# Quality Report

Generated with Pix4Dmapper version 4.6.4

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Additional information about the sections

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## Summary

| | |
|---|---|
| Project | 022054-400_400-1000-40_20220416 |
| Processed | 2022-04-18 21:35:32 |
| Camera Model Name(s) | FC6310_8.8_5472x3648 (RGB) |
| Average Ground Sampling Distance (GSD) | 3.25 cm / 1.28 in |
| Area Covered | 1.816 $km^2$ / 181.5915 ha / 0.70 sq. mi. / 448.9545 acres |

## Quality Check

| | | |
|---|---|---|
| **Images** | median of 47885 keypoints per image | ✓ |
| **Dataset** | 1083 out of 1126 images calibrated (96%), all images enabled | ✓ |
| **Camera Optimization** | 0.87% relative difference between initial and optimized internal camera parameters | ✓ |
| **Matching** | median of 12556.1 matches per calibrated image | ✓ |
| **Georeferencing** | yes, 33 GCPs (33 3D), mean RMS error = 0.01 US survey foot | ✓ |

## Preview

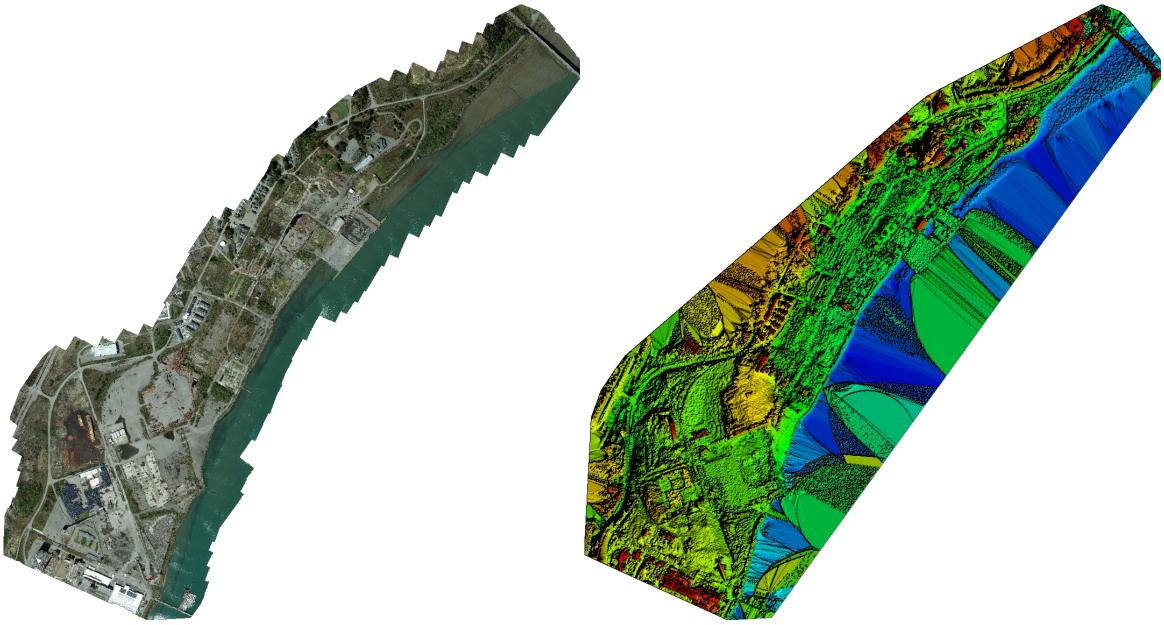


**Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.**

# Calibration Details

| | |
|---|---|
| Number of Calibrated Images | 1083 out of 1126 |
| Number of Geolocated Images | 1126 out of 1126 |

