXXXX e.g. IOGP3102 = Sand, IOGP3103 = Silt.

Based on these principles, ArcGIS layer files can be set up for each feature class (and raster, where applicable) utilized in the survey project. All related layer files can be made into group layer files. These group layer files will be based on the feature dataset themes set up inside the geodatabase, for example the Survey Measurements, Shallow Intermediate Geology and Environmental Samples group layers (see Figures 8 and 9).

4.4 General GIS Requirements

General requirements pertaining to the LSDM GIS deliverable that should be followed by the survey contractor are covered in the following subsections.

4.4.1 Software version

Where ESRI ArcGIS data deliverables are being used, they should be supplied in either ArcGIS Pro version 2.5 and above or ArcGIS Desktop version 10.5 and above, unless otherwise specified by the oil and gas company. The choice between ArcGIS Pro or Desktop should be defined by the oil and gas company based upon their internal software requirements. The survey contractor should liaise with the oil and gas company on the specific version of GIS software to be used.

4.4.2 Standard cartographic elements

As a general cartographic standard, a map document should have a map frame in layout/paper space and a map grid in real world/model space.

The following cartographic elements are recommended as minimum:

- Map title
- Legend
- Scale bar and relative scale
- North arrow
- Document control table including but not limited to Originator, Checker, Approver, Revision Number and Date
- Oil and gas company Document Reference Number, Project/Job Number
- Geodetic and projected CRS graticules and grids, including labels
- Horizontal and vertical CRS, including EPSG codes and names, and dynamic datum epoch (where applicable)
- Unit of Measurement Conversion Factor, e.g. Meter-Feet conversion factor
- The intended hard copy sheet size, such as A1, A2, A3, etc.
- File path and file name.

The map document may contain the layer files that were set up as described in Section 4.3 and the cartography elements for each chart, if either ArcGIS Desktop or ArcGIS Pro are used as the charting tool (Figures 5 and 6, respectively).

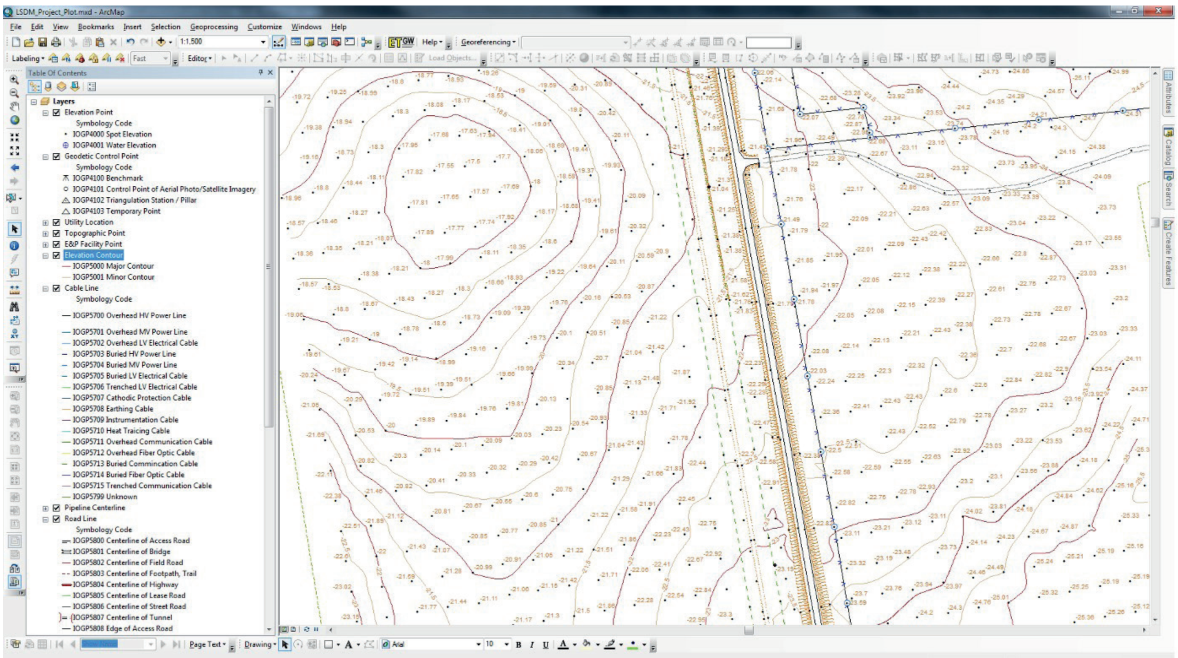

Figure 5: An example screenshot of an LSDM ArcGIS Desktop MXD that is set up with the correct symbology and layer structure.

