LAS Domain Profile Description:
Topo-Bathy Lidar

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Overview

This document describes a set of LAS enhancements to enable support for topographic-bathymetric (topo-bathy) lidar. The importance of these enhancements stems, in part, from the emergence of a new class of topo-bathy lidar systems that occupies the middle ground between conventional bathymetric and commercial topographic systems and provides seamless, high-resolution coverage across the backshore, intertidal, and shallow nearshore zones. Many users of these systems and the data they provide are interested in integrating the data into existing topographic lidar processing streams. However, the stock LAS specification does not currently support these data.

The Topo-Bathy Lidar Domain Profile adds point classification values for bathymetric point, water surface, derived water surface, submerged object, IHO S-57 object, and bottom not found depth. Extra Byte Variable Length Records (EXTRA_BYTES or Extra Byte VLRs) are added for pseudo-reflectance, uncertainty, water column depth, figure of merit, and processing specific flags. Note that some of the new attributes should be equally applicable to topo-only lidar.

The changes listed below have been vetted through members of the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) and other members of the coastal lidar community.

Point Classification Enhancements

The following are new point classifications for point types 6 to 10:

Classification Value	**Meaning**
40	Bathymetric point (e.g., seafloor or riverbed; also known as submerged topography)
41	Water surface (sea/river/lake surface from bathymetric or topographic-bathymetric lidar; distinct from Point Class 9, which is used in topographic-only lidar and only designates “water,” not “water surface”)
42	Derived water surface (synthetic water surface location used in computing refraction at water surface)
43	Submerged object, not otherwise specified (e.g., wreck, rock, submerged piling)
44	International Hydrographic Organization (IHO) S-57 object, not otherwise specified
45	No-bottom-found-at (bathymetric lidar point for which no detectable bottom return was received)

Extra Byte Variable Length Record Enhancements

The following are new point attributes to be added via Extra Bytes VLRs:

Unit	reserved (char[2])	data_type (uchar)	options (uchar)	name (char[32])	no_data (anytype[3])	Scale (double[3])	Description (char [32])
[dB]	100	4 (short)	00001xx1	(pseudo-) reflectance	0xFFFF, 0, 0	0.01, 0, 0	Radiometric calibration output
[m]	101	21 (uchar[3])	00001xx1	sigma xyz	0xFF, 0xFF 0xFF	0.01, 0.01, 0.01	XYZ coordinate uncertainty
---	102	1 (uchar)	00001xx1	water column optical depth	0xFF, 0, 0	0.25, 0, 0	Water column optical depth
---	103	1 (uchar)	00000xx1	figure of merit	0xFF, 0, 0	0, 0, 0	FoM for bottom measurement
---	104	1 (uchar)	00000000	Bathymetry flags	0,0,0	0,0,0	Flags
			bit 0 = 0 …no refraction bit 0 = 1 …refraction applied				

The “(pseudo-) reflectance” field (see table above) stores a value that is computed from the raw waveform or the recorded “intensity” value through some type of radiometric calibration procedure. While the types of corrections that may be applied as part of this process vary, the general goal is to produce an output that is more physically-meaningful (i.e., more closely related to actual surface characteristics) than the unitless, system-specific “intensity” values. These output data are often used in habitat mapping. If a rigorous radiometric calibration has not been performed, the calculated value may be termed “pseudo-reflectance” or “relative reflectance,” depending on the corrections applied. When a rigorous radiometric calibration is performed, this value may represent “true” surface/seafloor reflectance (i.e., the fraction of incident optical power that is reflected by the surface/seafloor) at the laser wavelength. In keeping with the conventions defined in RIEGL (2012), the units are decibels (dB). Because increments of 0.01 dB are deemed sufficient for this attribute the use of a signed short (data type 21) and a scaling factor of 0.01 are recommended.

The “sigma xyz” field represents the positional uncertainty (or “error”) in the X, Y, Z spatial coordinates of the georeferenced lidar point. The units are meters. These fields are potentially useful for any type of lidar data, but they are particularly important for bathymetric lidar, since the International Hydrographic Organization (IHO) S-44 requires a total propagated uncertainty (TPU) analysis as part of a hydrographic survey, including surveys conducted with lidar (IHO, 2008). Because increments of 1 cm are deemed sufficient for this attribute the use of an unsigned char[3] array (data type 21) and scaling factors of 0.01 are recommended.

Water column optical depth is the dimensionless product of depth and attenuation coefficient. It is an extremely important parameter in bathymetric lidar processing and analysis, as laser pulse energy decreases exponentially with optical depth. Because increments of .25 are deemed sufficient for this attribute the use of an unsigned char (data type 1) and a scaling factor of 0.25 are recommended.

Figure of merit (FoM) for bottom measurement is a metric for the quality of the bottom return. It is a function of signal characteristics, such as, bottom signal strength, shape, and width. Individual developers may differ in how they derive the FoM but must adhere to the range 0-255. In the future, the topographic-bathymetric lidar community may develop standards for computing FoM.

The bathymetric bit flags are intended as a means of indicating other point or processing attributes that have not yet been identified and/or do not merit a separate point class or separate Extra Byes VLR. Bit 0 is used to flag whether or not a refraction correction has been applied. Currently, the other 7 bits are open for future use.

References:

IHO (International Hydrographic Organization), 2008. IHO Standards for Hydrographic Surveys, 5th edition. Monaco: International Hydrographic Bureau, 36p: http://www.iho.int/iho_pubs/standard/S-44_5E.pdf

RIEGL, 2012. *LAS extrabytes implementation in RIEGL software*, RIEGL Laser Measurement Systems GmbH: http://www.riegl.com/uploads/tx_pxpriegldownloads/Whitepaper-LAS_extrabytes_implementation_in_RIEGL_software_01.pdf