AN IMPLEMENTATION OF THE ASPRS LAS STANDARD

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ABSTRACT:

The laser scanning technology has become de-facto as a successful measuring mean in numerous applications of remote sensing and mapping. A development of hardware has been followed by a development of a new data file format standard know as the American society for Photogrammetry and Remote Sensing (ASPRS) Lidar Exchange Format (LAS). This data format standard has been designed in order to make the exchange of lidar data, (pre-/post-) processing, analysis, and storing less time consuming and more convenient. There are three versions of the ASPRS LAS standard: 1.0, 1.1, and 2.0 (draft). A number of the manufacturers of hardware and software, laser scanning service providers and end users have already accepted a concept of ASPRS LAS as an industry standard. However, a less experienced end user might be confused by the different definitions of the term LAS that appear in literature and are used by various software vendors. The following main LAS definitions in remote sensing and geomatics exist: Land Analysis System by USGS, Log ASCII Standard by the Canadian Well Logging Society, LAS image format by ER Mapper, and ASPRS LAS by the ASPRS Lidar Committee. This paper explains the different common meanings of those terms. Several popular software products used for lidar data processing are also reviewed and the terminology associated with the file format defined. At this time there is no common tool available for converting from one ASPRS LAS format to another, and this can be a challenge when working with multiple formats. Only in one study case a version number of ASPRS LAS was clearly identified in the Import/Export tool. This paper also provides a comparison feature matrix of the different versions of ASPRS LAS.

1. INTRODUCTION

1.1 Abbreviations

ANSI – American National Standards Institute
ALS – Airborne Laser Scanning
ASPRS – The American Society for Photogrammetry and Remote Sensing
ASTM – The American Society for Testing and Materials
EDC – U.S. Geological Survey's EROS Data Center
GIS – Geographic Information System
GPS – Global Positioning System
IEEE - The Institute of Electrical and Electronics Engineers
INCITS L1 – InterNational Committee for Information Technology Standards
ISPRS – The International Society for Photogrammetry and Remote Sensing
ISWG - The IEEE Committee on Earth Observations Standards Working Group
ISO – The International Organization for Standardization
.LAS – the file extension of the ASPRS lidar data exchange format
LAS – Land Analysis System
LAS image USGS/AVHRR – raster image format in ERmapper
LAS – Log ASCII Standard
Laser – Light Amplification by the Stimulated Emission of Radiation
Lidar – LIght Detection And Ranging
NIST – The National Institute of Standards and Technology
OGC – The Open Geospatial Consortium, Inc. (= OpenGIS®)
PRR – Pulse Repetition Rate
SPIE – The International Society for Optical Engineering
TC211 – Technical Committee 211 “Geographic information/ Geomatics” in the ISO
TC211 WG6 – ISO/TC211 Working Group #6 “Imagery”
TLS – Terrestrial Laser Scanning
U.S. ATEC – U.S. Army Topographic Engineering Center
USGS – U.S. Geological Survey

1.2 Background

Laser scanning has become a new trend in the areas of applications where precise 3D data collection of a remote scene and capturing of high resolution elevation point data are required. During the last decade a large number of the projects, where this technique has been studied, evaluated and assessed, have been conducted. Numerous reports reported that it is an efficient and trustable method for 2.5D and 3D digitizing remotely located objects and large scenes, and mapping. The big advantage of this technique is that it can provide a much more reliable representation of the actual surface shape for 3D modeling and 3D mapping as compared to traditional remote sensing means like photogrammetry.

The laser scanning technology continues to become more mature and advanced. Since the middle of 90^{th}, when the first commercial airborne laser scanning systems penetrated a market (Samberg, 1996), progress in the development of hardware has occurred dramatically. Also laser data post-processing, analysis, and utilization has been significantly improved and increased. There is already a variety of the areas of applications where both airborne laser scanning (ALS) and terrestrial laser scanning (TLS) are widely used. They are, for example, 3-D city modeling, man-made feature extraction, the forestry, flood mapping, plant industry, documentation of cultural heritage, and homeland security. Nowadays, a number of projects in mapping and civil engineering extensively utilize the laser/lidar data.

1.3 Lidar Data Acquisition Techniques

Briefly, a laser source of laser scanning system can be operated in a pulsed or continuous wave mode. A narrow laser beam is deflected across a scene. A distance between a laser sensor and a target is typically determined based on the time-of-flight (TOF) principles. When this information is combined with information about scan angle and positional (i.e. INS/POS) and navigation (i.e. GPS, GLONASS, and GALLELIO) data, then a 3D position of a footprint of the laser beam can be precisely calculated in a local co-ordinate system. Nowadays, both ALS and TLS provide a laser point cloud which is stored as a file which consists of XYZ coordinates, intensity, and time tags, at least. A 3D model is generated from that lidar dataset. Further, the post-processed lidar dataset is usually converted in a suitable format by using appropriate software. Thus, the lidar data can be taken to any commercial GIS or CAD software.

In the middle of 1990, topographic laser scanning systems were much less powerful than modern systems. Their typical main operating performances were the following: a pulse repletion rate (PRR) in the order of 2-7 kHz, scan rate of 2-25 Hz, and the flight operating altitude above ground level up to 300 m (á 1000 feet). The obtained average laser point density was 0.25 points/m^2 at the flight speed of a carrying platform of 70 m/s (136 knots). Although ALS was able to distinguish between multiple reflections, it was not capable of recording and storing the single returns (echoes) of the first and the last pulse simultaneously (Samberg, 1996). Commercial terrestrial laser scanners were not yet well studied and exploited in everyday practice at that time.

