Implementing LAS v1.4 Support in Airborne LIDAR Workflows

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Outline

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  - Non-Trivial Conversions & Strategies
- Pitfalls to Watch Out For
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- Q/A

CueTip available at support.geocue.com

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Motivation

- Support for LAS v1.4 PDRF 6-10 now required for USGS deliverables.
- GeoCue and LP360 are compliant with LAS v1.4.
- Terrasolid does not support v1.4 so a conversion strategy is necessary for these workflows.
- Legacy data sets exist that may need to be updated to v1.4.

GeoCue

Motivation

- Source v1.4 files may not be fully compliant; understanding is a prerequisite to compliance.
- Confusion over what is or is not acceptable practice when it comes to “v1.4 compliance”.
- Lack of any well-defined testability for compliance.

Disclaimers (COA)

- We believe this is a temporary situation; end-to-end v1.4 workflows will be standard by the end of 2015.
- We believe in transparency; there are many choices to be made in conversion methods. Be open about how you implement conversions.
- Review your conversion methods and get written approval from your end user prior to implementation.

ASPRS LAS File Format

- LAS Working Group (ASPRS Lidar Division) (L. Graham)
- Originally released by in May 2003.
- Current version is v1.4 (R13) (November 2011).
- Full technical specification available from asprs.org
- Significant changes between versions that impact conversion methods.

LAS Data File Structure

- Binary data file (.las) structured as follows:

Table 1: LAS 1.4 Format Definition	
Public Header Block	Header
Variable Length Records	VLR
Point Data Records	PDR
Extended Variable Length Records	EVLR

- Wave packets were introduced in v1.3 to support waveform data, but are not covered in this discussion. (Waveform data is considered supplemental by USGS.)

Point Data Record Formats

- PDRs are further differentiated by assigning a specific Point Data Record Format (PDRF).
- v1.2/v1.3 has a core 20 bytes of information in PDRF 0 and additional information defined in PDRFs 1-5.
- v1.4 has additional PDRF definitions 6-10 that includes an additional 10 bytes (30 bytes total) of core information.

PDRF Summary

PDRF	Description
0	Core 20 bytes shared by PDRF's 0-5
1	Adds GPS time information.
2	Adds three color channels for storing RGB values (colorized points).
3	Adds GPS time and RGB channels.
4	Adds GPS time and wave packets (for waveform data)
5	Adds GPS time, RGB channels and wave packets.
6	Core 30 bytes shared by PDRFs 6-10 including mandatory GPS time.
7	Adds three color channels for storing RGB values (colorized points).
8	Adds RGB channels and a fourth NIR channel.
9	Adds wave packets.
10	Adds wave packets and RGB channels.

PDRF 1 v PDRF 6

Item	Format	Size (PDRF 1)	Size (PDRF 6)	Format	Item
X*	long	4 bytes	4 bytes	long	X*
Y*	long	4 bytes	4 bytes	long	Y*
Z*	long	4 bytes	4 bytes	long	Z*
Intensity	unsigned short	2 bytes	2 bytes	unsigned short	Intensity
Return Number*	3 bits (0-2)	3 bits	4 bits	4 bits (0-3)	Return Number*
Number of Returns*	3 bits (3-5)	3 bits	4 bits	4 bits (4-7)	Number of Returns*
			4 bits	4 bits (0-3)	Classification Flags
			2 bits	2 bits (4-5)	Scanner Channel*
Scan Direction Flag*	1 bit (6)	1 bit	1 bit	1 bit (6)	Scan Direction Flag*
Edge of Flight Line*	1 bit (7)	1 bit	1 bit	1 bit (7)	Edge of Flight Line*
Classification*	unsigned char	1 byte	1 byte	unsigned char	Classification*
Scan Angle Rank*	char	1 byte	1 byte	unsigned char	User Data
User Data	unsigned char	1 byte	2 bytes	short	Scan Angle*
Point Source ID*	unsigned short	2 bytes	2 bytes	unsigned short	Point Source ID*
GPS Time*	double	8 bytes	8 bytes	double	GPS Time*

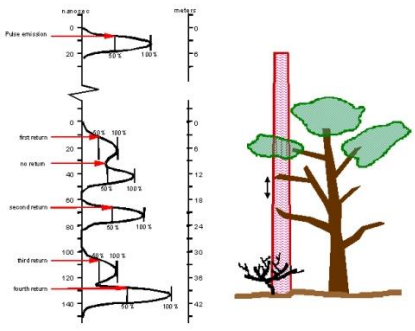
- 28 bytes for 13 items (1) v 30 bytes for 15 items (6).
- Up-conversion is less complicated than down-conversion.