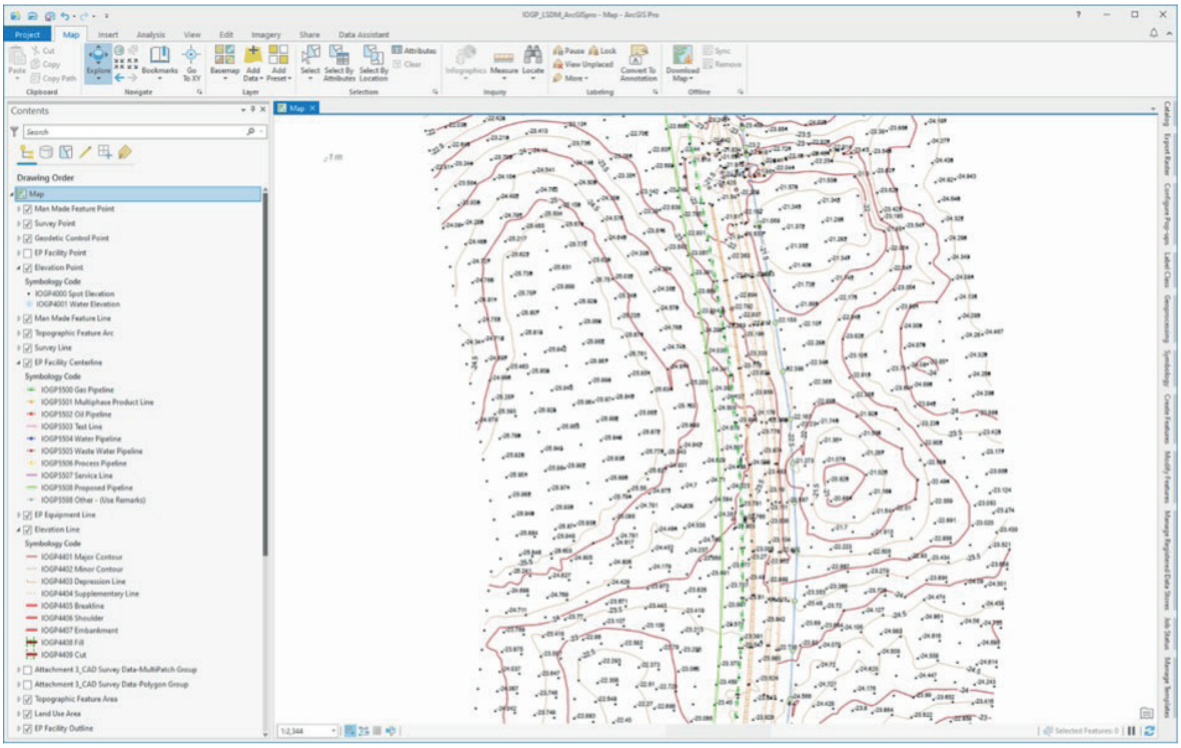

Figure 6: An example screenshot of an LSDM ArcGIS Pro Project (APRX) that is set up with the correct symbology and layer structure.

4.4.3 Topology rules

The survey contractor should observe the following topology rules during compilation of GIS data:

- No unresolved node errors or line segment intersections
- Line features should not contain under-shoots, over-shoots, or duplicate entities
- Unnecessary line splits should be removed and only occur at nodes and logical intersections
- No polygon slivers, no self-crossing polygon boundaries, no polygons with negative area
- No open polygons - all polygon features should be closed
- Line features, including contours, should not be broken, or gaps inserted for the sole purpose of placing a label (e.g., height value).

4.4.4 Raster and Geo-referenced Image

The Survey Contractor should observe the following rules during compilation of raster data sets:

- NO-DATA values should be set to No Data, RGB(0,0,0) or RGB(255,255,255)
- NO-DATA values should not be found inside image data area
- Include any associated DEMs, world files, and other files that may have been used for registering and rectifying as part of the delivery
- Include un-rectified source imagery as part of the delivery.

4.5 ArcMap Map Document (MXD) setup

Where an ArcMap Map Document (MXD) is required for the survey project (if specified by the oil and gas company), the MXD should be set up such that the data source options are set to 'relative path names' as shown in Figure 7.

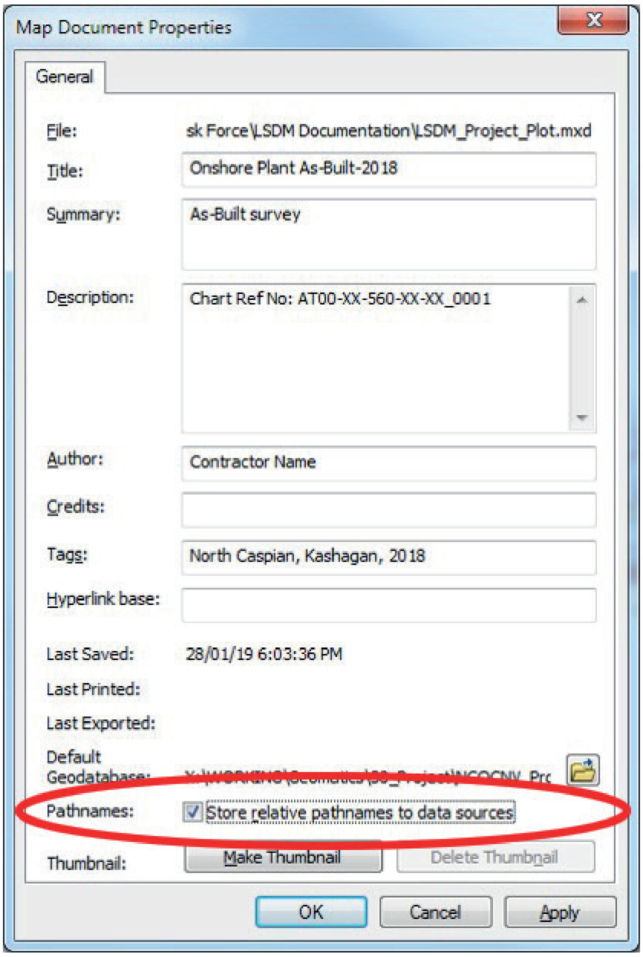

Figure 7: Setting up relative path names as the data source option in ArcMap (File>Map Document Properties)

5. Data delivery folder structure guidance

The recommended folder structures for the land survey data deliverables are illustrated in Figures 8 and 9, for ArcGIS Desktop and ArcGIS Pro respectively.