Product specific technical information about currently available commercial hardware can be found from (Lemmens, 2007b; Lemmens, 2007c), and directly on the web sites of vendors of topographic and terrestrial laser scanning systems, i.e. Optech, Leica Geosystems, Riegl, Toposys, Blom, and Zoller+Fröhlich. Briefly, the summarized main operating performances of ALS are the following: PRR up to 200 kHz, scan rate up to 653 Hz, and the flight operating altitude above ground level up to 4000 m (á 13120 feet). The achievable average laser point density is typically 40 points/m^2 at the flight speed of a carrying platform of 70 m/s (136 knots). Furthermore, modern ALS can benefit from a full wavelength digitizing technology. TLS can today operate at PRR up to 190 kHz in pulsed mode, and up to 500 kHz using phase shift measurements. Operating distance is up to 4000 m (á 13120 feet). Achievable scan angle step size can be as low as 0.00067° x 0.009° (Lemmens, 2007c). (Fowler et al, 2007) provides a comprehensive overview of the entire technologies.

1.4 Existing Laser Data File Formats

There are three major parts of a laser scanning process: data capture, data processing, and data archiving for future applications. In the beginning, various hardware manufacturers developed a number of their own propriety laser data file formats depending on the customer requirements of the commercial firms, and on the kind of product required. A continuing development of hardware and the new areas of applications demand more suitable file formats for the new purposes.

There are many different laser data file formats existing. Table 1 shows a summary of those file formats only which more often appear in the technical documentations, reports and literature. Additional data file formats, which are used in a production process of a digital elevation model (DEM) or a digital terrain model (DTM), are listed in (Maune et al., 2007), page 466. Among them is ASPRS LAS, which is a binary file format used for delivering and managing of laser scanner data.

As it is well known, a typical output of a laser scanning campaign is raw point clouds which are stored in files. These file can be stored in generic ASCII format, i.e. .TXT, .CVS, and .DBF. In general, they are the text files containing lists of XYZ points arranged in columns. Any regular columned ASCII format can be used, if it consists, in general, of the following main information: number of lines to skip at the beginning of the file, X (Easting) column, Y (Northing) column, Z (Altitude) column, and, optionally, intensity column, and RGB columns.

Format	Type	Notes
.3DD	binary	Riegl
.ASC	ASCII	text file
.BIN	binary	TerraScan
.CMP	propriety	Optech's REALM, comprehensive format
.CSD	propriety	Optech's REALM
.DAT	ASCII	text file
.DVZ	propriety	project file in FUSION/LDV
.IXF		Optech's ILRIS parser
.LAS	binary	ASPRS LAS
.LDA	binary	FUSION/LDV
.LDI	propriety	index file in FUSION/LDV
.LDX	propriety	index file in FUSION/LDV
.PTC		TerraScan classification file
.PTS	ASCII	Leica Geosystems
.PTX	ASCII	Leica Geosystems
.QTC	propriety	QT Modeler, ungridded point clouds, no interpolation or approximation
.QTT	propriety	QT Modeler, surface model, gridded data set
.RAW	ASCII	raw lidar points
.TEW	binary	TopEye Mark II
.TS	binary	TerraScan
.TXT	ASCII	text file
.WRL	ASCII	used in 3D range imaging
.XLS	worksheet	Microsoft Excel
.XML		DTM file
.XYZ	ASCII	text file
.ZFC	binary	Zoller+Fröhlich
.ZFS	binary	Zoller+Fröhlich

Table 1. A summary of existing common laser data file formats

Furthermore, lidar data can be also delivered for importing in the following file formats: 3dp, 3di, 3dv, dxf, dxb, dwg, obj, 00t, dgd, pt, vml, iv, Cyclone native IMP object database format, Cyclone Object Exchange (COE) format, ASCII SVY, Leica's X-Function DBX format, and Land XML.

Other possible data export formats are 3dp, 3di, 3dv, txt, obj, dxf, dxb, dwg, ma, vrml, jpg, arch_d, 00t, zfs, zfc, pt, ptx, pts, ptc, rle, img, dxf, asc, vml, Cyclone Object Exchange (COE), ASCII (XYZ, SVY, PTS, PTX, TXT, customized format), BMP, TIFF, JPEG, SDNF 3.0 (Intergraph Steel Detailing Neutral File) PCF (Alias Piping Component File) Leica System 1200, LandXML, ASCII point data (XYZ, SVY, PTS, PTX, TXT), DFX, Leica's X-Function DBX format, and Land XML.

1.5 Motivation

It is obvious that inputs and outputs can vary significantly. Thus, it is necessary to develop a friendly interface and have a unique flexible lidar data file standard which will support different inputs and outputs as well as the integration with different software packages for the distribution and management of complex information.

There are several major reasons why ASPRS LAS has been proposed several years ago.

- Manufacturers' data file specifications vary from system to system.
- As it was shown in Table 1, there are a large number of various lidar data file formats existing. This makes data exchange very challenging.
- Uniform software support for different inputs and outputs is required for both ALS and TLS.
- Originally lidar data file, which is a text file, can consist of ten of millions of points. Therefore, the text file can consists of ten of millions of lines what requires a significant amount of hard disk space.
- Depending on lidar project specifications, lidar data files can be much larger than post-processed files, even, up to many Gigabytes, because, for example, there are too many decimals units as compared to actual lidar data accuracy.

