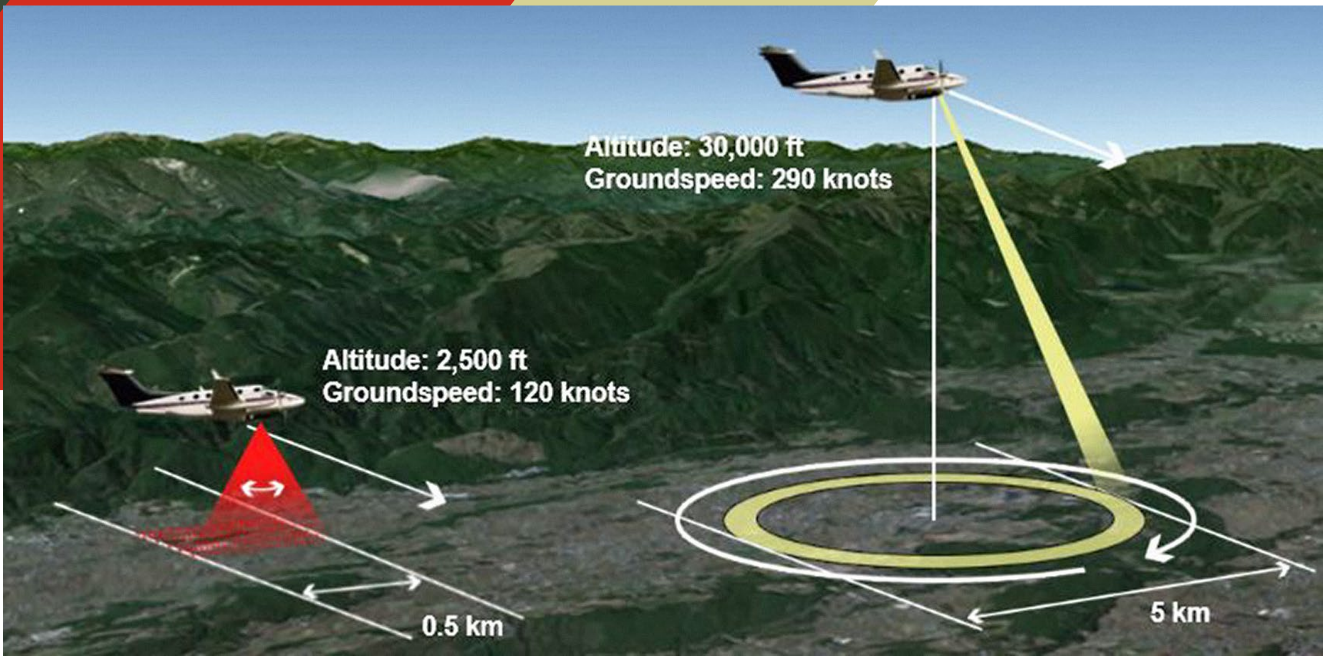


Shows the collection efficiency of Photo LiDAR versus Conventional LiDAR as presented at ILMF 2015.
Provided by Harris Corporation

Are We There Yet?

Conventional, Geiger-Mode, Linear Mode, and Single Photon LiDAR

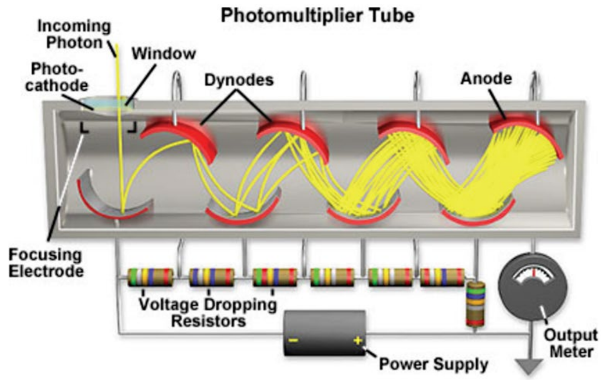
Recently there has been a lot of buzz about photon LiDAR sensors and how it will affect airborne LiDAR data collection as we know it. It is very hard to figure all this new technology out, what it does and how it compares to current widely used LiDAR technology. For the purpose of this article, the term conventional LiDAR will be used for traditional discrete return LiDAR technology and the new technology will be refer as photon LiDAR.