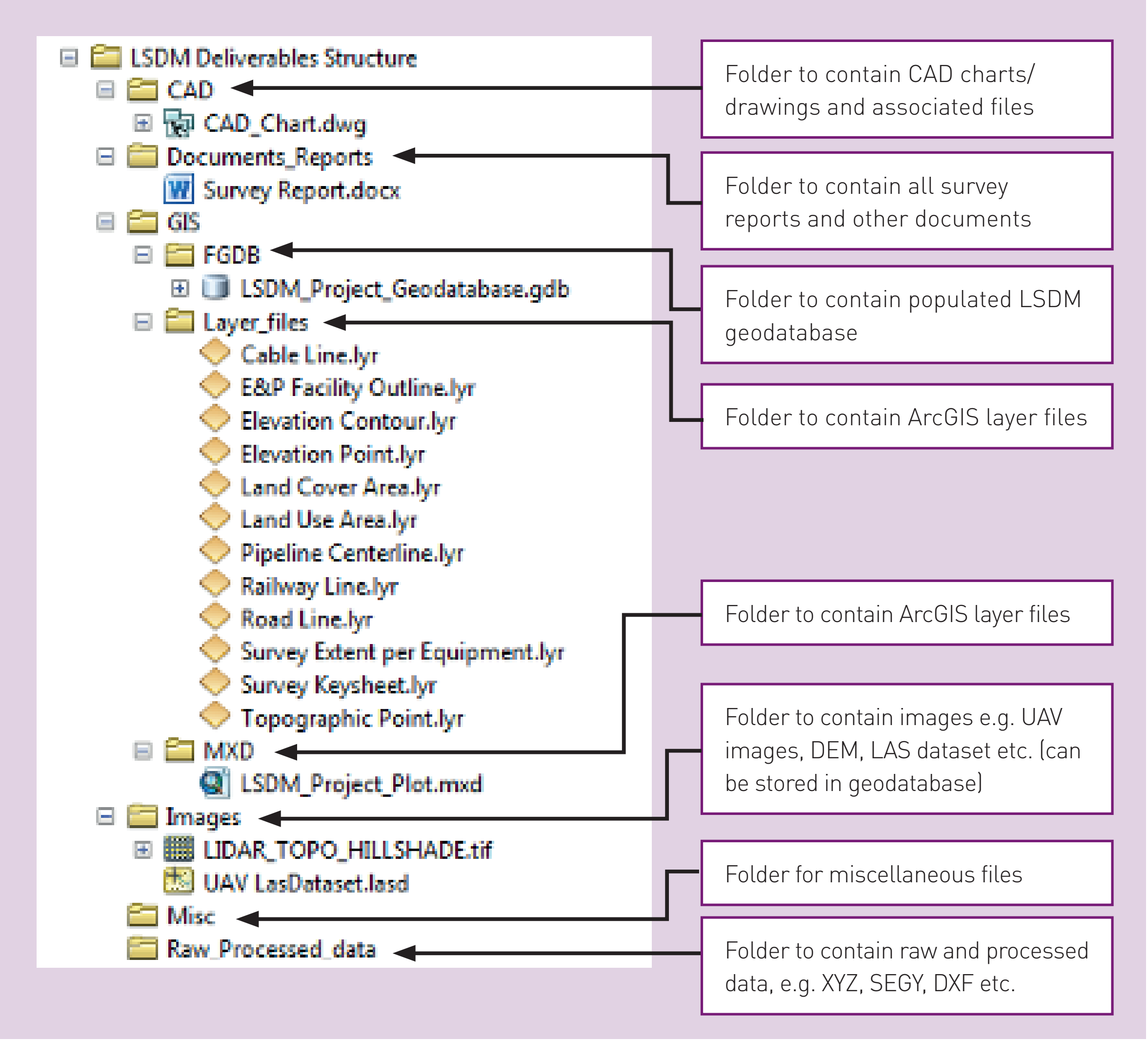

Figure 8: Recommended folder structure for data delivery – ArcGIS Desktop example

