Oregon LiDAR Data Standard

Version 1.1

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1.0 Introduction

LiDAR (Light Detection And Ranging) data sets that image both the earth's surface and the vegetation and structures on the surface are becoming available over significant parts of Oregon. Complete coverage of the state is desirable, but is years away in any realistic scenario. As various groups work towards this goal, it is important for the State of Oregon to adopt a standard regarding data structure for specific commonly delivered LiDAR data types.
LiDAR measurements are typically produce three distinct types of data:

- Point cloud or all returns data consist of the complete set of vector points collected by an airborne project. The points are defined by 3D coordinates and are typically attributed with additional information related to collection parameters, return intensity and interpreted classifications. Point clouds are the most complete and unprocessed form in which commercially collected LIDAR is delivered. Even so, point cloud data has typically been extensively processed from the raw sensor output. The proposed LiDAR data standard will deal only with this type of data.
- Surface elevation rasters are typically derived from subsets of the point cloud data, most commonly by TIN modeling. The most common raster is a bare earth DEM, derived from points classified as ground. A second common raster is a first return, or highest hit surface that represents the uppermost surface elevation recorded in any area of the image. The bare earth DEM is conceptually no different from a DEM derived from interpolation of contours or from photogrammeteric data, differing mainly in terms of resolution. Therefore the bare earth DEM's should be covered by the existing Oregon Terrestrial Raster Elevation Data Standard, Version 1.04, November 2003, at www.gis.state.or.us/coord/standards/elevstandarddraft.pdf by modifying that standard to include a range of raster resolution that extends down to the sub-meter level.
- Intensity images are false color raster images created from the LiDAR mass point cloud. -Images are produced by interpolating the infrared reflectance attributed to each point. As such they are directly analogous to high resolution satellite imagery, although in practice they resemble orthophotos . Intensity images are a relatively recent innovation in commercial LiDAR collection, and no standard is currently contemplated.

1.1 Mission and Goals of Standard

The Oregon LiDAR Data Standard (OLDS) will provide a consistent structure for data producers and data users to ensure the compatibility of datasets within the same framework layer and between other framework layers and themes.

1.2 Relationship to Existing Standards

The standard is related to and largely based on the ASPRS LAS v 1.1 format
http://www.asprs.org/society/divisions/ppd/standards/asprs_las_format_v11.pdf

1.3 Description of Standard

The OLDS describes the critical data format, data elements and metadata elements necessary to adequately describe, distribute, and use LiDAR derived point cloud data in Oregon. These vector data have multiple database fields attached to individual graphic elements.

1.4 Applicability and Intended Use of Standard

For Oregon geospatial data, this standard is applicable to the data sets that represent the height of the earth's surface and the height of randomly measured points on vegetation and structure above the surface relative to a given hypothetical surface or datum such as mean high tide or North American Vertical Datum 1988 (NAVD 88). The intended use of this standard is to ease the exchange and transfer of LiDAR point cloud data and to guide documentation that will enable data users to understand how the data were generated and their appropriate uses.

1.5 Standard Development Procedures

The LiDAR subcommittee of the Oregon Framework Implementation Team for Elevation (FIT-Elevation) is comprised of representatives from federal, state, and local governmental agencies in Oregon. This team created the first draft of the OLDS standards based on the existing OVES standard for initial presentation at the March 13, 2008 FIT standards forum.
Future LiDAR data standards will continue to be developed through a combination of periodic framework meetings and documents shared on the Oregon Framework web site, http://egov.oregon.gov/DAS/IRMD/GEO/fit/FIT.shtml .

1.6 Maintenance of Standard

The OLDS will be revised as needed when initiated by participants of the standards process.

2.0 Body of the Standard

2.1 Scope and Content of the Standard

The scope of the OLDS is to provide a standard for publicly available LiDAR point cloud data in Oregon. The content is focused on the critical metadata elements and database attributes required for individual data sets.