In addition, this particular study was motivated by the below following needs:

- A less skilled and proficient end user can be confused by the different meanings of the term LAS which appears in literature.
- Various vendors of lidar data processing tools refer to the ASPRS LAS file format in different ways in their products.

1.6 Activities on Lidar Data Format Standardization

The first steps towards lidar data format standardization were taken by the ASPRS Lidar Committee in the beginning of 2000. In 2003, the version 1.0 of ASPRS LAS, a binary file format, was approved by ASPRS and delivered to the remote sensing and mapping communities. Initially, it was designed and developed for the needs of ALS. In 2005, ASPRS LAS 1.0 was substituted by ASPRS LAS 1.1 with the minor changes. At the same time, TLS has become increasingly popular, in particular, for laser scanning of cultural heritage.

As laser scanning techniques, ALS and TLS, are becoming more mature and everyday practice, they have been attracting more attention of various groups of professionals. For example, (Barber et al., 2003) reported about a lidar initiative started by a Heritage3d consortium (http://www.heritage3d.org). (Barber, 2006) provided an interesting overview of a foreseeing application of ASPRS LAS for purposes of TLS, in particular.

Also other professional organizations started to look over ASPRS LAS (Table 2). The participants of the different ISO projects in the working group 6 of geographic information and geomatics, i.e. 19101-2 (Preference model – Imagery), 19115 (Metadata – Extensions for imagery and gridded data), and 19130 (Sensor and data models for imagery and gridded data), have initiated work to update those projects with a lidar standard. In 2003, NIST in co-operation with ASTM has begun a research for lidar calibration, and evaluation of performances of 3D imaging systems. The aim of this research is to "facilitate the development of consensus-based standards for 3D imaging systems. These standards are expected to include terminology, test protocols for performance evaluation and reporting of test results, and data exchange formats. The availability of standards would i) help clarify manufacturers' specifications to enable meaningful comparisons between various commercially available instruments, ii) encourage uniform guidelines for manufacturers' specifications, testing, and reporting, and iii) facilitate interoperability". ISWG has recently issued a call for developing lidar standards. SPIE and its lidar group of interest are more participating in co-operation with NIST, and have no initiative of its own in developing lidar standard. In 2007, the ANSI INCITS L1 committee initiated a project to make ASPRS LAS 2.0 a U.S. National Standard.

	ALS	TLS
ANSI	x	x
ASPRS	x	x
ASTM	na	x
ISO	x	o
ISPRS	x	x
ISWG	o	o
NIST	na	x
SPIE	na	na

Table 2. A participation of the different organizations in the development work of lidar standards (x – active, o – passive, na – no special activities)

1.7 Materials

From a list of commercial terrain visualization software tools, which consists of more than 500 products, we focused our attention on the most popular lidar data post-processing and management utilities (U.S.ATEC, 2006):

- PCI Geomatica Focus 10.0 from PCI Geomatics, Inc.
- PCI Geomatica Lidar Engine 1.0 from PCI Geomatics, Inc.
- Leica Photogrammetry Suite 9.1 from Leica Geosystems
- ERDAS Imaging 9.1 from Leica Geosystems
- ERmapper 7.1 from Leica Geosystems (former ER Mapper)
- MapInfo 8.5 Pro from MapInfo, Corp.
- ENVI 4.3 from ITT Visual Information Solutions
- IDL 6.3 from ITT Visual Information Solutions
- TerraScan build 007.004 from Terrasolid Ltd.
- LIDAR 1 CuePac 4.0 from GeoCue, Corp.
- LAS Reader for ArcGIS 9 from GeoCue, Corp.
- ArcGIS 9.2 Workstation from ESRI, Inc.
- FME Pro 2007 from Safe Software Inc.
- Quick Terrain Modeler 6.0.2 from Applied Imagery
- Global Mapper 8.0 from Global Mapper Software, LLC
- LIDAR Analyst 4.1 from Visual Learning Systems, Inc.
- MARS Explorer Pro 4.0 from Merrick & Company
- FUSION/LDV 2.51 by Robert J. McGaughey from USDA Forser Service
- MATLAB R2007a from MathWorks, Inc.

Those software utilities can be divided in three groups: stand-along, plug-ins, and development tools. PCI Geomatica Focus 10.0, Leica Photogrammetry Suite 9.1, ERDAS Imaging 9.1, ER Mapper 7.1, MapInfo 8.5 Pro, ENVI 4.3, IDL 6.3, LIDAR 1 CuePac 4.0, ArcGIS 9.2 Workstation, FME Pro 2007, QT Modeler 6.0.2, Global Mapper 8.0, MARS Explorer 4.0 Pro, FUSION/LDV 2.51, and MATLAB R2007a are stand-along. TerraScan build 007.004 and LIDAR Analyst 4.1 are optional modules for MicroStation, and ERDAS Imaging and ArcGIS, respectively. LAS Reader for ArcGIS 9 is a plug-in for ArcGIS 9.x. PCI Geomatica Lidar Engine 1.0 is a plug-in for PCI Geomatica software. MATLAB is only mentioned, because it is widely used by the academic community and R&D people, who deal with laser scanning, although there is no ASPRS LAS support directly. From the other side, there is available a toolbox called SeisLab, which supports the Log ASCII Standard developed by the Canadian Well Logging Society: LAS 2.0 and LAS 3.0 (SeisLab, 2007). Those files also have .las extension.

