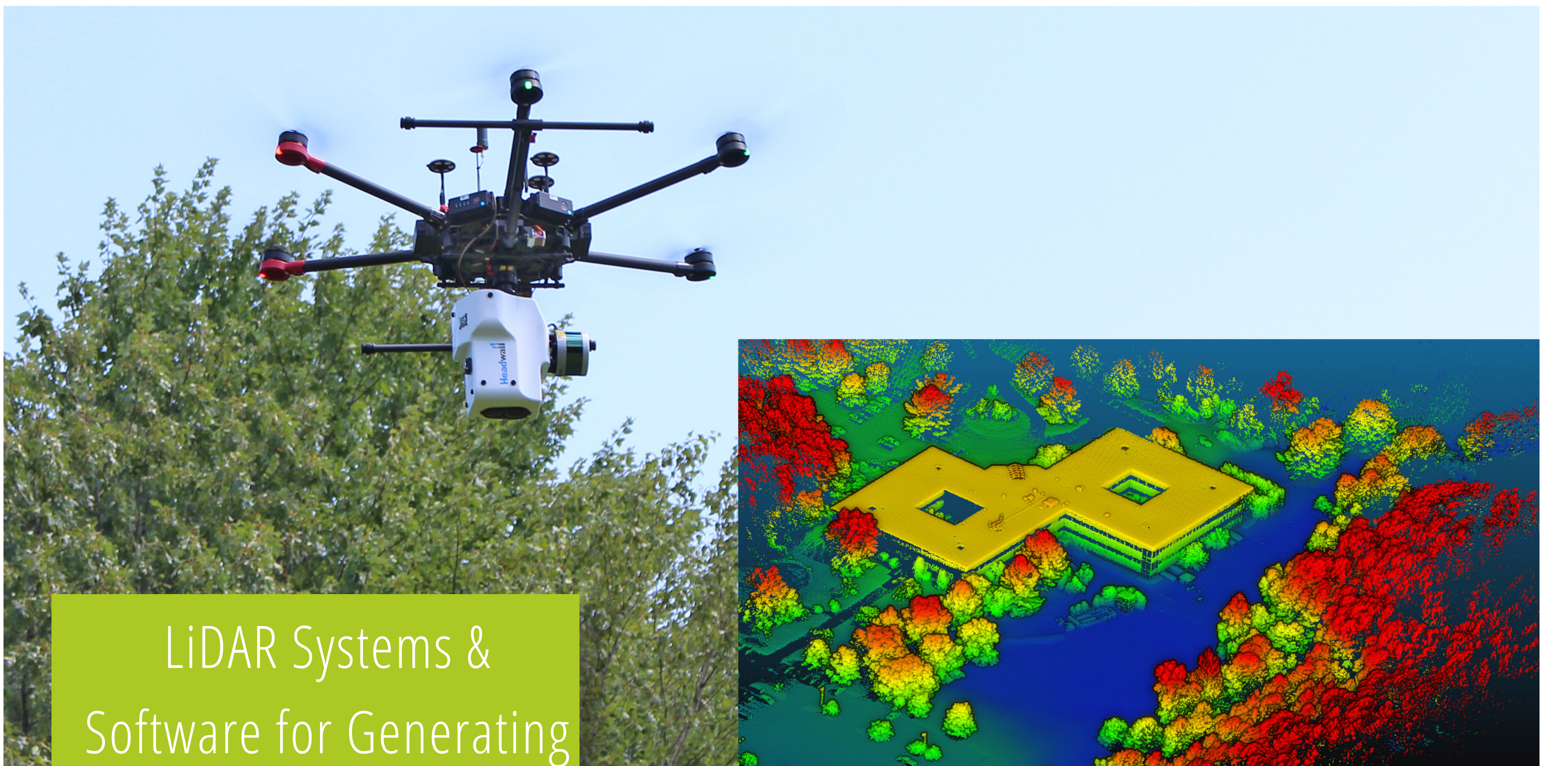
LiDAR Systems & Software for Generating 3D Terrain Data

Product Datasheet

PRODUCT DATA SHEET



LiDAR Systems & Software for Generating 3D Terrain Data

- Integrated hyperspectral & LiDAR payload and turnkey systems
- Capture point-cloud and hyperspectral data simultaneously
- Dual returns for better canopy characterization
- Boresighted with GPS for extremely precise positioning
- Generates high-resolution LAS and DEM files
- Significantly less overlap required than photogrammetry

AIRBORNE HYPERSPECTRAL IMAGING & LIDAR: COMPLEMENTARY SYSTEMS

Hyperspectral imaging and light detection and ranging (LiDAR) are very much complementary. Hyperspectral imaging can remotely detect conditions such as crop disease, water deficits, or plant stress or vigor, while LiDAR measures distances with extreme precision using pulses of laser light. When combined with accurate positioning data from a global positioning system and inertial measurement unit (GPS/IMU) LiDAR data can be used to produce an extremely accurate digital elevation model (DEM) of terrain.