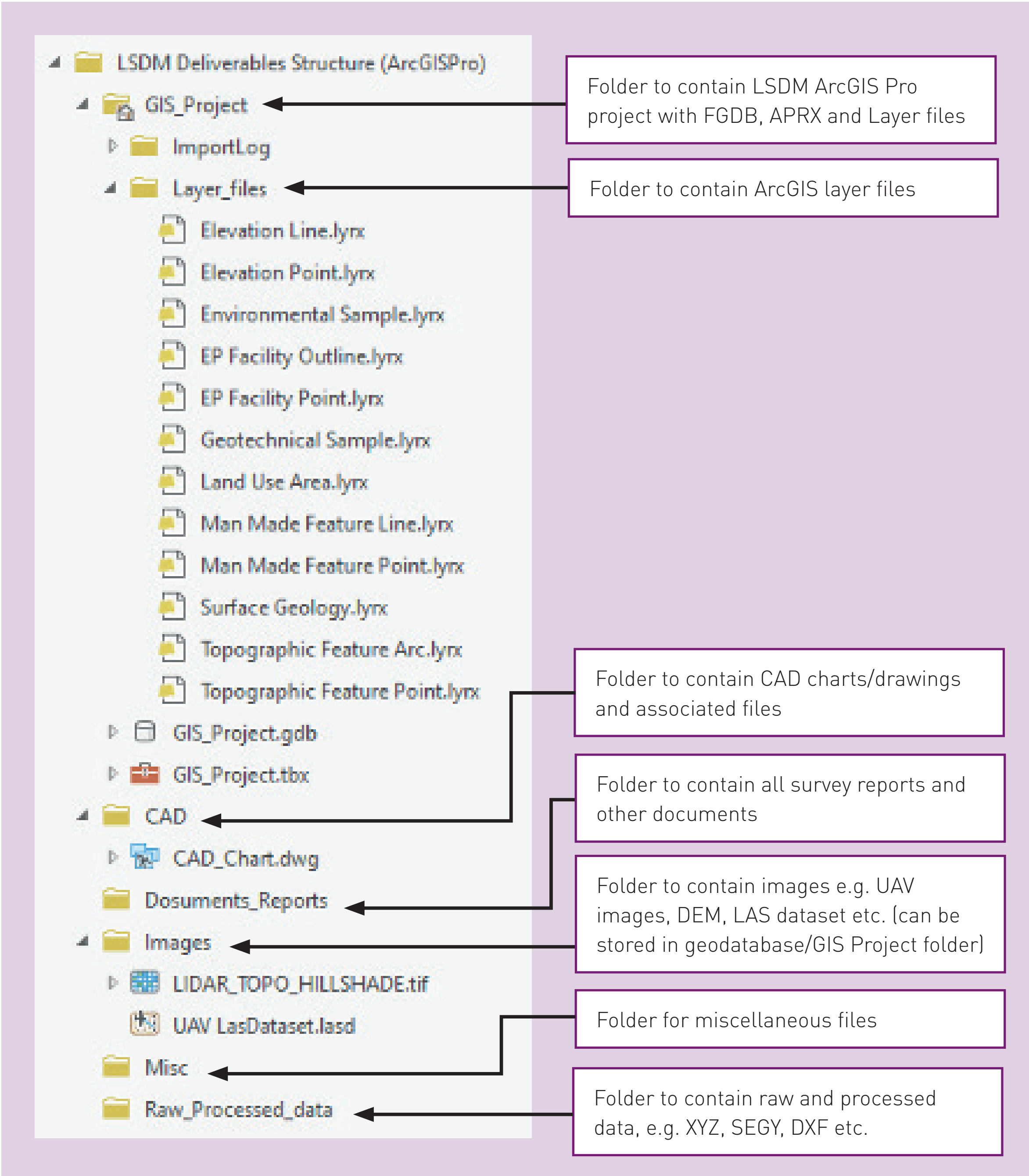

Figure 9: Recommended folder structure for data delivery – ArcGIS Pro example

This directory structure enables the delivery of all datasets from a survey, including the GIS deliverable (ESRI geodatabase, MXD, layers etc.), CAD deliverables, survey/processing reports and survey data formats such as SEGD/SEGY, XTF, GeoTIFF images, positioning data, etc. This allows all hyperlinks within the geodatabase feature classes to be set up using relative path names within this structure.

6. Governance, version management, and contractor feedback

Governance and version management of the LSDM model is under the custodianship of the IOGP Geomatics Committee, Geo-information Subcommittee. If, in the process of delivering survey results and data in the LSDM format, the survey contractor experiences issues with the model, it is encouraged to provide feedback directly to IOGP (publications@iogp.org).

Maintenance of the LSDM is considered to be the process of supporting the data model after delivery, in order to correct a significant problem or error in the existing data model, and to provide assistance, direction and coordination from six months to one year of issue of the model version, along with the delivery of any additional relevant documentation.

Enhancement of the LSDM is considered as the process of modifying the data model after delivery, and which is intended to increase or decrease functionality and capability from the existing design.