2. EXISTING LAS DEFINITIONS

Remote sensing community including different vendors of hardware and software (U.S.ATEC, 2006; Lemmens, 2007) has already widely accepted a lidar data exchange file format standard called ASPRS LAS. However, the term LAS is widely used somewhere else too. This can be sometime confusing, especially, when end user is familiar with another application of the term LAS than in the ALS and TLS applications. In order to clarify a situation in this case, we gathered in this section the several most common definitions of LAS which were pulled out from the different open information sources too.

2.1 ASPRS LAS

The ASPRS LAS file format is a public binary file format for exchanging of lidar data between vendors and customers, and maintains information specific to the nature of the data. It is an alternative to proprietary systems or generic ASCII files, which can be very large and slowing down the interpretation of data as a consequence. Also in ASCII files lidar specific information can be lost.

There are currently two active ASPRS LAS versions: 1.0 and 1.1. The version 2.0 is undergoing a final revision and approval. The INCITS L1 project will consider ASPRS LAS as a basic lidar file format for approval as a lidar standard by ANSI.

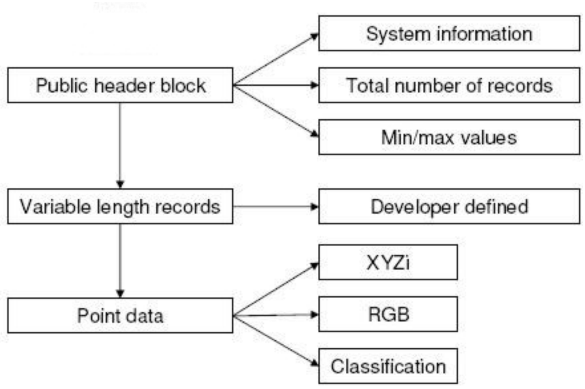

Figure 1. Simplified structure of ASPRS LAS ver. 1.1 (adopted from (Barber, 2006))

In general, the latest release of ASPRS LAS version 1.1 has the following file structure (Fig. 1). There are three block: public header block, variable length records, and point data block. A name of generating software, version number, and statistics like minimum and maximum values of XYZ are stored in the public header block. Variable length records can consist of project specific information. Laser point data, i.e. XYZ values, intensity value, and the results of classification are recorded in the point data block. More detailed specifications can be found at http://www.asprs.org/society/divisions/ppd/standards/lidar_exchange_format.htm.

2.2 Log ASCII Standard

In 1990, the Canadian Well Logging Society designed a floppy disk format standard, and named it LAS (Log ASCII Standard). Its purpose was to complement the LIS (Log Information Standard) and DLIS (Digital Log Interchange Standard) formats which, in own turn, were designed for own specific purposes. Each LAS file had an extension ".LAS". The first official ver. 1.2 was released in September 1990. The LAS file ver. 1.2 consisted of the header information which described optical curves only (LAS format specifications for ver. 1.2, 1990). A media used at that time was a 3.5 inch 720K DOS compatible floppy disk. The floppy disks in the LAS format must be MS/DOS or PC/DOS compatible. Its version 2.0 was released in 1992. In 2000, the LAS file format standard received a version 3.0 with expanded features in order to meet the increasing demands of the end users (LAS format specifications for ver. 3.0, 2000).

This type of the data file format standard was promoted and widely used by the members of the Canadian Well Logging Society, i.e. the petroleum industry and organizations involved in exploring mineral resources. However, this file format standard is not a common practice among the remote sensing and mapping communities.

2.3 Land Analysis System

In comparison with the data file format standards, an entirely specific use of the LAS term is the Land Analysis System (LAS). This is a software system which has been widely used by the U.S. Geological Survey's EROS Data Center (EDC) as an image processing, image and statistical analysis, and raster GIS system originally developed in co-operation with the NASA's Goddard Space Flight Center. The EDC has provided the LAS softawer to outside users since 1983. It is public-domain software which is available to any government or private institution.

The LAS installation package consists of three main modules: Transportable Applications Executive (TAE), Land Analysis System (LAS), and AVHRR Data Acquisition and Processing System (ADAPS). TAE acts as a user interface between the end-users and the system. It manages the execution of the LAS applications. The LAS consists of image analysis routines designed to ingest, manipulate, and analyze digital image data and provide the user with a wide spectrum of functions and statistical tools for image analysis. The ADAPS module has been originally used for receiving, archiving, and processing the data of Advanced Very High Resolution Radiometer (AVHRR) from Tiros-N polar orbiting satellites (System Manager's Guide of the Land Analysis System, 2004). The last LAS version was release 7.4 in November 2001. LAS 7.4 has been used on the computer systems that support the following configurations: SGI IRIX 6.5 using the SGI MIPSpro C and Fortran compilers (version 7.3.1.2m), SUN Solaris 2.7 on a SPARC processor using gcc and g77 (version 2.95.2), various RedHat, Mandrake, and SuSe Linux distributions with gcc 2.95 and 2.96 RH compilers. Previous versions of LAS have also been installed on DEC/VAX computers running VMS 4.7 or higher operating systems, SUN2 and SUN3 computers running SUN/OS operating system, Gould PowerNode computers running UTX 2.0 or higher operating systems, IBM RS6000 computers running AIX operating system, IBM RT computers running AIX operating system, and Data General running DG/UX 5.4.1.