## Initial Image Positions

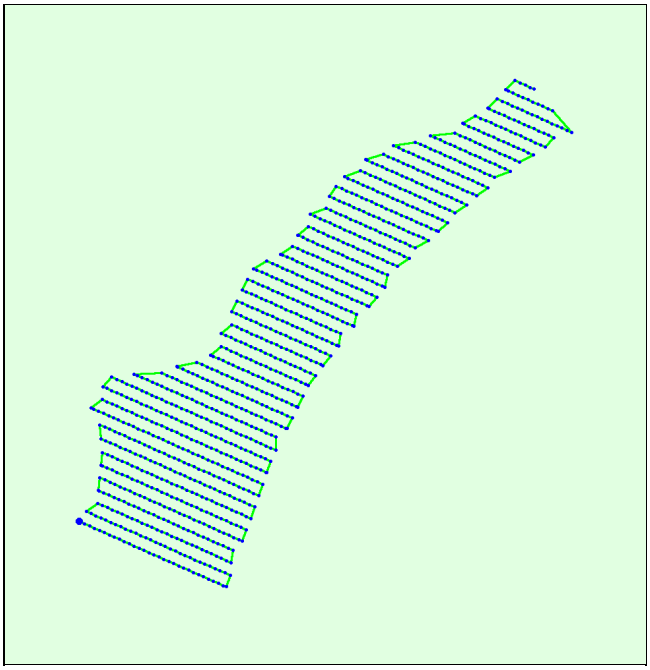
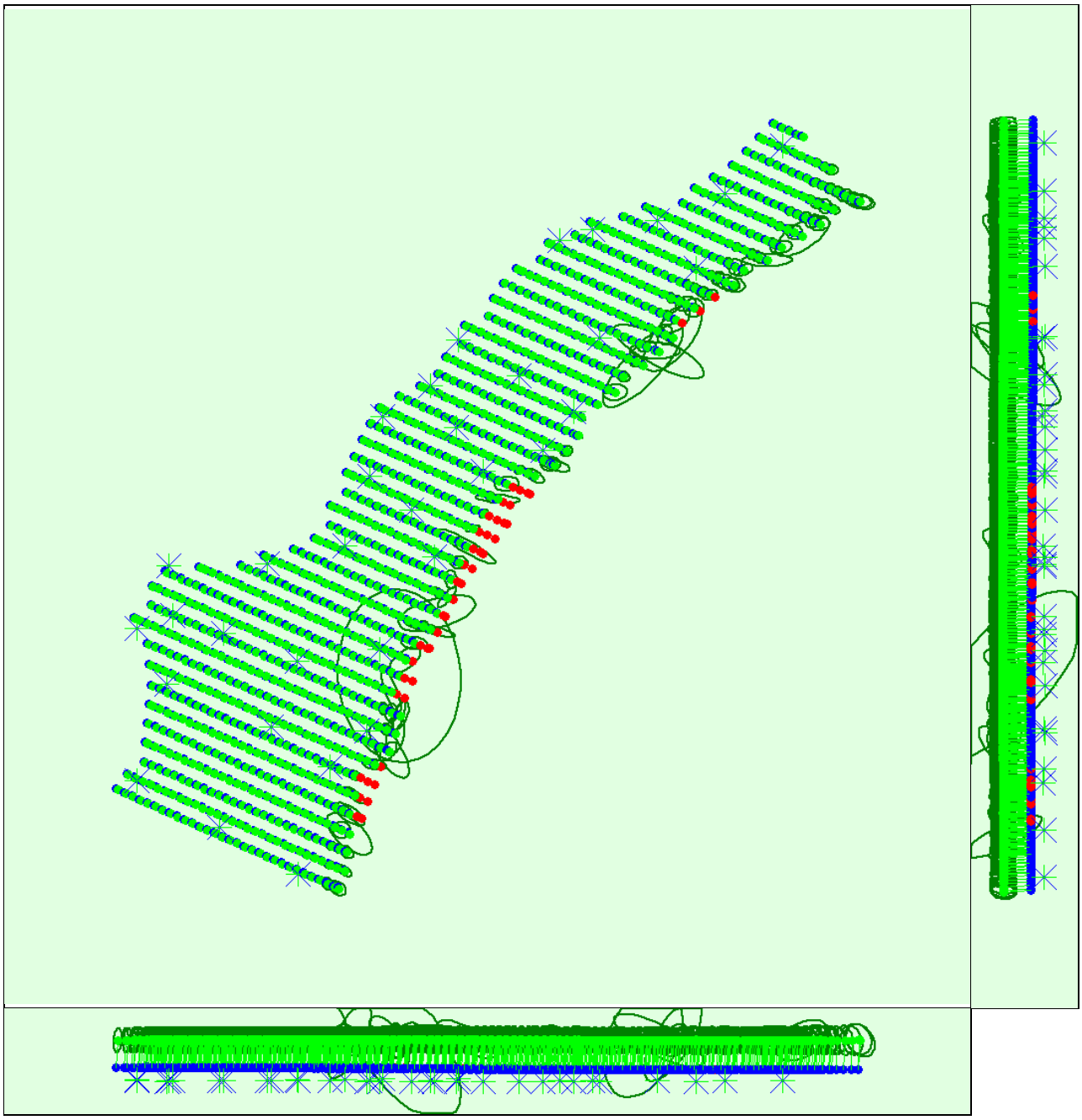


**Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.**

## Computed Image/GCPs/Manual Tie Points Positions



Uncertainty ellipses 500x magnified

**Figure 3: Offset between initial (blue dots) and computed (green dots) image positions as well as the offset between the GCPs initial positions (blue crosses) and their computed positions (green crosses) in the top-view (XY plane), front-view (XZ plane), and side-view (YZ plane). Red dots indicate disabled or uncalibrated images. Dark green ellipses indicate the absolute position uncertainty of the bundle block adjustment result.**

## Absolute camera position and orientation uncertainties

| | X [US survey foot] | Y [US survey foot] | Z [US survey foot] | Omega [degree] | Phi [degree] | Kappa [degree] |
|---|---|---|---|---|---|---|
| Mean | 0.073 | 0.063 | 0.244 | 0.006 | 0.008 | 0.002 |
| Sigma | 0.073 | 0.070 | 0.057 | 0.010 | 0.010 | 0.006 |

## Overlap

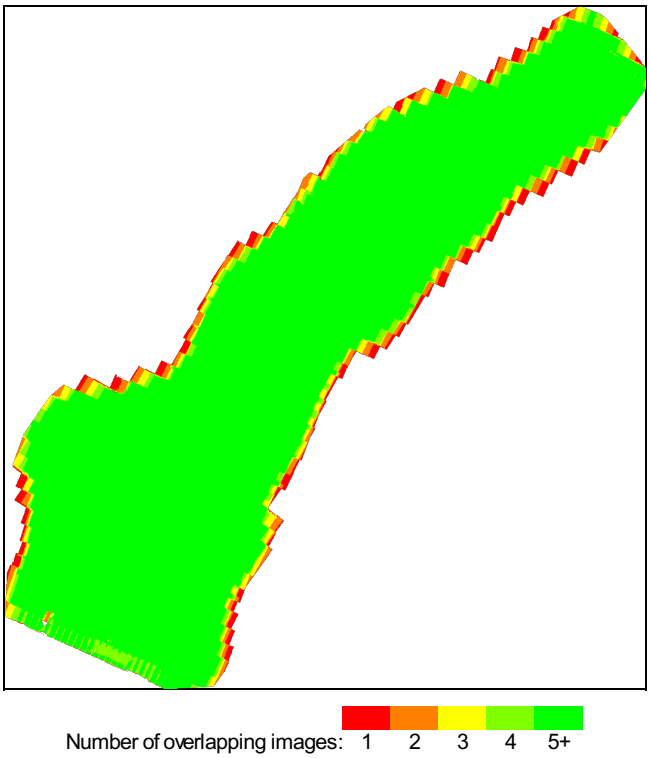



**Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.**
**Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint matches is also sufficient for these areas (see Figure 5 for keypoint matches).**