Abbreviations

ASCII	American Standard Code for Information Interchange
ASPRX	ESRI ArcGIS Pro Project
CAD	Computer-Aided Design
CURIE	Compact Uniform Resource Identifier
CRS	Coordinate Reference System
DEM/DTM	Digital Elevation Model/Digital Terrain Model
ESRI	Environment Systems Research Institute, Inc., owner of ArcGIS suite of software products including ArcGIS Enterprise, ArcGIS Pro and ArcSDE (Spatial Data Engine)
EPSG	Former 'European Petroleum Survey Group' acronym. It is now known as the Geomatics Committee of IOGP. One of the primary products of the group is the 'EPSG Registry', which defines and codifies CRSs globally, including their component parts (Datum and Projection details, Units of Measure etc.).
ERW	Explosive Remnants of War. Any military munitions hazards – objects buried or lying on the surface of land or seabed that have the potential to pose a risk to people or equipment.
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
IOGP	The International Association of Oil and Gas Producers
LIDAR	Light Detection and Ranging. LIDAR is a survey method that measures distance to a target by illuminating the target with pulsed laser light and measuring the reflections with a sensor
LSDM	Land Survey Data Model
MXD	ESRI ArcMap Document
O&G Company	Oil and Gas company (also sometimes referred to as 'Operator' or 'Exploration & Production' (E&P) Company)
OGC URN	Open Geospatial Consortium Universal Resource Name
ROW	Right of Way
SEG-Y, SEG-D, IOGP P-format	Society of Exploration Geophysicists 'Y-type' and 'D-type' geophysical data formats. IOGP Geophysical or Wellbore 'Position format' type data

UAV	Unmanned Aerial Vehicle. UAVs capture aerial imagery and perform asset inspections, topographic & route surveys etc. by recording detailed and accurate land survey and mapping data. They are also referred to as 'Un-crewed', and 'Vehicle' may be replaced by 'System' ('UAS'). Colloquially, they are often referred to as 'drones'
UML	Unified Markup Language
URI	Uniform Resource Identifier
WKT	Well Known Text
XYZ	Coordinate file listing of Easting, Northing and Height/Depth (X, Y, Z) in the projected CRS of the survey. Typically, this is a final 'processed' dataset.

References

1. IOGP website http://www.iogp.org/Geomatics contains the following documents and materials:
    - Data Model Template (ESRI)
    - Data Dictionary
    - IOGP Land Survey Data Model – Guidelines for delivery and use of the LSDM (this document)

    The model comprises:
    - Enterprise Architect Project File (.eap)
    - XML Schema (.xml)
    - ESRI file geodatabase (.gdb)

2. International Mine Actions Standards (IMAS): www.mineactionstandards.org
Technical Note 07.11/01-2016 Land Release Symbology

3. Energistics: www.energistics.org
Energistics Unit of Measure Dictionary Version 1.0

4. International Organization for Standardization: www.iso.org
ISO 19115:2003 – Geographic information - Metadata

Appendix A: CRS & Coordinate Epoch, and Coordinate Operation examples

For brevity, the *CRS and Coordinate Epoch* and *Coordinate Operation* table examples shown below include only those attribute fields relevant to the description of the CRS, coordinate epoch or coordinate operation.

Example 1 – Static CRS used for both acquisition and delivery (no coordinate operation)

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	ED50 / UTM Zone 31N	Projected	EPSG:23031					True	True	

Example 2 – Dynamic CRS used for both acquisition and delivery (no coordinate operation)

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	ITRF2014	Geocentric	https://epsg.org/crs_7789/ITRF2014.html				2022.05	True	True	

Example 3a – Compound CRS in EPSG Dataset used for both acquisition and delivery (no coordinate operation)

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	ETRS89 + CD Norway depth	Compound	EPSG:9883					True	True	

Example 3b – Compound CRS not in EPSG Dataset used for both acquisition and delivery (no coordinate operation)

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	ETRS89 + MSL depth	Compound			002	003		True	True	
002	ETRS89	Geographic 2D	EPSG:4258					False	False	Horizontal component of compound CRS.
003	MSL depth	Vertical	EPSG:9672					False	False	Vertical component of compound CRS.

Example 4 – Static CRS used for acquisition and a different static CRS used for delivery (change of geodetic datum)

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	WGS 84	Geographic 3D	https://epsg.org/crs/wkt/id/4979					True	False	EPSG:4979 is based on a datum ensemble in which the time-dependency of WGS 84 is ignored.
002	ED50 / UTM Zone 31N	Projected	https://epsg.org/crs/wkt/id/23031					False	True	

Coordinate Operation table

Coordinate Operation ID	Source ('from') CRS	Target ('to') CRS	Coordinate Operation Name	Coordinate Operation Type	Coordinate Operation Date	Coordinate Operation Authority Code	Coordinate Operation WKT	Remarks
001	001	002	ED50 to WGS 84 (18)	Transformation	2021-10-04	https://epsg.org/transformation/wkt/id/1311		"Common offshore" transformation.

Example 5 – Dynamic CRS used for acquisition and delivery but with a change of coordinate epoch, point motion operation in EPSG Dataset.

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	SRGI2013	Geocentric	EPSG:9468				2020.05	True	False	
002	SRGI2013	Geocentric	EPSG:9468				2012.00	False	True	

Coordinate Operation table

Coordinate Operation ID	Source ('from') CRS	Target ('to') CRS	Coordinate Operation Name	Coordinate Operation Type	Coordinate Operation Date	Coordinate Operation Authority Code	Coordinate Operation WKT	Remarks
001	001	002	Indonesian Deformation Model 2020	Point motion operation	2021-10-04	EPSG:9375		Reduces SRGI2013 coordinates at survey epoch 2020.05 to frame reference epoch 2012.00 using the Indonesian Deformation Model 2020.