This LAS development work stopped in 2004. Now, LAS 7.4 distribution is available from the ftp site at the Pennsylvania State University: ftp://dbftp.essc.psu.edu/pub/code/las.

2.4 LAS image format

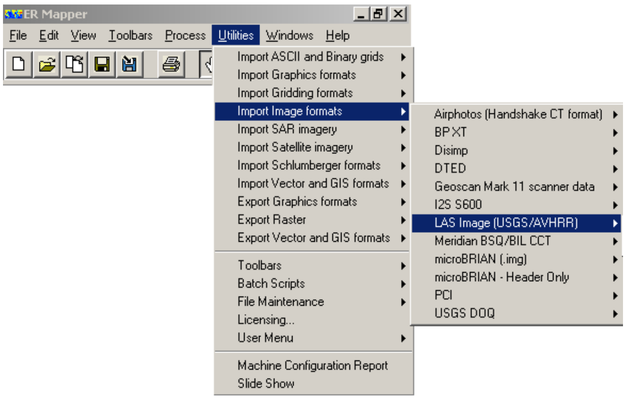

Figure 2. Import tool in ER Mapper 7.1

Import LAS Image reads LAS USGS/AVHRR Image file format data and creates an ER Mapper raster dataset. The source file must be a LAS Image format file (.img). This is the image file (raster) LAS format.

The LAS 5.0 Image file format is supported for read access by the GDB library. The LAS image (USGS/AVHRR) format is used to store various types of geocoded image data. Typically, a LAS image will consist of several related files. The two used by the GDB library are the .ddr and .img files. The .ddr file contains header information and geocoding, while the .img file contains the actual imagery. Either file may be used to refer to the LAS image, but both must exist in the same directory with the same base name (ER Mapper online help).

3. IMPLEMENTATION OF ASPRS LAS

For a visualization purpose and demonstration, there are the following examples of different geospatial utilities which have integrated a lidar processing routing and support ASPRS LAS.

3.1 FME Pro 2007

FME Pro 2007 (Feature Manipulation Engine) typically allows reading from and writing to a supported data format. However, it supports ASPRS LAS reading only (Fig. 3). The lidar reader extracts features from a LAS file, and passes them on to further processing.

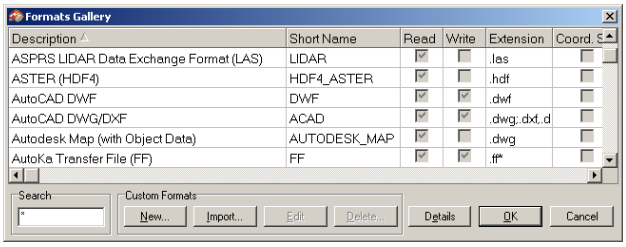

Figure 3. ASPRS LAS support in FME Pro 2007

3.2 Quick Terrain Modeler 6.0.2

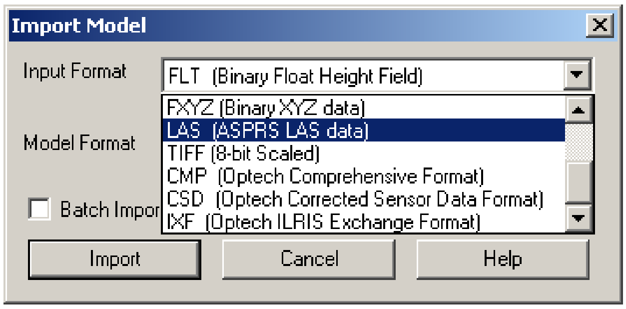

Figure 4. Import file formats in QT Modeler 6.0.2

3.3 LiDAR Tools for ENVI 4.3 and IDL 6.3

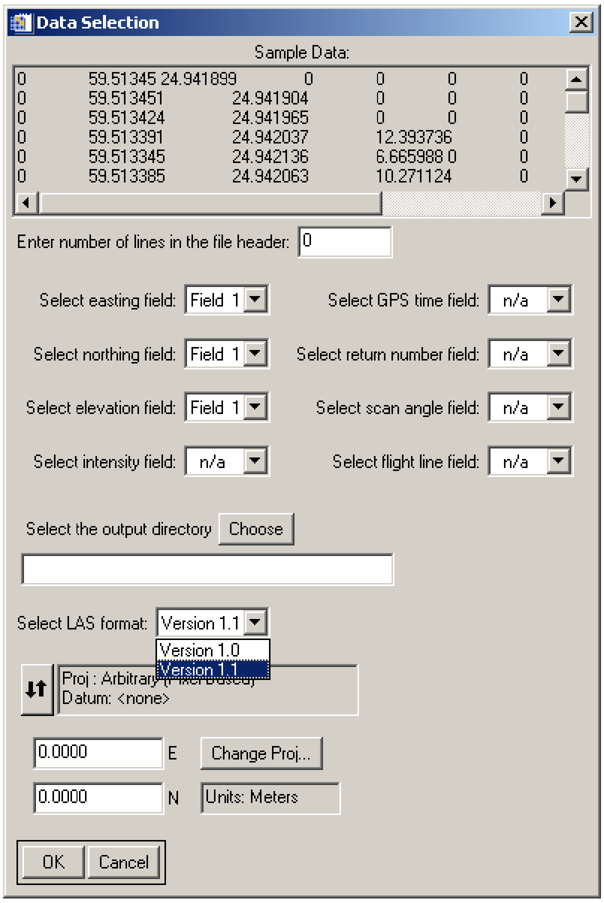

Figure 5. Import ASCII-to-LAS wizard in LiDAR Tools for ENVI 4.3 version dated 20 July 2007