2.2 Need for the Standard

The OLDS is needed in Oregon to ensure that when users acquire data from disparate sources, they can use, display, and analyze the data within the context of the stated spatial accuracy and appropriate use of the data. When followed, the standard minimizes the possible errors associated with inconsistent data.

2.3 Participation in Standards Development

The lidar point cloud standard has been in development since March 2008. Agencies interested in using elevation data are welcome to participate in standards development. The standard is also open to public review and comment.

2.4 Integration with Other Standards

The OLDS follows the same format as the Oregon Elevation Vector Standard, on which it is based. The relationship with other non-elevation data standards is primarily georeferencing.

2.5 Technical and Operation Context

2.5.1 Data Environment

The data environment for OLDS is vector point features that represent spot elevation values. The exchange format for vector point cloud data files is the .LAS format file, which is a binary open data

structure that includes 3D coordinates and an array of LiDAR specific data attributes. This exchange medium is supported by some GIS software suites used in Oregon, and a free utility to convert between .LAS files and ASCII text files is available (http://www.fs.fed.us/eng/rsac/fusion/). Information about the technical specification for the LAS format can be found at:
http://www.lasformat.org/

2.5.2 Reference Systems

The coordinate reference systems typically used in Oregon are the Universal Transverse Mercator (UTM), the Oregon State Plane and the custom Oregon Lambert. The applicable UTM zones are zone 10, which comprises all land in Oregon to the west of 120 degrees west longitude, and zone 11, which comprises all land to the east of 120 degrees west longitude. The State Plane North and State Plane South zones are divided along Oregon county boundaries near 44 degrees north latitude. The custom Oregon Lambert coordinate system is described at http://www.gis.state.or.us/data/format.html . Commonly used vertical reference systems include, NAVD29, and NAVD88, with the preferred system being NAVD88.

2.5.3 Airborne and GPS Collection Systems

The LiDAR system used to collect data should be described with reference to IMU type and sample rate. LiDAR data locations are entirely dependent on GPS measurements, and GPS procedures used should be described within metadata.

2.5.4 Integration of Themes

Filtered subsets of point cloud data can be used to develop DEM's or DTM's of the bare earth surface or to create vector elevation points or lines. Interpretations of bare earth DEM's can be used to locate and map roads, streams, lakes and coastlines as well as soil and geology polygons. Filtered subsets of point cloud data can be used to make DEM's that depict vegetation or structures and these DEM's can be used to map building footprint and height, vegetation cover and height and structure, roadways, bridges and powerlines.

2.5.5 Encoding

The vector data model is appropriate for this type of elevation data. Vector-based spatial objects must conform to topological rules. The applicable topological rules for points are **no coincidence of points.**

2.5.6 Resolution

Point cloud resolution (expressed as nominal laser pulses per square meter) is a function of project design and ranges from a tenths of a pulse per square meter to tens of pulses per square meter. In order to ensure that lidar collected in Oregon meets the needs of the full range of users, a minimum resolution of 4 pulses per square meter is required.

2.5.7 Accuracy

The accuracy of points in a point cloud data set are a function of the precision of the instruments used in capturing the point coordinates. Data recorded by the LiDAR unit, inertial measuring unit (IMU), and GPS unit aboard the aircraft and differential GPS units on the ground are coordinated to produce calibrated coordinates. In order to ensure that lidar collected in Oregon meets the needs of the full range of users, vertical accuracy as measured on flat, unobscured surfaces must be 20 cm RMSE or better.

2.5.8 Edge Matching

LiDAR points cloud data is typically tiled, but the tiling should not result in loss of points or duplication of points along tile boundaries. Tiles are defined with respect to the density of data to produce files of workable size.

2.5.9 Feature Identification Coding

Unique Feature Identification Coding is not required.

2.5.10 Attributes

Attributes are categorized in two principal ways: points, and associated characteristics.