Example 6 – Dynamic CRS used for acquisition and delivery but with a change of coordinate epoch, point motion operation not in EPSG Dataset (1)

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	WGS 84 (G2139)	Geocentric	EPSG:9753				2018.34	True	False	
002	WGS 84 (G2139)	Geocentric	EPSG:9753				2017.12	False	True	

Coordinate Operation table

Coordinate Operation ID	Source ('from') CRS	Target ('to') CRS	Coordinate Operation Name	Coordinate Operation Type	Coordinate Operation Date	Coordinate Operation Authority Code	Coordinate Operation WKT	Remarks
001	001	002	WGS 84 (G2139) @2018.34 to WGS 84 (G2139) @2017.12	Point motion operation	2021-10-04		"POINTMOTIONOPERATION[" "Average of velocities at IGb14 stations ABCD and BCDE"", SOURCECRS[GEOGCRS[""WGS 84 (G2139)"",... ID[""EPSG"",9753]]], METHOD[""Point motion (geocentric Cartesian)"",ID[""EPSG"",1064]], PARAMETER[""Point motion velocity X"",-0.0396, LENGTHUNIT[""metres per year"",3.16887651727315E-08,ID[""EPSG"",1042]],ID[""EPSG"",1052]], PARAMETER[""Point motion velocity X"",-0.0050, LENGTHUNIT[""metres per year"",3.16887651727315E-08,ID[""EPSG"",1042]], ID[""EPSG"",1053]], PARAMETER[""Point motion velocity Z"",0.0541, LENGTHUNIT[""metres per year"",3.16887651727315E-08,ID[""EPSG"",1042]], ID[""EPSG"",1054]], OPERATIONACCURACY[999]]"	Reduces WGS 84 coordinates at survey epoch 2018.34 to 'delivered' coordinate epoch 2017.12 using average of station velocities at nearby IGb14 active reference stations ABCD and BCDE.

Example 7 – Dynamic CRS used for acquisition and delivery but with a change of coordinate epoch, point motion operation not in EPSG Dataset (2)

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	ATRF2014	Geocentric	https://api.epsg.org/def/crs/epsg/0/9307/wkt				2017.53	True	False	CRS and coordinate epoch for pipeline survey ('original CRS').
002	ATRF2014	Geocentric	https://api.epsg.org/def/crs/epsg/0/9307/wkt				2021.25	False	True	CRS and coordinate epoch for data delivery.

Coordinate Operation table

Coordinate Operation ID	Source ('from') CRS	Target ('to') CRS	Coordinate Operation Name	Coordinate Operation Type	Coordinate Operation Date	Coordinate Operation Authority Code	Coordinate Operation WKT	Remarks
001	001	002	ATRF2014 @2017.53 to ATRF2014 @2021.25	Point motion operation	2021-08-02		POINTMOTIONOPERATION["Change of coordinate epoch (ATRF2014)", SOURCECRS[GEODCRS["ATRF2014", DYNAMIC[FRAMEEPOCH[2020.0]],-DATUM["Australian Terrestrial Reference Frame 2014",ELLIP-SOID["GRS 980",6378137,298.257222101, LENGTHUNIT["metre", 1,ID["EPSG",9001]],ID["EPS-G",7019]],ID["EPSG",1291]], CS[Cartesian,3,ID["EPS-G",6500]],AXIS["Geocentric X (X)",geocentricX,LENGTHUNIT["-metre",1,ID["EPS-G",9001]]],AXIS["Geocentric Y (Y)",geocentricY, LENGTHUNIT["-metre",1,ID["EPSG",9001]]], AXIS["Geocentric Z (Z)",geocentricZ, LENGTHUNIT["metre", 1,ID["EPS-G",9001]]],ID["EPSG",9307]]], METHOD["Australian Plate Mo-tion Model "], PARAMETER["Point motion velocity X",1.50379,TIME-UNIT["milliarc-seconds per year",1.53631468932076E-16]], PARAMETER["Point motion velocity Y",1.18346,TIMEU-NIT["milliarc-seconds per year",1.53631468932076E-16]], PARAMETER["Point motion velocity Z",1.20716,TIMEU-NIT["milliarc-seconds per year",1.53631468932076E-16]], OPERATIONACCURACY[0.03]]	Applies Australian plate motion model to change ATRF2014 coordinates from survey epoch 2017.53 to epoch 2021.25. Equivalent to applying transformation ATRF2014 to GDA2020 (EPSG:9459) at epoch 2017.53 concatenated with the same transformation applied in reverse at epoch 2021.25.

Example 8a – Transforming ellipsoidal height in a geographic 3D CRS to gravity-related height in a vertical CRS using a geoid model*

* Example to illustrate how to record a transformation, *Is Acquisition* and *Is Current* attribute fields are deliberately not populated (additional CRS entries required to complete these tables are left out to not obfuscate the CRSs relevant to the example).