LiDAR Tools software comes with each LiDAR-equipped payload package from Headwall. These systems, such as the Hyperspec® Co-Aligned VNIR+SWIR sensor or Nano-Hyperspec® sensor, are mounted to a DJI Matrice M600 Pro, providing flight-ready operation, and represent the gold standard for lightweight remote-sensing airborne platforms. And adding LiDAR only contributes 0.8kg to the imaging payload weight.

The combination of hyperspectral imaging and LiDAR is especially powerful because the entire dataset can be acquired simultaneously, maximizing efficiency by minimizing flight time. Requirements for overlap of adjacent flight paths are also significantly less than those for photogrammetry. The DEM file that the LiDAR Tools software provides is utilized in the process of orthorectification of the hyperspectral imaging data.

Headwall's focus is integrating multiple sensor modalities and providing the tools necessary for the most efficient and productive workflow for data exploitation. Customers benefit from our expertise in the capture and interpretation of data from our robust and proven platforms, whether imaging payload systems added to a UAV or an entire integrated solution including imaging and positioning packages and the UAV itself.

Figure 1. The upper image shows a typical Headwall turnkey airborne hyperspectral imaging & LiDAR system. In this case, the lightweight unmanned aerial vehicle (UAV) is a DJI Matrice 600 Pro with Headwall high-performance GPS/IMU and an imaging payload (see expanded-box lower image) consisting of a Headwall Nano-Hyperspec® sensor (left) and Headwall LiDAR sensor (right). Other configurations are available.

CONFIGURATION	AIRBORNE PLATFORM	HYPERSPECTRAL IMAGER	SPECTRAL RANGE	GPS/IMU	LiDAR CHANNELS
TURNKEY	DJI M600 Pro	Nano-Hyperspec®	400–1000nm	Standard or High Performance	16
		Hyperspec® Co-Aligned VNIR-SWIR	400–2500nm[2]	High Performance	16
INTEGRATED FLIGHT-READY PAYLOAD	Customer-Supplied DJI M600 Pro	Nano-Hyperspec®	400–1000nm	Standard or High Performance	16
		Hyperspec® Co-Aligned VNIR-SWIR	400–2500nm[2]	High Performance	16
CALL[1]	DJI M600 Pro	Hyperspec® SWIR	900–2500nm	Standard	Note[3]
	Customer-Supplied DJI M600 Pro	Hyperspec® SWIR	900–2500nm	Standard	Note[3]
		None	N/A	Standard	Note[3]

[1] Contact Headwall or authorized reseller to discuss your needs.
[2] Headwall co-aligned hyperspectral imaging systems generate two sets of data that together cover the entire spectral range.
[3] Contact Headwall or authorized reseller to discuss available configurations.

HEADWALL STANDARD & HIGH-PERFORMANCE GPS FOR DEMS

WHY BUY THE HIGH-PERFORMANCE GPS/IMU?

- Significantly more accurate than Standard (Gen 1 or Gen 2) GPS/IMU, even without postprocessing
- Superior vertical accuracy over Standard (Gen 1 or Gen 2) GPS/IMU that aids LiDAR applications

When utilizing otherwise identical airborne platforms, the quality of the point-cloud data captured from the integrated LiDAR systems differs due to the presence of either the Standard (Gen 2) or the High-Performance GPS/IMU. Headwall highly recommends purchasing the High-Performance GPS/IMU for LiDAR-equipped systems. The primary difference between Headwall's standard and high-performance GPS/IMU systems is accuracy of altitude, roll, pitch, and heading data.

Note the clarity of the point-cloud image in Figure 2 on the right, captured on a Headwall unmanned aerial vehicle (UAV) system equipped with the High-Performance GPS/IMU, versus the image on the left, captured on a system equipped with the Standard (Gen 2) GPS/IMU.

In addition to affecting LiDAR data, inaccuracies in GPS/IMU data result in image distortions that impact the ortho-mosaicking of flight-swath images, as shown in Figure 3.

Headwall's High-Performance GPS/IMU coupled with post-processing software significantly reduces image distortions, enabling more accurate ortho-mosaicking of multiple flight swath images. Optional Headwall Smart Target Base Stations enable PPK[5] anywhere a GPS signal is available. Data can be downloaded 1 to 2 hours after flight versus waiting 24 hours or more when relying on NGS Continuously Operating Reference Stations (CORS) data.

