

**QUESTIONS & ANSWERS FOR [AMERICAN TRAILS](#) WEBINAR:
Assessing Trails: LiDAR Assisted Trail Topography Evaluation (LATTE)
April 29, 2021**

Barry asks: I've heard that the first-generation Teslas used a form of LiDAR in their autopilot system. Is that true? **That is true. Elon has used LiDAR at the beginning, but has abandoned it and is not very happy with it now. (Although very recently this stance has changed) What I think are the reasons for his departure, are the incredible data size / storage needed for this application, through the pipe real time data processing and unlike photography and facial / object recognition, LiDAR only has coordinate value, scan angle, timing, intensity value (reflectance values of objects). LiDAR does not auto classify in real time yet. Most likely in the future these downsides will be solved by more R&D and more units in the field.**

Charles asks: What wavelengths are used in the LiDAR discussed in this webinar?

Since a typical eye-safe **LiDAR** will have a frequency of 200 THz and a **wavelength** around 1.5 mm, a typical **LiDAR** will have a **wavelength** about 20,000 times smaller than the X-band tracking radar, and 200,000 times smaller than the L-band search radar, with corresponding increases in carrier frequency. Typical LiDAR is RED Laser which works great on land, but newer LiDAR sensors are Green Laser and can see through Water with specific conditions met, ie: Depth, Turbidity and Clarity.

Christopher asks: What software do you recommend for your LiDAR Analysis with your point cloud data? **Global Mapper with the LiDAR Module, TerraSolid which has multiple modules depending on your needs and Cloud Compare which is a Free Viewer and has some simple functionality. LAS Tools is of notable mention as well.**

Ellen asks: If a local volunteer group wanted to scan trails to about 2' contours accuracy, what tools do you recommend? **ZEB Revo Discovery or Zeb Revo Horizon would be ideal for this contour interval output. The next step is, would you like Relative or Absolute Accuracy? Relative is a registered scan with no surveyed / measured ground control points in the scan environment and Absolute Accuracy has the registered cloud scaled to measured points (X'S on the ground and in the scan) which makes it measurable and highly accurate to the real world.**

I would like to understand what hand unit was used as well. **We used the First Incarnation of the Zeb Revo in 2016. Zeb Revo RT, Zeb Revo Discovery and Zeb Revo Horizon are the most current forms.**

What was gained by using a tripod in terms of value for trail renovation? Was the higher precision worth the additional time? **On the project it was used for, yes, as it needed a high level of accuracy to design repairs of existing structures. Many other circumstances could require that level of accuracy but, for general trail information the handheld or backpack is sufficient.**

Eric asks: What is the rough cost of these handheld units? **\$30,000 - \$110000 + Software and Operator**

Henry comments: Looking for correlations with my senior project in environmental resource conservation. **The Terrestrial and Handheld units may work for As is Situations, meaning what the environment looks like at time of scan, but will give less about environmental feedback, ie water sample info, exact tree species delineation... Lidar allows one to make management decisions at the landscape level in a more efficient and cost-effective manner. It also gives us a comprehensive picture at the landscape scale. Usually environmental resource conservation efforts are a much larger size (acres), so**

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UAV / Traditional Airplanes with Photo / IR Band – Hyperspectral Equipment or large format aerial lidar to cover the areas efficiently and cost effectively would be best. Flood analysis works great with these tools. If it is a smaller area, then I think handheld and tripod mounted would be helpful. Keep in mind that LiDAR is a tool with line of site properties, meaning more twists and turns, the more scanning needed. We would love to hear more on this one, to give an exact answer.

Jane asks: Does LiDAR have the ability to identify plant species? Possibly, but through visual comparison, not automatically. If a field assessment takes place, the trees could be classified by species this way. Tripod Mounted RGB LiDAR – Color Added to the Point Cloud would be helpful with this as it is very accurate and extremely high resolution so that you can actually make out leaf types and trunk dimensions. Ideally what I think you are looking for is the Multi or Hyperspectral Scan, which can delineate exact species based on Reflectance characteristics. A Douglas Fur tree may reflect Red, where a Palo verde may reflect green. This is just an example of how it may work. The product needed for this is a Headwall Photonics, Micasense or Red Edge Sequoia.