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acqui-sition	Is Current	Remarks
001	ETRS89	Geograohic 3D	EPSG:4937							
002	ODN (Offshore) height	Vertical	EPSG:7707							

Coordinate Operation table

Coordinate Operation ID	Source ('from') CRS	Target ('to') CRS	Coordinate Operation Name	Coordinate Operation Type	Coordinate Operation Date	Coordinate Operation Authority Code	Coordinate Operation WKT	Remarks
001	001	002	ETRS89 to ODN (Offshore) height (1)	Transformation	2021-10-04	EPSG:7713		

Example 8b – Transforming ellipsoidal height in a geographic 3D CRS to depth in a vertical CRS using a hydroid model that is in the EPSG Dataset*

* Example to illustrate how to record a transformation, *Is Acquisition* and *Is Current* attribute fields are deliberately not populated (additional CRS entries required to complete these tables are left out to not obfuscate the CRSs relevant to the example).

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	ETRS89	Geograohic 3D	EPSG:4937							
002	CD Norway depth	Vertical	EPSG:9672							

Coordinate Operation table

Coordinate Operation ID	Source ('from') CRS	Target ('to') CRS	Coordinate Operation Name	Coordinate Operation Type	Coordinate Operation Date	Coordinate Operation Authority Code	Coordinate Operation WKT	Remarks
001	001	002	ETRS89 to CD Norway depth (1)	Transformation	2021-10-04	EPSG:9884		

Example 8c – Transforming ellipsoidal height in a geographic 3D CRS to depth in a vertical CRS using a hydroid model that is not in the EPSG Dataset*. In this example the full CRS WKT definition is omitted for brevity.

* Example to illustrate how to record a transformation and a conversion, *Is Acquisition* and *Is Current* attribute fields are deliberately not populated (additional CRS entries required to complete these tables are left out to not obfuscate the CRSs relevant to the example).

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	ETRS89	Geographic 3D	EPSG:4937							
002	ODN (Offshore) height	Vertical	EPSG:7707							
003	ODN (Offshore) depth	Vertical		VERT-CRS[...]						

Coordinate Operation table

Coordinate Operation ID	Source ('from') CRS	Target ('to') CRS	Coordinate Operation Name	Coordinate Operation Type	Coordinate Operation Date	Coordinate Operation Authority Code	Coordinate Operation WKT	Remarks
001	001	002	ETRS89 to ODN (Offshore) height (1)	Transformation	2021-10-04	EPSG:7713		OSGM15 geoid model applied.
002	002	003	ODN (Offshore) height to ODN (Offshore) depth	Conversion	2021-10-04	EPSG:7812		Height <> Depth conversion.

Example 9 – IOGP GN24 fig B.2 Offshore 1 well example (corrected). In this example the full CRS and coordinate operation WKT definitions are omitted for brevity.

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	WGS 84	Geographic 3D	EPSG:4979					True	False	CRS for pipeline survey ('original CRS').
002	WGS 84 + MSL height	Compound	EPSG:9705					False	False	
003	WGS 84	Geographic 2D	EPSG:4326					False	False	
004	MSL height	Vertical	EPSG:5714					False	False	
005	ED50 / UTM Zone 31N	Projected	EPSG:23031					False	False	Horizontal component of compound CRS.
006	Offshore-1 height	Vertical		VERTCRS[...]				False	False	Datum = KB.
007	Offshore-1 depth	Vertical		VERTCRS[...]				False	False	
008	Offshore-1 depth (ft)	Vertical		VERTCRS[...]				False	False	International foot. Vertical component of compound CRS.
009	ED50 / UTM 31N + Offshore-1 depth (ft)	Compound		COMPOUNDCRS[...]	005	008		False	True	CRS for deliverable ('delivered CRS').

Coordinate Operation table

Coordinate Operation ID	Source ('from') CRS	Target ('to') CRS	Coordinate Operation Name	Coordinate Operation Type	Coordinate Operation Date	Coordinate Operation Authority Code	Coordinate Operation WKT	Remarks
001	001	004	WGS 84 to WGS 84 + MSL height	Transformation	2018-08-02	EPSG:9706		Applies EGM2008 geoid model.
002	003	005	ED50 to WGS 84 (18)	Transformation	2018-08-06	EPSG:1311		Common Offshore transformation applied in reverse.
003	004	006	MSL height to Offshore-1 height	Transformation	2018-08-02		COORDINATE-OPERATION[...]	Applies 28.1m height offset MSL to KB.
004	006	007	Offshore-1 height to Offshore-1 depth	Conversion	2018-08-02		COORDINATE-OPERATION[...]	Height Depth Reversal.
005	007	008	Offshore-1 depth to Offshore-1 depth (ft)	Conversion	2018-08-02		COORDINATE-OPERATION[...]	Applies unit conversion of 1/0.3048.

Example 10 – Data acquisition using a dynamic CRS used for acquisition, delivery in static CRS. In this example the full CRS WKT definitions are omitted for brevity.