There are several variations of photon LiDAR sensors making their way into the commercial LiDAR marketplace. This technology, much like the widely used conventional LiDAR technology comes out of defense mapping. It is ironic that conventional LiDAR faced a similar situation when it was introduced as an alternative to photogrammetric mapping nearly 20 years ago.

The potential for photon LiDAR is similar to what conventional LiDAR was to photogrammetric mapping, but it would be wise to be cautiously optimistic about the new technology. Conventional LiDAR was mistreated and misused on several programs when it was first introduced. There is great potential for the new photon LiDAR technology, but it comes with its own concerns and constraints. It could be a couple of years until we understand its strengths and what it is best used for.

It doesn't seem that the new photon LIDAR technology is fully understood by the average elevation data user and this is cause for a lot of concern. The mapping profession has just gotten our hands around conventional LiDAR, when to use and not to use it in the past 5 to 10 years. At a minimum the technology is super cool and provides obvious benefits.

BY JAMES WILDER **YOUNG**



Photomultiplier and how it works to produce billions of photons as presented by Lewis Graham of GeoCue at presented at MAPPS Summer 2014 conference.

The photon LiDAR sensors operate at 532, 1064 and 1550nm on the light spectrum. There are different reasons why the sensors operate at different wavelengths which share similar rational to current conventional LiDAR. The sensor operating at 532nm provides both topographic and bathymetric information. The sensor that operates at 1064nm appears to provide much higher point densities and the one that operates at 1550nm can be operated at very low altitudes. This photon LiDAR sensor was originally designed to be used for real time LiDAR interpretation for applications such as aircraft and space craft approaches and landings. The big advantage to these systems is that they can collect much more, high density data from much higher altitudes.

There are about 5 x 10^{14} photons in a single airborne laser scanning pulse. This is billions and billions of photons. The sensors samples a feature several times and produces an aggregate from multiple pulses. These sensors operate at much lower power than the conventional LiDAR sensors. The highest efficiency sensors can collect up to 10 times more data than the latest conventional sensors at similar point densities.

This raises the question of atmospheric conditions as they relate to both types of sensors and the environment as it relates to a given area of interest (AOI). If a photon LiDAR is operated at 27,000 feet or even 40,000 feet and a conventional LiDAR is operated at between 6000 and 9000 feet day or night where is the cloud layer? That being said, if an AOI that takes 10 days to fly with conventional LiDAR and 1 day with a photon LiDAR and the clouds are at 15000 feet for 9 days and there is 1 day of clear skies, then the efficiency is the same for both sensors.

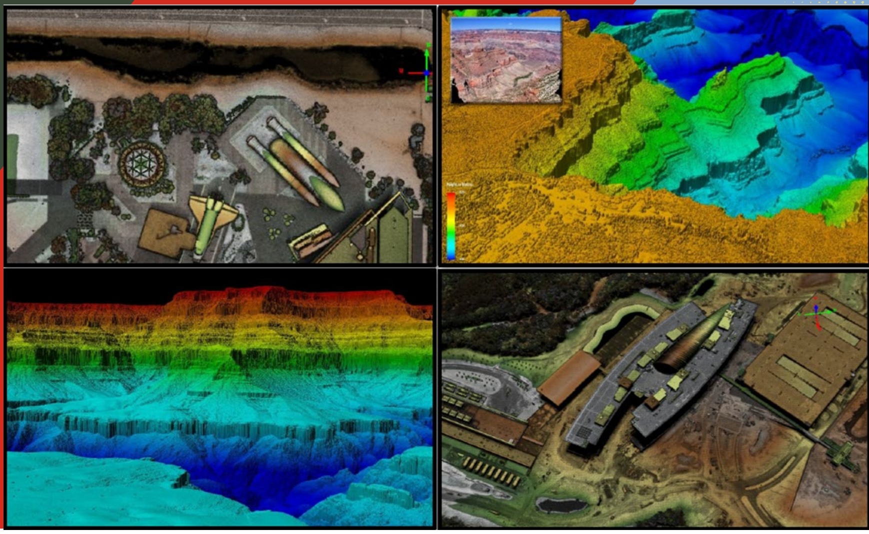
How does the cost of operating a jet or high altitude aircraft related to a lower altitude aircraft with a conventional LiDAR. There are a lot of practical issues to consider when comparing the two types of sensors.