Javier asks: What do you use as control points to accurately compare through time the changes in remote trails? For control points we use 1'x1' or 2'x2' squares that are painted Black and White chessboard pattern. The Lidar picks these up in the reflectance band very well. You would set them all first, scan them and then come back and measure each one, and pick them up as you go. If you have the Zeb Revo Horizon, very minimal control will be needed because this unit is SLAM and GPS enabled.

Jeffrey asks: I can use a drone to make a 3D scene using overlapping photos but I don't think that system allows me to get bare earth. Do you need a LIDAR system to derive bare earth? You can create a very dense point cloud with Photos with Pix4d, Metashape or Dronedeploy just to name a few. The drawback with this method is that when you have Vegetation or Objects in the DSM Cloud (All objects ie: cars, houses and vegetation), on the ground where no Photons reflected back to the camera or obscured by shadow, there will be massive holes in these areas when you go to bare earth the cloud in Post Production. If these areas are not critical to the project that is okay, because the software will interpolate from Point A (X,Y,Z) over the Blank Hole to Point B (X,Y,Z). If this area is critical it would be a good idea to get ground survey info in this area and supplement the point cloud with accurate X,Y,Z in this area. LiDAR has the distinct advantage over cameras, as it is sending so many pulses of measured light to the ground and back, that it gets the Ground, the Tree Trunk, the leaves and then the crown of the tree. Higher Density lidar, the better Result for better coverage and more robust clarity in the point cloud. Also with Pixel to Point, the distortion in the lens creates anomalies in the 3D environment (everything off the ground) and they will not be straight or linear as they would be in LiDAR.

Joe asks: What FAA rule prevents flying drones over trails? The fact that people are on the trail? Can a pilot with the correct license and permit get around this? Definitely not in wilderness or National Parks unfortunately. The rules on flying over people have changed and in most places, now allow flight over people in residential areas. Parks and Preserves may or may not allow flight. Signs will be posted and fines will be levied if you are reported. We mentioned in the presentation that over 30000+ Miles will be unavailable for UAV's no matter what waiver is available. It will always be a case by case situation, and it is better to follow the law, then not and have something catastrophic happen and have very serious issues and ramifications come from a day out flying. I have personally been involved with the UAV industry since 2011 and it is always better to be safe than sorry.

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What LiDAR capture device are you using? Can it be used both handheld and as a UAV payload?

There is a wide variety of LiDAR Capture Devices available:

Tripod: Leica RTC 360 / Leica Black 360

Faro Scanners

Topcon Scanners

Handheld: ZEB REVO RT

ZEB REVO Horizon

ZEB Revo Discovery Upgrade

Robin Backpack LiDAR

CHC USA LiDAR Back Pack

UAV and LiDAR: DJI M300 and the 45 Megapixel Camera and L1 LiDAR System

DJI M600 + L1 LiDAR or Reigl VUX-1 (or newest in this series)

Emesent HoverMap System

Can you filter vegetation versus soil versus bedrock using the .LAS returns when the LiDAR is collected horizontally (handheld)? Vegetation versus soil, yes. Soil versus bedrock, no. We're looking into ground penetrating radar for this purpose.

What software are you navigating and analyzing the data in? Both for pre-processing/filtering and design? Global Mapper with the LiDAR Module, TerraSolid which has multiple modules depending on your needs and Cloud Compare which is a Free Viewer and has some simple functionality. LAS Tools is of notable mention as well. Then onto ACAD and Civil 3D.

When do you decide to use Pixel to Point? When the first return roughly equals ground elevation (no vegetation)? Pixel to Point is good for very clear areas, ie limited vegetation. Pixel to Point has no return information like LiDAR does. It only has georeferenced points that are colored – RGB.