CRS and Coordinate Epoch table

CRS and Coord Epoch ID	CRS Name	CRS Type	CRS Authority Code	CRS WKT	Compound CRS Horizontal Component	Compound CRS Vertical Component	Coordinate Epoch	Is Acquisition	Is Current	Remarks
001	ATRF2014	Geocentric	EPSG:9307				2021.25	True	False	CRS for pipeline survey ('original CRS').
002	GDA2020	Geographic 3D	EPSG:7843					False	False	
003	GDA2020 + AVWS height	Compound	EPSG:9462					False	False	
004	GDA2020	Geographic 2D	EPSG:7844					False	False	Horizontal component of compound CRS.
005	AVWS height	Vertical	EPSG:9458					False	False	Vertical component of compound CRS, derived from AUSGeoid 2020_20180201 geoid model.
006	MSL depth (AVWS depth)	Vertical		VERT-CRS[...]				False	False	AVWS depth taken as MSL depth with no correction.
007	GDA94	Geographic 2D	EPSG:4283					False	False	
008	AGD66	Geographic 2D	EPSG:4202					False	False	
009	AGD66 + AVWS depth (AGD66 + MSL depth)	Compound		COM-POUND-CRS[...]	008	006		False	True	CRS for deliverable ('delivered CRS').

Coordinate Operation table

Coordinate Operation ID	Source ('from') CRS	Target ('to') CRS	Coordinate Operation Name	Coordinate Operation Type	Coordinate Operation Date	Coordinate Operation Authority Code	Coordinate Operation WKT	Remarks
001	001	002	ATRF2014 @2021.25 to GDA2020 (1)	Transformation	2021-08-02	EPSG:9459		Applies Australian plate motion model to change survey coordinate epoch 2021.25 to ATRF2014 frame reference epoch 2020.00, then null transformation ATRF2014 to GDA2020 at epoch 2020.00. Includes implicit geocentric to geographic 3D conversion.
002	002	003	GDA2020 to GDA2020 + AVWS height (2)	Transformation	2021-08-06	EPSG:9693		Applies AGQG 20201120 quasigeoid model.
003	005	006	AVWS height to AVWS depth	Conversion	2021-08-02	EPSG:7812		Height <> Depth conversion.
004	004	007	GDA2000 to GDA94	Transformation	2021-08-02	EPSG:8048		GDA94 to GDA2000 (1) (EPSG:8048) applied in reverse.
005	007	008	GDA94 to AGD66	Transformation	2021-08-02	EPSG:15979		AGD66 to GDA94 (12) (EPSG:15979) applied in reverse.

Appendix B: Associations between land survey data types and LSDM feature classes

Table 1: General guide associating land survey data types and LSDM geodatabase feature classes

ID	Data Type	Deliverable Format	Equipment/Data Source	Comment
1	**Pipeline/flight route position data**	LSDM (Survey Point, Survey Lines and Geodetic Control Point)	O&G company provides proposed route/ flight lines. Contractor provides survey route lines and benchmark position data.	Required for UAV flight and proposed pipeline route survey
2	**Survey Chart Extent**	LSDM (Chart Index)	Contractor provides, based on charts generated.	May include hyperlinks to the charts in PDF or other format.
3	**Survey Extents/ Project Details**	LSDM (Survey Keysheet and Job Details table)	O&G company provides survey project extent and unique survey activity identification number. Job Details table also completed by O&G company with contract numbers etc.	Survey Keysheet is the extent of a survey project.
4	**Survey coverage/ limits per equipment type**	LSDM (Survey Equipment Limits)	Contractor provides equipment areas-of-use polygons	Usually determined from outer limits of datasets e.g. mosaic, topo data.
5	**Topographic, land use and land cover, geomorphology and surface geology**	LSDM (Topography_ SurfaceGeomorphology, Survey Measurements)	GNSS, Total Station equipment	Includes most of the features except O&G Infrastructure data.
6	**O&G Infrastructure (production facilities, company-specific infrastructure, transmission pipelines and crossings), Civil**	LSDM (Infrastructure dataset)	GNSS, Total Station and UAV equipment	Company owned facilities and pipeline events from as-built and UAV surveys etc. Third party and cultural data
12	**Seismic Data**	1. Raw data and processed data (SEG-D/SEG-Y) 2. Velocity profile data 3. LSDM (Line of Profile)	Single and multi-channel seismic profiling equipment	Line of Profile feature class represents location of particular cross-section, interpreted from seismic data. Can be hyperlinked to profile generated
13	**Interpreted Seismic Horizon**	LSDM (Isopach, Isochorn) ESRI Raster / Terrain datasets ASCII X,Y,Z file (below horizon ground level)	Single and multi-channel seismic profiling equipment	Operator to provide seismic horizon and ASCII file naming conversion.

Topographic and other features mapped during land surveys in oil and gas exploration and production are currently collected in a variety of CAD, GIS, ASCII and other file types and formats. This leads to difficulties in management of the survey data, including integration of such data within corporate databases and data management systems, and in the external exchange and sharing of the data with partners, regulators, and other parties.

IOGP Headquarters

City Tower, 40 Basinghall St, London EC2V 5DE, United Kingdom
T: +44 (0)20 3763 9700
E: reception@iogp.org

www.iogp.org

IOGP Americas

T: +1 713 261 0411
E: reception-americas@iogp.org

IOGP Asia Pacific

T: +60 3-3099 2286
E: reception-asiapacific@iogp.org

IOGP Europe

T: +32 (0)2 790 7762
E. reception-europe@iogp.org

IOGP Middle East & Africa

T: +20 120 882 7784
E: reception-mea@iogp.org