3.4 LIDAR 1 CuePac 4.0

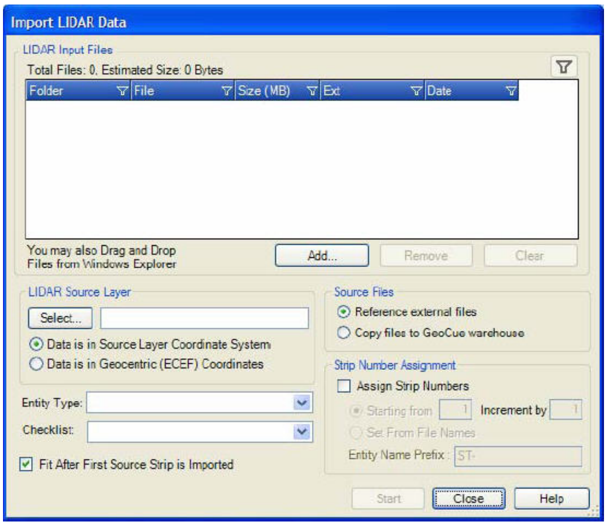

Figure 6. Lidar data import wizard in LIDAR 1 CuePac 4.0

3.5 Global Mapper 8.3

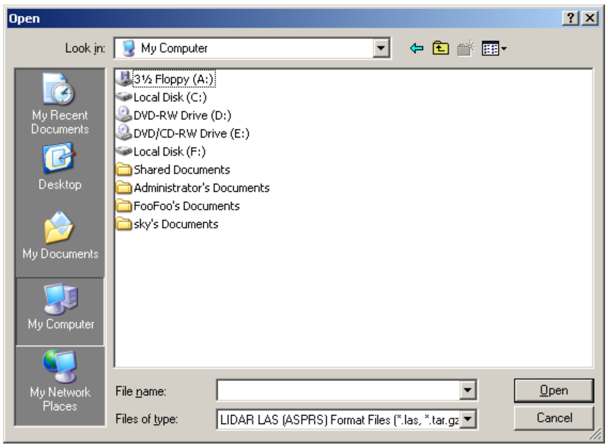

Figure 7. Input file formats in Global Mapper 8.0.3

3.6 PCI Geomatica Focus 10.0

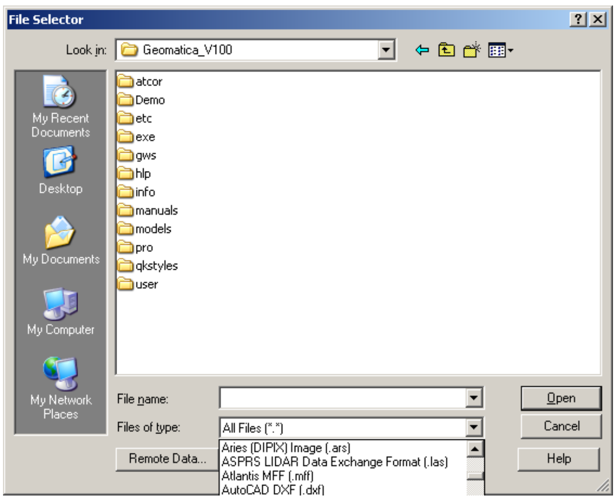

Figure 8. Laser data import window in Geomatica Focus 10.0

3.7 FUSION/LDV 2.51

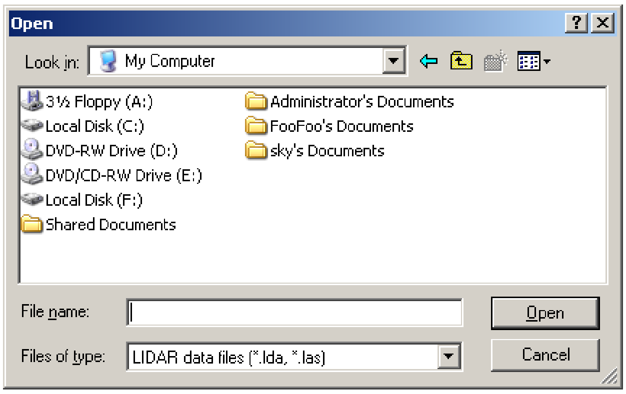

Figure 9. Import/Export tool in FUSION/LDV 2.51

3.8 LIDAR Analyst 4.1

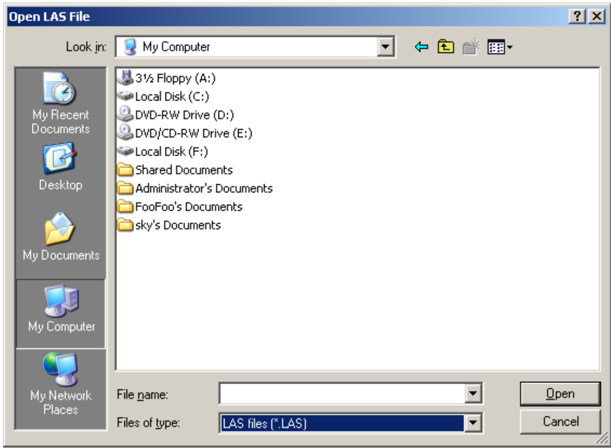

Figure 10. Input LAS file in LIDAR Analyst 4.1

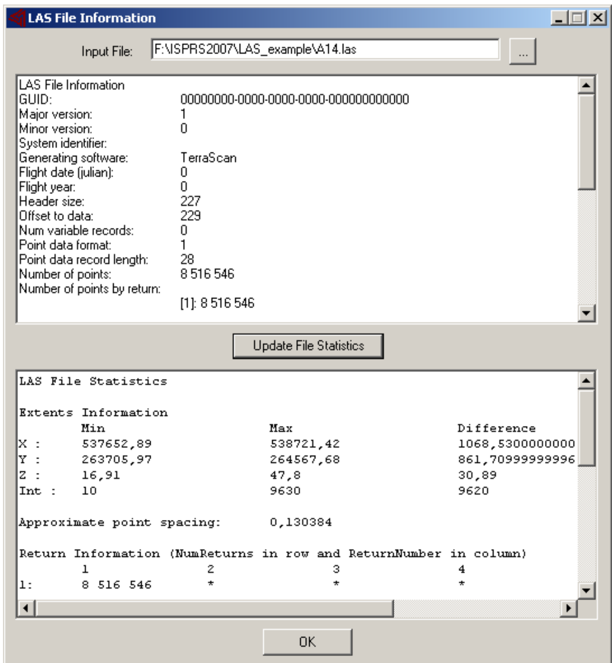

Figure 11. Attributes of ASPRS LAS file in LIDAR Analyst 4.1

3.9 TerraScan 007.004

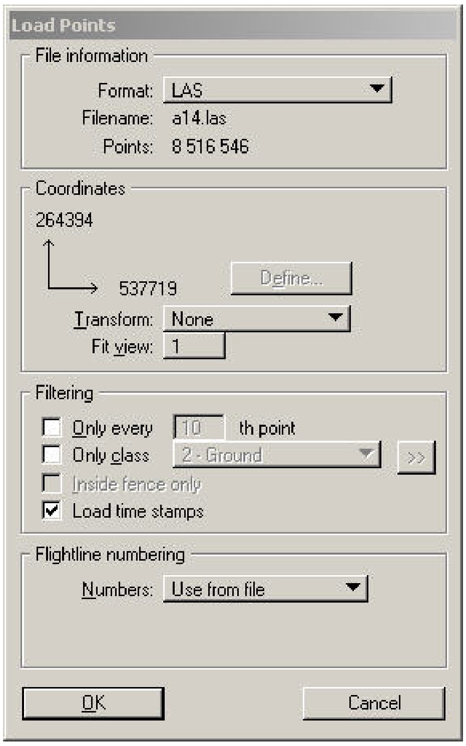

Figure 12. Import laser points from LAS file in TerraScan

3.10 MARS Explorer Pro 4.0

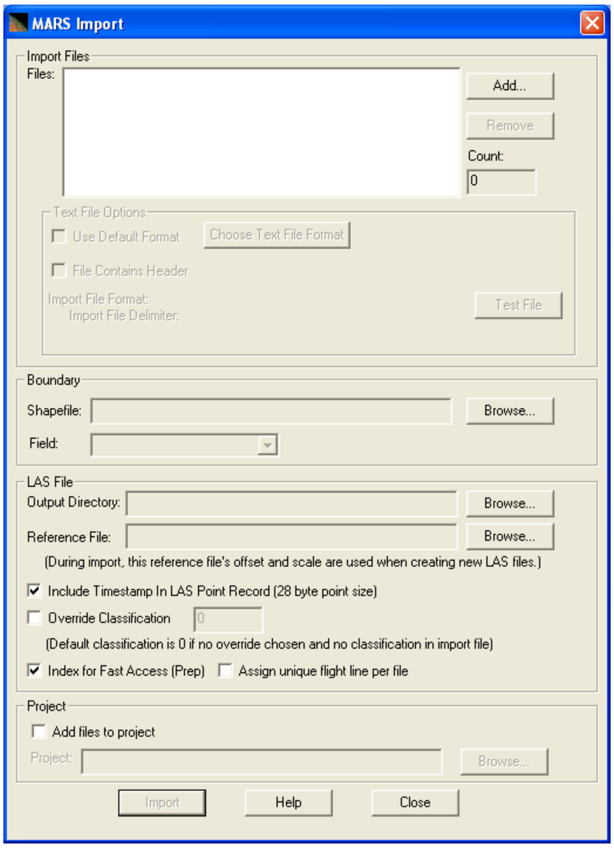

Figure 13. Import wizard in MARS Explorer Pro 4.0

3.11 Leica Photogrammetry Suite 9.1 / ERDAS Imaging 9.1

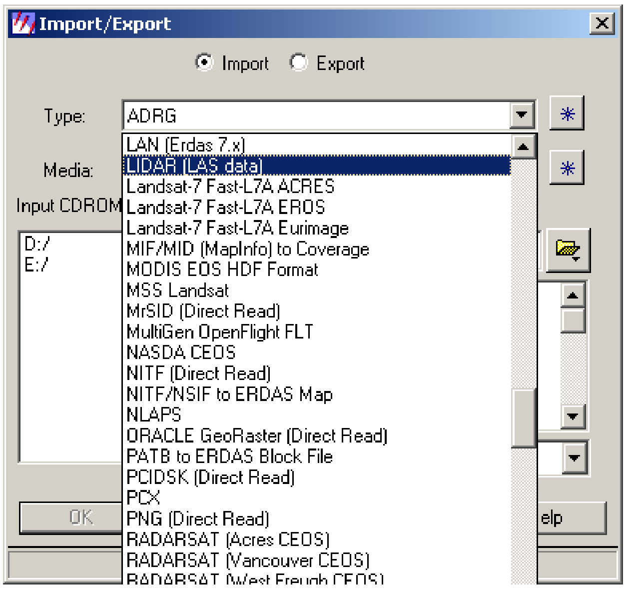

Figure 14. Import/Export tool in LPS 9.1/ERDAS Imaging 9.1

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

19 software packages have been studied. It is obvious that the ASPRS LAS file format has reached its worldwide popularity. A number of stand-along lidar data processing utilities have already added the ASPRS LAS support to their import tools (Fig. 3, 4, 6, 7, 8, 9, 13, and 14). However, only few of them are capable of delivering of (post-)processed lidar data in the ASPRS LAS file format (Table 3). Also there are available optional modules for lidar data processing like LIDAR Analyst 4.1 for ERDAS Imaging (Fig. 14), LIDAR Analyst 4.1 for ArcGIS, LiDAR Tools for ENVI (Fig. 5), and TerraScan (Fig. 12), which runs on top of MicroStation.

