Utilization of Small Unmanned Aircraft Systems for Acquiring High-Resolution Elevation Data

West Fork Lead and Zinc Mine near Bunker, Missouri

April 2016

DJI Inspire with dual cameras on-board (Zenmuse X3 and Ricoh GR)
Flown by the USGS contracted to 417 Drone Imaging, Springfield, MO

The U.S. Geological Survey (USGS) Unmanned Aircraft Systems (UAS) National Project Office in Denver, Colorado is working to implement the use of UAS technology into assisting with mapping data acquisition and derivation of datasets for point cloud creation, digital surface model and orthophotography generation. Contracted small UAS flights were used over the West Fork Lead and Zinc Mine near Bunker, Missouri in cooperation with the USGS Missouri Water Science Center in Rolla, Missoui. Use of small consumer UAS, inexpensive commercial off-the-shelf cameras and computer vision structure-from-motion software allows for creation of very accurate data using this technology. This project investigates accuracy assessment and comparisons of aircraft and sensor and illustrates a new capability of supplementing other mapping capabilities.

Eight RTK Level GPS points were surveyed by the USGS Rolla, MO

ORTHOPHOTO MOSAIC

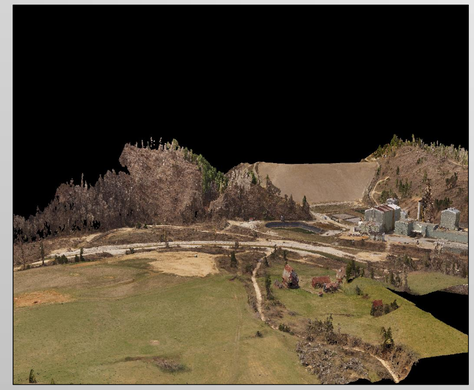
DENSE POINT CLOUD

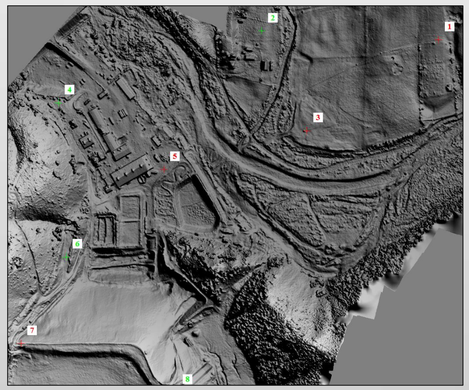
DIGITAL SURFACE MODEL

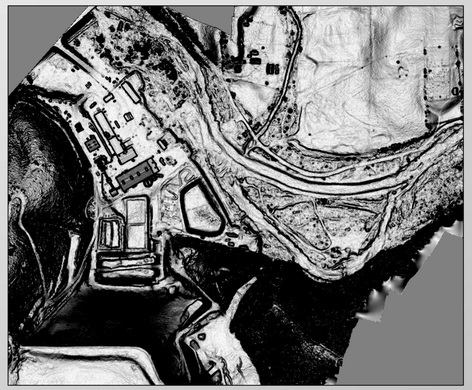
SLOPE VALUES

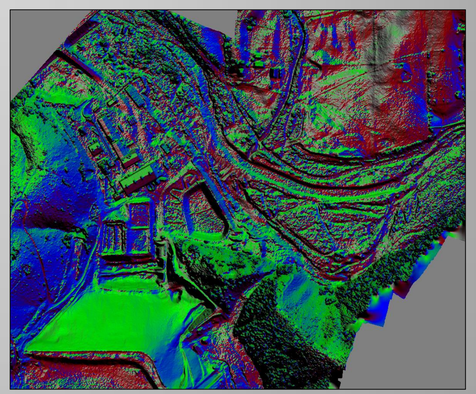
SLOPE ASPECT

DJI Inspire – Zenmuse X3

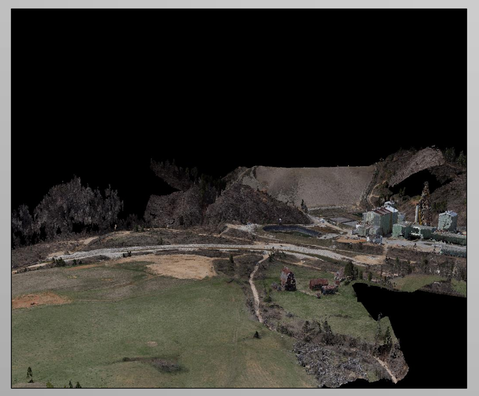


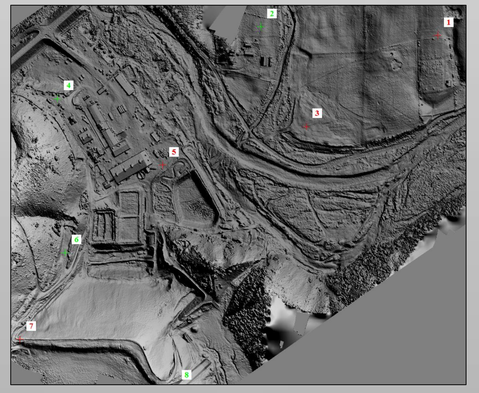


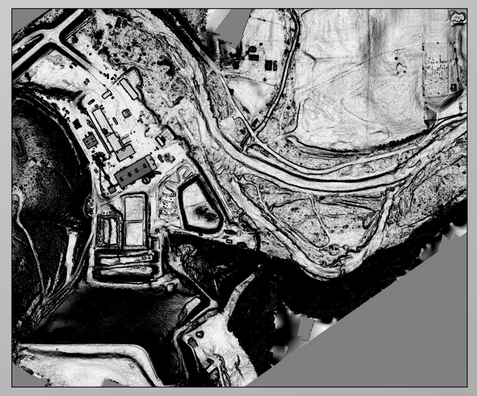


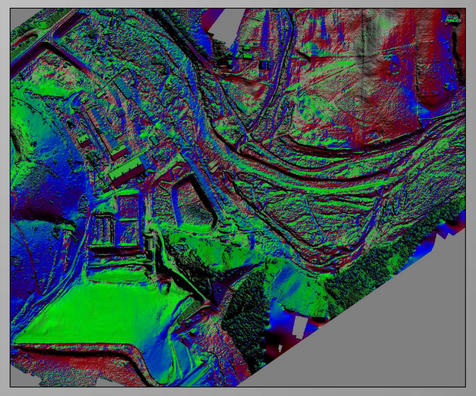


DJI Inspire - Ricoh GR









Utilizing the DJI-Inspire UAS Platform with an on-board Zenmuse X3 FC350 12-megapixel camera and a Ricoh GR camera 16-megapixel camera for simultaneous still frame image collection, two separate three-dimensional models were created using Agisoft Photoscan (v. 1.2.4.2399) to derive the geospatial data. Flying at an approximate height of 325 ft. (100 m) above ground level in four separate flights, a ground sample distance of 5.18 cm (pixel) with the Zenmuse camera, and 3.42 cm (pixel) with the Ricoh GR camera were achieved.

	# of Images	GPS Pts.	Check Pts	GSD (cm)	Area Cover. (Km²)	Fly Alt (m)	Reproj. Err (pix)
DJI Zenmuse	1047	4	4	5.18	1.29	134	0.32
Ricoh GR	1046	4	4	3.42	1.11	136	0.313

The dense point cloud generated from the images generate the color values assigned to the x,y and z coordinate values to create a realistic modeled representation of the study area. The structure-from-motion software is capable of generating several hundred million points from the correlated images.