John asks: Is resolution high enough to map the exact path of an established trail? Could Lidar be used to map the sidewalks of a municipality? Yes & yes, for ADA compliance a Tripod Mounted scanner would be recommended.

Jon asks: Approximately how long did the Puerto Rico LiDAR data collection take, both in terms of field time and data processing time? Three days to collect, one week to register the cloud to the control and 7 days to complete all mapping processes.

You use a lot of ground control and check points to check the accuracy of your data-can you give a bit more info about what these are? IE are you collecting data at each one, and if so, with what equipment? This could be a very long answer, but I will keep it short. You will need to find an established geodetic point on or around the property that you are setting up the control network for the project. On the known point you will set a tripod and GPS Unit and burn static (not moving) gps collection for up to 6-8 hours, the control on the trail will be set and then measured with the Rover GPS (Moveable) and all points will be averaged / combined to the static point in post processing. You will then use the panel / coordinate data to register your point cloud and create a highly accurate horizontal and vertical value for all points in the cloud. The Zeb Revo Discovery is promising no ground control and is a combo of

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SLAM and GPS Technology. If you are from the survey community, which I am, no targets equals no redundancy. So technically, the jury is still out on this one.

Can you give some ballpark pricing for the different technologies you are using, both hardware and software? Tripod Scanner – \$75000 and Up + Software + Operator,
Handheld \$30,000 – 110000 + Software + Operator
UAV and Camera – \$5-15000 + Software and Operator and
UAV with LiDAR and Camera – \$35-150,000

These are extremely rough guesstimates. A good rule of thumb, is you will buy a system based on what you need it to do and the deliverables that the client / project requires.

Matt asks: What make model of handheld LIDAR unit(s) do you recommend. Do any communicate better than others with AutoCAD?

Handheld: ZEB REVO Horizon or Zeb Revo Discovery
Robin Backpack LiDAR
CHC USA LiDAR Back Pack

The process will be control, scan, register, reality capture then to ACAD. Fundamentally, this flow will be the same with all scanners to ACAD.

Matthew asks: I'm interested in hearing about how this technology can help us monitor trails for widening (trailside vegetation mortality), soil loss, braiding, and other common problems.

Yes, it can be used for these purposes. The caveat is that there needs to be a large enough inventory to be cost effective. Not 1-5 miles but, very useful over this amount and more economical at 20 miles and above.

Melanie asks: Where can one come by a handheld LiDAR device?

<https://geoslam.com/>

Will the workflow be provided to us? - If you went out on your own, you will work with customer support to arrive a workflow for your needs. When you work with Okanogan and LATTE, the workflow is already complete and the process is set.

Michele asks: How much does a handheld unit cost? About \$30,000 - \$110000

Samuel asks: Who makes the hand-held scanners, and how much do they cost? How wide a swath of usable point data do they collect along collect a trail?

- <https://geoslam.com/solutions/zeb-revo-rt/>

\$50000 + Software + Operator

30 Meter Spray, But Highly accurate at 15 Meters

120 degrees Field of View

Stanley asks: How can this be used to help calculate deferred maintenance on trails? By applying the LATTE protocol to the data set, we are able to call out maintenance issues.

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How much do these handheld units cost? **About \$30,000 - \$110000**

Veronique asks: Could this tool calculate automatically trail access information such as typical & maximum grade, typical & maximum cross-slopes, typical & minimum trail width, and presence of obstacles in a simple report? **The LiDAR scanner collects the trove of data as a Point Cloud, after which processing with the LATTE protocol derives this information.**

Wendy asks: I may have missed this at the beginning...how much does this important equipment generally cost and of course some training? **About \$30,000 - \$110000**

William asks: Re: Trail difficulty rating - can you, with any accuracy determine slopes for ADA requirements? **Yes, longitudinal and cross-slope can be determined very accurately**

Is it attached to a computer or battery pack? **Battery Pack with hard drive**