Only LiDAR Tools for ENVI clearly identifies the different versions of ASPRS LAS supported, for example, in its ASCII-to-LAS importing tool what was a bit surprise (Fig. 5).

There are the different lidar file format names. They appear in import/export tools of various SW packages as follows:

- LAS
- LAS files (*.LAS)
- ASPRS LIDAR Data Exchange Format (LAS)
- ASPRS LIDAR Data Exchange Format (*.las)
- LIDAR LAS (ASPRS) Format Files (*.las, *.tar.gz)
- LIDAR (LAS data)
- LIDAR data files (*.lda, *.las)
- LAS (ASPRS LAS data)
- LAS format

Advantages:

- ASPRS LAS has been already recognized and accepted as in industry lidar standard worldwide
- Binary file format allows to speed up entire lidar data processing and project management processes

- Applied binary file format allows to significantly reduce a space required for lidar data storage
- Allows to share entire lidar data set between different end user's over a net or the Internet, and manipulate in small pieces independently
- The ANSI INCITS L1 committee initiated a project to make ASPRS LAS 2.0 a U.S. National Standard

Disadvantages:

- No ASPRS LAS conversion tool exist
- Various vendors use different names of ASPRS LAS in their software packages
- Absence of a version number in the import tools
- Help documentation does not always well explain what ASPRS LAS version is supported by a particular software

Software	Read	Write
PCI Geomatica Focus 10.0	+	-
PCI Geomatica LidarEngine 1.0	+	-
Leica Photogrammetry Suite 9.1	+	+
ERDAS Imaging 9.1	+	+
ER Mapper 7.1	-	-
MapInfo 8.5 Pro	-	-
ENVI 4.3	+	-
IDL 6.3	+	+
LIDAR 1 CuePac 4.0	+	+
ArcGIS 9.2 Workstation	+	-
FME Pro 2007	+	-
QT Modeler 6.0.2	+	+
Global Mapper 8.0	+	+
MARS Explorer 4.0 Pro	+	-
TerraScan build 007.004	+	-
LIDAR Analyst 4.1	+	+
LAS Reader for ArcGIS 9	+	-
MATLAB R2007a	-	-

Table 3. A summary of reading and writing capabilities of ASPRS LAS by various geospatial software utilities