	# of Images	Pts. Generated	# of Faces Generated	Resolution (cm)	Density (pts/m²)
DJI Zenmuse	1047	156,025,358	10,328,850	10.4	93
Ricoh GR	1046	244,335,344	16,156,495	6.83	214

The two digital elevation models derived from the simultaneous collects of 1046 images resulted in accuracies noted in the following charts when compared to four independent ground GPS (RTK level) checkpoints shown in green.

DJI Zenmuse

Name	ΔEasting	ΔNorthing	(ΔEasting)²	(ΔNorthing)²	(ΔEasting)² + (ΔNorthing)²	ΔElevation	(ΔElev)²
Target2	-0.0674	-0.1294	0.0045	0.0167	0.0213	0.1428	0.0204
Target4	-0.1021	-0.8908	0.0104	0.7935	0.8040	0.1915	0.0367
Target6	0.1186	-0.2841	0.0141	0.0807	0.0948	-0.0250	0.0006
Target8	-0.5175	0.0300	0.2678	0.0009	0.2687	-0.3116	0.0971
				Sum	1.1888	Sum	0.1548
				Average	0.2972	Average	0.0387
				RMSE	0.5452	RMSE	0.1967
				NSSDA	0.9435	NSSDA	0.3405

Ricoh GR

Name	ΔEasting	ΔNorthing	(ΔEasting)²	(ΔNorthing)²	(ΔEasting)² + (ΔNorthing)²	ΔElevation	(ΔElev)²
Target2	0.0476	0.0126	0.0023	0.0002	0.0024	0.1368	0.0187
Target4	-0.0531	0.0842	0.0028	0.0071	0.0099	0.1595	0.0254
Target6	-0.0094	0.0389	0.0001	0.0015	0.0016	-0.1050	0.0110
Target8	-0.1455	0.1840	0.0212	0.0338	0.0550	-0.2456	0.0603
				Sum	0.0689	Sum	0.1155
				Average	0.0172	Average	0.0289
				RMSE	0.1313	RMSE	0.1699
				NSSDA	0.2272	NSSDA	0.2941

Slope values can be compared at the specific target points to get a general idea of the similarities or differences in the way the surface models are derived and the assurance of accurate data when used for geospatial studies. The number of triangulated faces or the mesh generated, and the specific algorithms can have a varying degree of results on the model. Below is a comparison of the two cameras.

Ricoh GR	DJI Zenmuse	
Name	Slope Value (Degrees)	Slope Value (Degrees)	Diff. Slope Value (Degrees)
Target 1	3.47	1.98	1.49
Target 2	7.09	6.63	0.46
Target 3	3.94	2.17	1.77
Target 4	1.17	3.46	-2.29
Target 5	1.90	2.81	-0.91
Target 6	4.03	2.78	1.25
Target 7	10.51	0.25	10.26
Target 8	10.99	23.28	-12.29

Slope aspect can be compared at the specific target points to get a general idea of the similarities or differences in the way the surface models are derived and the assurance of accurate data when used for geospatial studies. The number of triangulated faces or the mesh generated, and the specific algorithms can have a varying degree of results on the model. Below is a comparison of the two cameras.

Ricoh GR	DJI Zenmuse	
Name	Slope Aspect (Deg. 0-360)	Slope Aspect (Deg. 0-360)	Diff. Slope Aspect (Degrees)
Target 1	260	261	1
Target 2	87	98	11
Target 3	177	222	45
Target 4	360	15	15
Target 5	123	5	118
Target 6	203	143	60
Target 7	30	89	59
Target 8	55	80	25

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