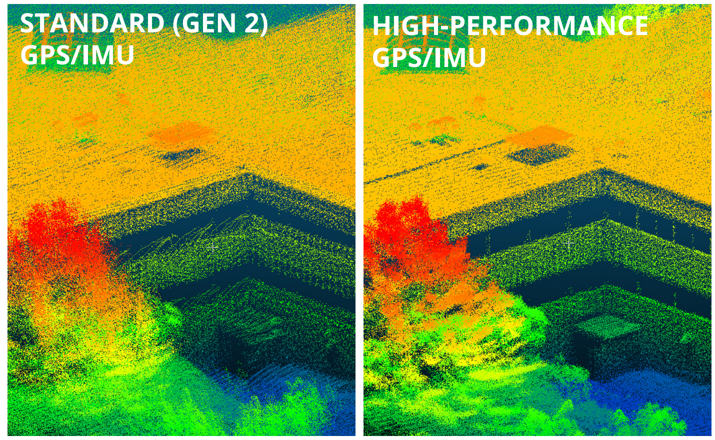


Figure 2. Here are point-cloud images taken from otherwise identical Headwall airborne hyperspectral imaging platforms with LiDAR. The point-cloud image on the left was taken using the Standard (Gen 2) GPS/IMU. The point-cloud image on the right was taken with the High-Performance GPS/IMU. Point-cloud data was visualized using the open-source program CloudCompare[4], with coordinates exported to scalar fields and the display range for height (Z) made as close to identical as possible (red = high, blue = low).

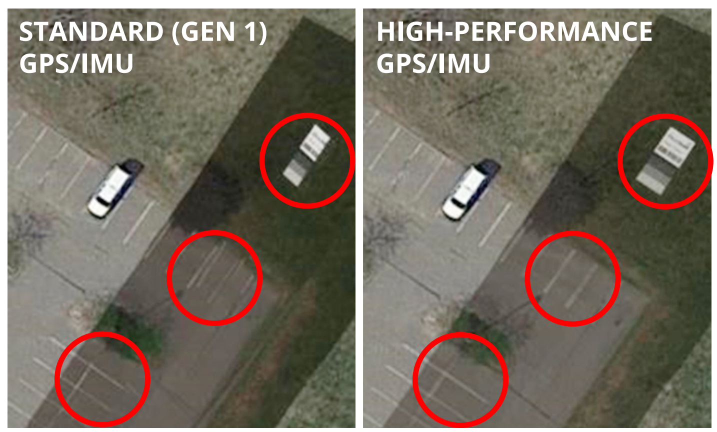


Figure 3. Multiple flight swaths were orthorectified and stitched together in the above images, left using the Standard (Gen 1) GPS/IMU and right using a High-Performance GPS/IMU. Notice the image distortions of the parking lot lines and the reflectance tarp with standard GPS/IMU data.

GEOLOCATION ERROR FOR DIFFERENT ALTITUDES (ALL VALUES IN METERS)						
Altitude (m)	10	20	50	100	200	500
Standard GPS (Gen 2)[6]	±3.833	±3.891	±4.064	±4.354	±4.933	±6.669
High-Performance GPS[7]	±2.651	±2.705	±2.864	±3.131	±3.664	±5.262
High-Performance GPS[7] (after PPK[5])	±0.102	±0.117	±0.163	±0.239	±0.392	±0.850

GENERAL ACCURACY RATINGS						
GPS/IMU Model	X (m)	Y (m)	Z (m)	Roll (deg)	Pitch (deg)	Heading (deg)
Standard GPS (Gen 2)[6]	2	2	2.5	0.1	0.1	0.3
High-Performance GPS[7]	1.5	1.5	1.5	0.04	0.04	0.03
High-Performance GPS[7] (after PPK[5])	0.05	0.05	0.05	0.025	0.025	0.08

[4] CloudCompare is an open-source software program for 3D point-cloud and mesh processing and visualization that is free to use for any purpose, including commercially or for education. This freedom is defined by the GNU General Public License (GPL).

