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LiDAR Trends and Developments

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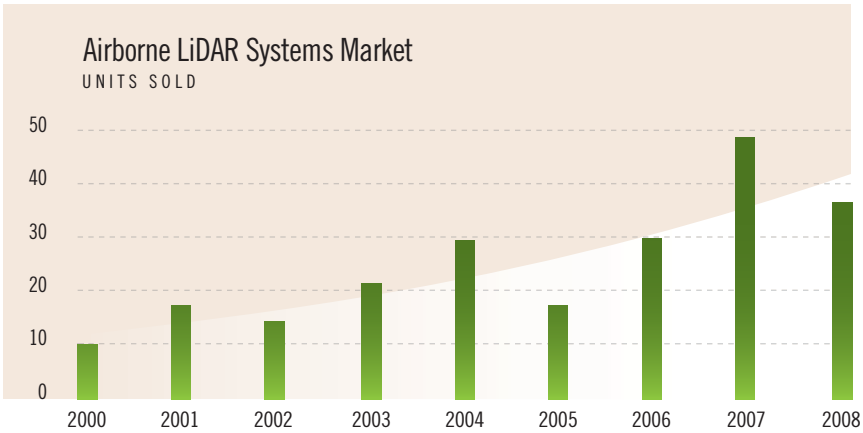
LiDAR (Light Detection and Ranging) became available to the commercial market in about 1994 evolving from the defense industry. At that time, sensors operated at 5 to 10Khz repetition rates or 5000 to 10,000 pulses per second. Additionally, most sensors were proprietary. These sensors were single pulse systems operating in first or last pulse mode. It was very difficult for LiDAR companies to convince potential customers to use LiDAR as it was not well known in the mapping industry. Adoption was slow in the early years as traditional surveyors and photogrammetrists became to approve and use the technology.

Starting in early 2000, multi- return 50Khz systems where introduced. These systems yielded between 4 to 6 returns and intensity information. Most recently, systems operating at 200Khz to approximately 400Khz have been developed and are currently used in the industry. Some of these systems have the ability to emit two pulses in the air at the same time. In addition, The LiDAR manufacturers have developed full waveform digitizers for their sensors which provide all the information from the pulse. This emerging technology is intriguing to certain markets such as the forestry industry. Most systems operating at above 200Khz are used for low altitude, corridor mapping and very dense collections. Larger scale collections, such as county wide mapping and state programs utilize systems operating at between 50 and 200khz with up to 4 returns per pulse including intensity information. LiDAR manufacturers suggest that we could see repetition rates of 500khz in the very near future.

Currently, it is estimated that 280 LiDAR systems have sold since the mid-1990's and that there are roughly between 90 and 100 of sensors operating in the United States with nearly half of that number operating in the rest of the world.

The graph below provided by Leica Geosystems illustrates the sensor sales trends since 2000. There have been significant developments in all aspects in LiDAR in the last two years which include software, hardware, processing and applications.



"The LiDAR market is growing all around the world, but LiDAR handling software is not and there is a void in LiDAR processing software."
Richard Vincent –Virtual Geomatics

Lidar providers have been pressed by their clients to provide more accurate data with better classification results. This is based on the discovery of increasing uses of the data and diverse applications. New and improving methodologies created by the providers is possible with better accuracy while improving the ability to deliver quantifiable data. LiDAR providers are setting expectations and standards from their experience for which the software industry is responding to provide better tools to get the clients what they need. Several software companies have emerged in the last couple of years as a result of this need. Historically, LiDAR data was typically produced to provide a bare earth surface in several forms. Currently, programs are required to include not only bare earth but vegetation, building, bridges and water to mention some of the required classifications. In some cases, clients are requesting classification of vegetation in separate classes. This presents a difficult task for the providers and the software developers. The providers are expected to quantify the results and are driven to provide the best results in all classification categories. Consequently, the available software can be limited. There is an increasing need to provide software that utilizes expanded data sources which facilitate the enhancement of LiDAR data such as; Hyperspectral, Multi-spectral, Meterodological and Digital Imagery data.

The good news is that LiDAR and software providers are working at a feverous pace to meet the needs of clients' demands. It can be expected that LiDAR data sets will be provided with several new identified classes and in the desired formats.

LiDAR data formats and the amount of data opened up a whole other can of worms. About six years ago, ASPRS and some industry folks decided to develop a LiDAR format standard known as the LAS format for LiDAR data. This binary format was critical to the success of LiDAR, but as the industry developed, the requirements of this format changed. The standard needed to change and thus the software needed to change to accommodate the new formats. ASPRS is in the process of developing a new standard to better facilitate the industry needs and based on trends of the industry, the LAS format will have to continue to adapt to the industry.

LiDAR sensor hardware technology continues to improve at a rapid rate. Every two years it appears that the repetition rate doubles. This is limited by the electronics of the systems' ability to deal with the data as it is collected. The biggest advance in recent years is the ability to have two pulses in the air at the same time making it possible to fly higher and collect more data in a shorter time period. The accuracy of the the data continues to improve but is limited by the satellite navigation system. The GPS satellite navigation system has greatly improved over the last 6 years providing the ability to collect LiDAR around the clock. As a result of the improvements in the sensors and the GPS satellite navigation system, improved vertical and horizontal accuracies exist today. These accuracies are a function of many variables such as; flight altitude, scan frequency, scan angle, repetition rate, beam divergences, GPS constellation and atmospheric conditions, to name a few. Generally, accuracies at very low altitudes with helicopter platform sensors are available in the range of 2 to 3 centimeters RMSEz vertically. Fixed wing platform sensors yield accuracies as good as 3 to 4 centimeters but most companies would not sign up for these accuracies. Typically, clients can expect accuracies between 9.14 centimeter RMSEz to 18.5 centimeters RMSEz vertically when flying between 800 and 1400meters in single pulse mode depending on the application and product requested. Horizontal accuracy, although difficult to quantify, with fixed wing platform sensors yield between 18 and 27 centimeters RMSE when flying between 800 to 1400meters AGL (Above Ground Level) when flying in single pulse mode. Typically, like accuracies can be achieved in multi-pulse mode at between 2000 and 2400 meters.

The most significant trend in sensor hardware is the addition of other sensor types to the LiDAR sensor platforms. This is driven by the need for additional information for uses such as transmission, pipeline and forestry applications as well as coastal collections. Hyperspectral, multi-spectral, CIR, RGB and digital video sensors are coupled with LiDAR sensors to provide the necessary information

6in GSD CIR image from an Applanix 39 Megapixel DSS aerial camera.

requested by clients. This information provides the LiDAR vendors the ability to process the data more efficiently in these distinct applications.

LiDARgrammetry has emerged as an accepted practice as a result of the intensity information provided from the sensors. Images are generated from the intensity information in either 2-D or stereo with breaklines and cadastral data generated from these images. Largely, breaklines from the intensity images are generated and the accuracy of this information is a function of the point sample density and the associated accuracies. In addition, the error associated with the interpolation to the raster image contributes to the accuracy of the resulting products..

The outlook for the LiDAR industry continues to be very positive and expansion can be seen in the increasing demands from new markets . As a result, those involved in the industry are encouraged to develop better sensors and new processing architectures to support clients requirements. Significant advances continue to be made in all aspects of LiDAR. The industry will provide new solutions involving other sensors coupled with LiDAR systems.. Point density and point acquisition speed (i.e pulse rate) continue to dominate as the prime specifications by which the market measures the systems and industry. Historical trends indicate that technological advances will continue to be introduced at a staggering rate.