One of the early concerns with the photon LiDAR sensors was the potential of ghosting in urban and vegetated areas. This would create voids in the data set where conventional LiDAR would not have this problem. Recently, the designers of the photo LiDAR sensors developed a scanning system that rotates in a circular pattern to reduce the ghosting significantly. This appears to work well in urban areas and potentially would produce a better data set in vegetated areas as well. Upon review of vegetated areas it would appear that ground representation is much better in the more recent photon LiDAR sensors.

The data generated from these photon LiDAR sensors can be very noisy compared to the conventional LiDAR sensors. There has been times that the conventional LiDAR sensors if not tuned properly can show similar noise but not to the extent of the photon LiDAR. The photon LiDAR has significant returns as a result of atmospheric conditions and additional returns that appear to be below the ground. Additionally, it is sometimes hard to determine a vegetation return versus noise within the vegetation canopy, so caution should be used if vegetation returns is important to a specific project.

The key to this technology is in the processing of the data. Recent presentations would indicate that the process is automated and after this the data is good. Cautious optimism is the best way to describe this process as the results are not readily available and there is much anticipation to review this data from within the LiDAR profession. It should be understood that the defense industry has been using this information for several years and it is ideal for their uses because these systems can collect large areas in a very fast time frame. Much like conventional LiDAR almost two decades ago the new technology may need to change, adapt to the commercial market and play by a different set of rules.

One of the major hurdles for these sensor and service providers is getting the acceptance of the technology and adapting the current widely accepted specifications within the LiDAR market. When was the last time a RFP did not have some element of the USGS LBS specification in it? It seems like most



Four examples of very detailed and impressive results from Geiger-Mode LiDAR as presented at ILMF 2015.
Provided by Harris Corporation

wide area collections require some level of this specification. The specification is very clear in requiring that data elements such as fully calibrated RAW swath be provided. There is a requirement for all returns being present in the data set including a class for noise data.

The vegetation return information is required in different ways. The relative accuracy is now required to be 6cm and 8cm within swath and between swaths, respectively. The header information as it relates to the ASPRS LAS 1.4 format needs to be a certain way. It is clearly stated that the absolute accuracy of QL2 data has to be 10cm as tested. The photon LiDAR data processing procedures typically provide a fully calibrated data set that is delivered automated with the potential absences of swath information in some cases. This is not to say that these sensor and service providers can't get there, but right now this presents a challenge.

Additionally, how will these photon LiDAR sensors function as compared to Conventional LiDAR sensors on high accuracy LiDAR projects such as power line and corridor mapping projects or are they even considered for this type of work? What is the highest accuracy that these sensors can achieve and how do photon sensors represent the features such as power lines? How does that compare to the current highly accurate conventional helicopter based sensors we currently use? Can a LiDAR provider expect to get HD video, weather information, still images, thermal and digital imagery in conjunction with these type of photon LiDAR platforms?

These are all questions that should be asked when considering this technology. It should be noted that potentially the photon LiDAR sensors in conjunction with high altitude large format digital camera system could provide a very favorable solution to current orthophotography and LiDAR projects. When does this make sense based on the cost versus conventional methods? If the sensors are co-mounted in one aircraft it has to be cheaper than our current method or is it?

There has been much discussion over the last few months on how these system represent the ground and how the processing is conducted to actually represent the ground. It would appear that with different photon LiDAR sensors and service provider's processes, the result is much different. This sounds like a broken record when you think of conventional LiDAR and how it developed over the last 20 years and is perceived. It is very true though. Resulting data from photon LiDAR sensors and service providers show exceptional detail and are quite impressive. In other cases the data can be marginal at best and it would appear that the data has been nominalized to make the ground look like something we think it is suppose too look like.

It would be very naïve and short sided to discount the potential of this technology. It is new and there are going to be detractors and advocates of this technology. As in most new technology it is important to fully research, understand what a technology does, what the advantages and limitations are of this new technology. It would appear that there are not very many professionals that fully understand the technology's potential and limitations.

Early indicators suggest that this technology will provide another solution for our profession, but will it replace current technology? That is yet to be determined. Until we fully understand it we are not going to know and the hope is that cautious optimism will prevail with photon LiDAR until we as a profession can get our minds around it. The best aspects of this technology, is it challenges the LiDAR profession to get better and keep our eyes open because there is always someone trying to make something cheaper, better and faster.

James Wilder Young C.P. (Jamie) is currently a Senior Geomatics Technologist for Merrick & Co. located in Greenwood Village, Colorado. His experience includes all aspects of LiDAR including sensor development, applications development, data acquisition, data processing and project management.