[5] Post-Processed Kinematic (PPK), a GPS correction technique that corrects location data after drone data has been captured and downloaded

[6] Weight of Headwall Standard GPS (Gen 2, part number 1010A-00278) with enclosure = 30g

[7] Weight of Headwall High-Performance GPS (part number 1005A-31279 or 1004A-31277) without enclosure = 60g, with enclosure = 200g

LIDAR TOOLS SOFTWARE FOR GENERATING TERRAIN DATA

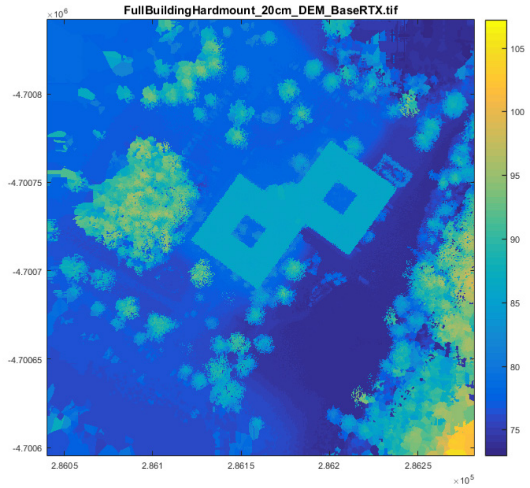


Figure 4. Two-dimensional image created from a DEM file saved by LiDAR Tools from the LiDAR point cloud captured during a flight over a commercial office park.

Figure 5. Headwall LiDAR Tools pixel-level fusion of hyperspectral and LiDAR data overlaid onto 3D terrain using third-party software. (RED = steep features, e.g. cliffs and trees; GREEN & BLUE = difference between vegetation and ground). Image courtesy BeamIO.

LiDAR Tools software comes with every integrated airborne system with LiDAR sold by Headwall. The software runs on contemporary 64-bit Windows and Linux operating systems, and allows saving of LiDAR LAS files, as well as digital elevation model (DEM) files.

Inaccurate DEM data will cause errors in magnification and geolocation, since the distance from the sensor to the object sets magnification. Although DEM data from the US Geological Survey (USGS) can be obtained for free, it is typically limited to 1-meter resolution or as coarse as 30-meter resolution in remote locations. Outside of the United States, accurate DEM data may have a high cost associated with it or may not be available at all.

The ability to fly a UAV at will (presuming weather conditions are favorable) to obtain high-resolution DEM data can make a tremendous difference in accuracy, and produce images of strikingly high quality. See the comparison images below.

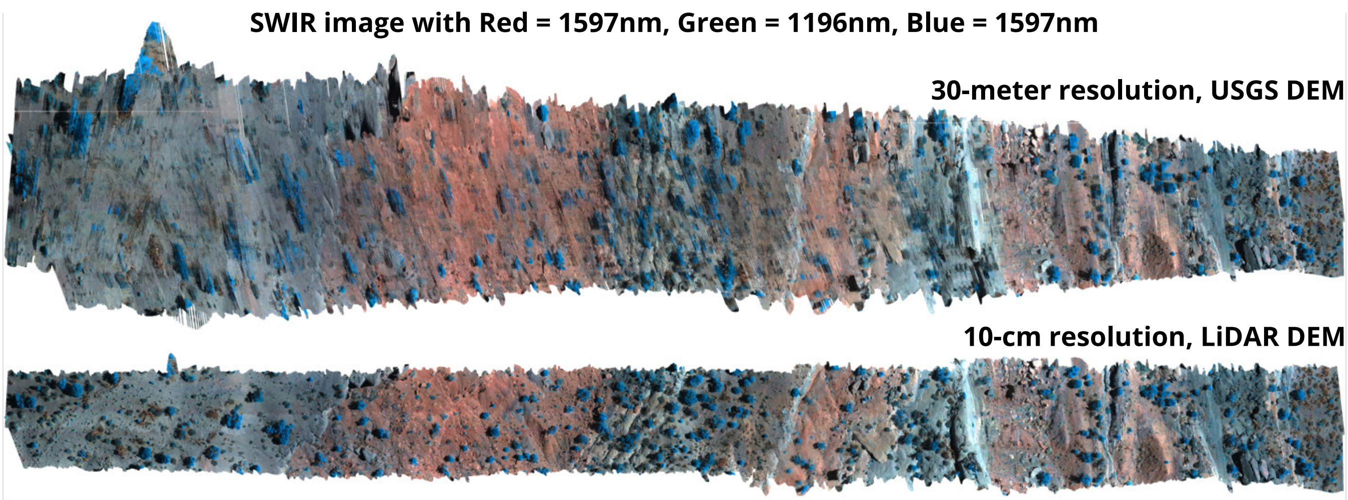


Figure 6. The top image was produced by orthorectifying a hyperspectral imaging swath taken by a Headwall UAV using 30-meter resolution USGS DEM data, while the bottom image was produced by orthorectifying the same hyperspectral imaging swath using 10-cm resolution DEM data obtained using the integrated LiDAR. Notice the distortions in the top image created using the 30-meter DEM data, which are absent in the bottom image.

June 2019