2.5.10.1 Points

In this context, points are geospatial objects that represent spot elevations of randomly intersected features. Attributes are X, Y and Z coordinates at a minimum, but may also include pulse number, return number, intensity, flight line number, scan angle, GPS time and feature class.

2.5.10.3 Associated Characteristics

Associated characteristics are any of the additional information that is collected and shared in relation to point cloud data. See Section 3 for the specification of minimal characteristics.

2.5.11 Transactional Updating

Changes to the surface of the earth and to vegetation and structures will occur due to human activities or periodic natural events such as floods, fires, volcanoes, earthquakes, or landslides.   When new point cloud data becomes available that overlap existing coverage, both data sets should be maintained separately, and clearly distinguished, to allow for serial change analysis.

2.5.12 Records Management

Past versions of point cloud data should be maintained for all areas and should be archived due to legal or administrative decisions that may have been made based on them.

2.5.13 Metadata

The OLDS follows the Oregon Core Metadata Standard for geospatial data. Metadata detailing the characteristics and quality of submitted point cloud data must be provided, including the version of this standard which the dataset uses. Metadata should make every effort to meet the more rigorous standards set forth in the Federal Metadata Content Standard, where feasible. Metadata must provide sufficient information to allow the user to determine if that data will meet the intended purpose, as well as telling the user how to access the data. Metadata must provide a process description summarizing collection parameters (flying height above ground, IMU type, ground GPS procedures, target spot spacing, kilohertz setting, and percent overlap) as well as process description highlighting steps toward delivered point cloud.

3.0 Data Characteristics

3.1 Minimum Graphic Data Elements

3.1.1 Points

All points are to be delivered in LAS 1.1 or 1.2 (format 1).

3.2 Minimum Attribute or Non-graphic Data Elements

3.2.1 Points

LAS 1.1 and 1.2 Format are identical in that LAS 1.1 readers will read 1.2 files. The difference between the two versions is that LAS 1.2 includes two formats which feature GPS Absolute GPS Time or supports ancillary image data on a per point basis. LAS 1.3 is intended to support wave form ability. At this point in time full wave form data is beyond processing abilities for most state agencies, at this time LAS 1.3 is not used. For more information on LAS formatting.

(http://www.asprs.org/society/committees/standards/asprs_las_format_v11.pdf)
(http://www.asprs.org/society/committees/standards/asprs_las_format_v12.pdf)

Item	Format	Size	Required
X	long	4 bytes	*
Y	long	4 bytes	*
Z	long	4 bytes	*
Intensity	unsigned short	2 bytes	*
Return Number	3 bits (bits 0-2)	3 bits	*
Number of Returns (given pulse)	3 bits (bits 3-5)	3 bits	*
Scan Direction Flag	1 bit (bit 6)	1 bit	*
Edge of Flight Line	1 bit (bit 7)	1 bit	*
Classification	unsigned char	1 byte	*
`Scan Angle Rank (-90 to +90) – Left side	unsigned char	1 byte	*
User Data	unsigned char	1 byte	
Point Source ID	unsigned short	2 bytes	*
(1.2 format 1) GPS Time	double	8 bytes	*
(1.2 format 2) Red	unsigned short	2 bytes	*
(1.2 format 2) Green	unsigned short	2 bytes	*
(1.2 format 2) Blue	unsigned short	2 bytes	*

ASPRS Standard LIDAR Point Classes

Classification Value (bits 0:4)	Meaning
0	Created, never classified
1	Unclassified[1]
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Model Key-point (mass point)
9	Water
10	Reserved for ASPRS Definition
11	Reserved for ASPRS Definition
12	Overlap Points[2]
13-31	Reserved for ASPRS Definition

References

LAS Specification Version 1.1, ASPRS, March 07, 2005 cited 2/2010
http://www.asprs.org/society/committees/standards/asprs_las_format_v11.pdf

LAS Specification Version 1.2, ASPRS, September 02, 2008 cited 2/2010
http://www.asprs.org/society/committees/standards/asprs_las_format_v12.pdf