Conversions [v1.2 (1) to v1.4 (6)]

- Trivial (9)
  - ✓ X
  - ✓ Y
  - ✓ Z
  - ✓ Intensity
  - ✓ Scan Direction Flag
  - ✓ Edge of Flight Line
  - ✓ User Data
  - ✓ Point Source ID
  - ✓ GPS Time
- Non-Trivial (6)
  - ✓ Return Number/Number of Returns (2)
  - ✓ Scanner Channel (1)
  - ? Classification & Classification Flags (2)
  - ? Scan Angle Rank/Scan Angle (1)

Return# & #Returns

- Related items stored as 3 bits in PDRF 1 and 4 bits in PDRF 6.
- Up-conversion is straightforward.



Source: ASPRS

Scanner Channel

- Scanner Channel is 2 bits in PDRF 6.
- No corresponding scanner channel information in PDRF 1. (Use user byte or class)
- Up/down conversions require a class-to-channel method. User Byte up-conversion is supported in GeoCue V2014.
- For single scanner airborne systems, setting scanner channel to '0' is a logical approach for up-conversion.

Classification & Flags

- PDRF 1 - Byte 16

Wthd	KP	Syn	Classes (0-31)				
0	1	0	0	0	0	1	0

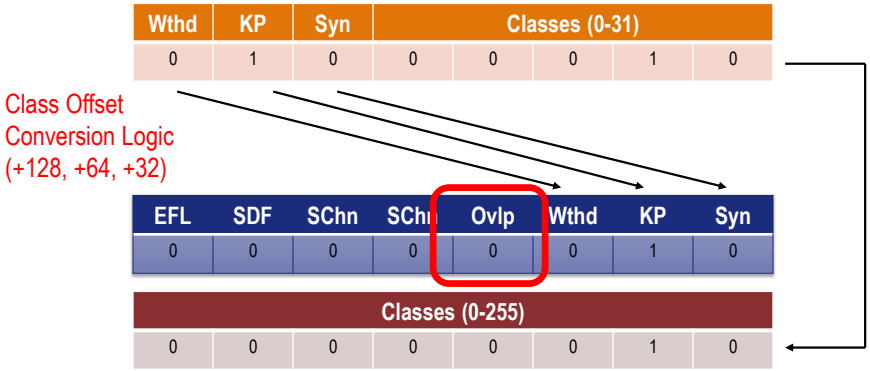
- PDRF 6 - Byte 16 & 17

EFL	SDF	SChn	SChn	Ovlp	Wthd	KP	Syn
0	0	0	0	0	0	1	0

Classes (0-255)							
0	0	0	0	0	0	1	0

Up-Conversion

- v1.2 (1) to v1.4 (6) with less than 32 classes:



Overlap

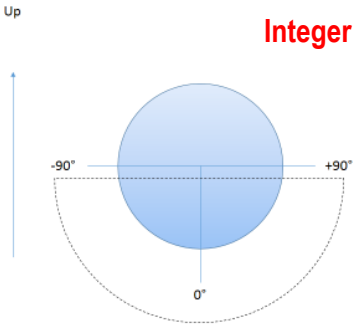
- Overlap flag must be set for USGS deliveries.
- Overlap flag is new in v1.4; previous LAS versions captured this information via the Overlap class (#12).
- Requires either:
  - A class-to-flag conversion method.
  - Use of a proxy flag (Synthetic) and appropriate class offset conversion logic.
  - ✓ Setting the overlap flag in v1.4 compliant software (e.g. LP360).

Scan Angle Rank/Scan Angle

PDRF 1

Scan Angle Rank
Looking in the direction of motion.
Integer angles.

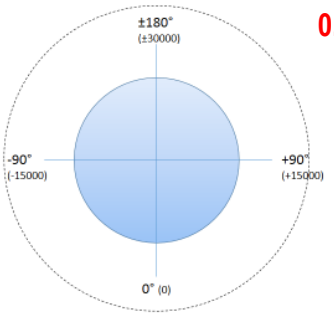
Integer



Scan Angle
Looking in the direction of motion.
Scaled in 0.006° increments.

PDRF 6

0.006°



- Up-conversion is mathematically straightforward.

Pitfalls – Unambiguous

- Overlap flag is required.
- Setting Coordinate Reference System (CRS) via Well Known Text (WKT) bit in Global Encoding and writing WKT to EVLR is required. (GeoTiff not permitted for PDRFs 6-10.)
- Adjusted Standard GPS Time is required.

Pitfalls - Ambiguous

- Is loss of resolution of scanner angle acceptable?
- Is setting scanner channel to '0' by default for single scanner airborne systems acceptable?
- Timestamps are required "at a precision sufficient to allow unique timestamps for each pulse".
- Overlap and Withheld flags must be "properly set" in raw LAS deliverables (in v1.4).
- How will compliance be verified?

A Quick Poll ….

WORKFLOW DEMONSTRATION