4.2 Recommendations

Initially, ASPRS LAS has been intended for the use with ALS only. However, its practical application and increasing popularity have proved that the ASPRS LAS concept can be used somewhere else. It seems to be already accepted as a defacto of industry standard worldwide. For example, the Heritage3D group has proposed to adopt ASPRS LAS as an attractive generic solution for the delivery, archiving, and exchange of both ALS and TLS data. However, in its present form (version 1.1) it is not suitable for storing and handling of TLS data. Some useful TLS practical examples and standard considerations are well presented in (Staiger, 2003; Aschoff, 2004; Mamatas, 2004).

There is one cosmetic issue. It appeared that a name of ASPRS LAS varies between various hardware and software manufacturers. Therefore, it is necessary to make this name unique like ASPRS LAS. We suggest updating their import and export tools, and simply changing the existing names to ASPRS LAS in the following releases or service packs. Also the version number of the ASPRS LAS file must be clearly identified in the import and export tools for a more convenience usage.

It is expected that the designers and developers of the next version of ASPRS LAS will take in consideration other existing laser scanning systems like bathymetric and active hyperspectral lidar systems in addition to ALS and TLS. At least, it must be possible to store their attributes in the existing or forthcoming variables, which must be easily recognized and interpreted.

It is expected that the proposed next version of the ASPRS LAS file format (version 2.0) will help establish a consistent understanding and should clear up a lot of the confusions (http://www.asprs.org/society/divisions/ppd/standards/lidar_exchange_format.htm).

4.3 References

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