# Bundle Block Adjustment Details

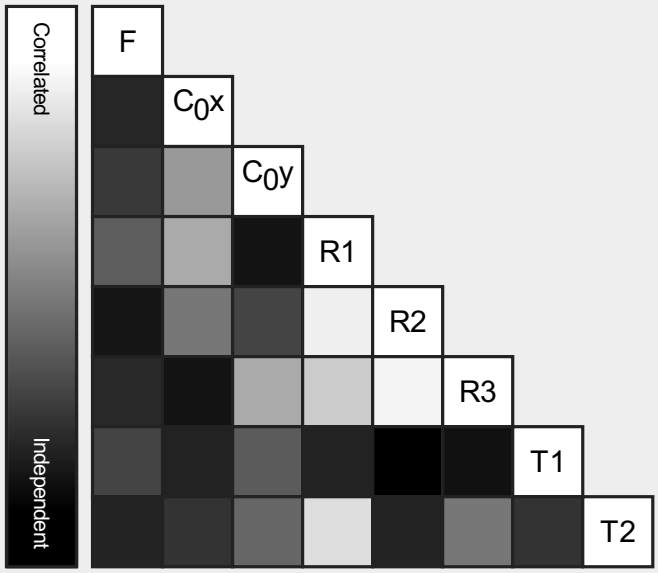
| | |
|---|---|
| Number of 2D Keypoint Observations for Bundle Block Adjustment | 13300852 |
| Number of 3D Points for Bundle Block Adjustment | 4190174 |
| Mean Reprojection Error [pixels] | 0.120 |

## Internal Camera Parameters

### FC6310_8.8_5472x3648 (RGB). Sensor Dimensions: 12.833 [mm] x 8.556 [mm]

**EXIF ID: FC6310S_8.8_5472x3648**

| | Focal Length | Principal Point x | Principal Point y | R1 | R2 | R3 | T1 | T2 |
|---|---|---|---|---|---|---|---|---|
| Initial Values | 3668.759 [pixel]<br>8.604 [mm] | 2736.001 [pixel]<br>6.417 [mm] | 1823.999 [pixel]<br>4.278 [mm] | 0.003 | -0.008 | 0.008 | -0.000 | 0.000 |
| Optimized Values | 3700.686 [pixel]<br>8.679 [mm] | 2736.605 [pixel]<br>6.418 [mm] | 1833.915 [pixel]<br>4.301 [mm] | -0.016 | 0.005 | 0.004 | -0.000 | -0.000 |
| Uncertainties (Sigma) | 2.240 [pixel]<br>0.005 [mm] | 0.356 [pixel]<br>0.001 [mm] | 0.371 [pixel]<br>0.001 [mm] | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |




The correlation between camera internal parameters determined by the bundle adjustment. White indicates a full correlation between the parameters, ie. any change in one can be fully compensated by the other. Black indicates that the parameter is completely independent, and is not affected by other parameters.

The number of Automatic Tie Points (ATPs) per pixel, averaged over all images of the camera model, is color coded between black and white. White indicates that, on average, more than 16 ATPs have been extracted at the pixel location. Black indicates that, on average, 0 ATPs have been extracted at the pixel location. Click on the image to the see the average direction and magnitude of the re-projection error for each pixel. Note that the vectors are scaled for better visualization. The scale bar indicates the magnitude of 1 pixel error.

## 2D Keypoints Table

| | Number of 2D Keypoints per Image | Number of Matched 2D Keypoints per Image |
|---|---|---|
| Median | 47885 | 12556 |
| Min | 20027 | 62 |
| Max | 82884 | 29929 |
| Mean | 46397 | 12281 |

## 3D Points from 2D Keypoint Matches

| | Number of 3D Points Observed |
|---|---|
| In 2 Images | 2486987 |
| In 3 Images | 760649 |
| In 4 Images | 343871 |
| In 5 Images | 189916 |
| In 6 Images | 101305 |
| In 7 Images | 69447 |
| In 8 Images | 51334 |
| In 9 Images | 40536 |
| In 10 Images | 32121 |
| In 11 Images | 24348 |
| In 12 Images | 21301 |
| In 13 Images | 19166 |
| In 14 Images | 19041 |
| In 15 Images | 15330 |
| In 16 Images | 4453 |
| In 17 Images | 3481 |
| In 18 Images | 2853 |
| In 19 Images | 2470 |
| In 20 Images | 1495 |
| In 21 Images | 69 |
| In 22 Images | 1 |

### 2D Keypoint Matches

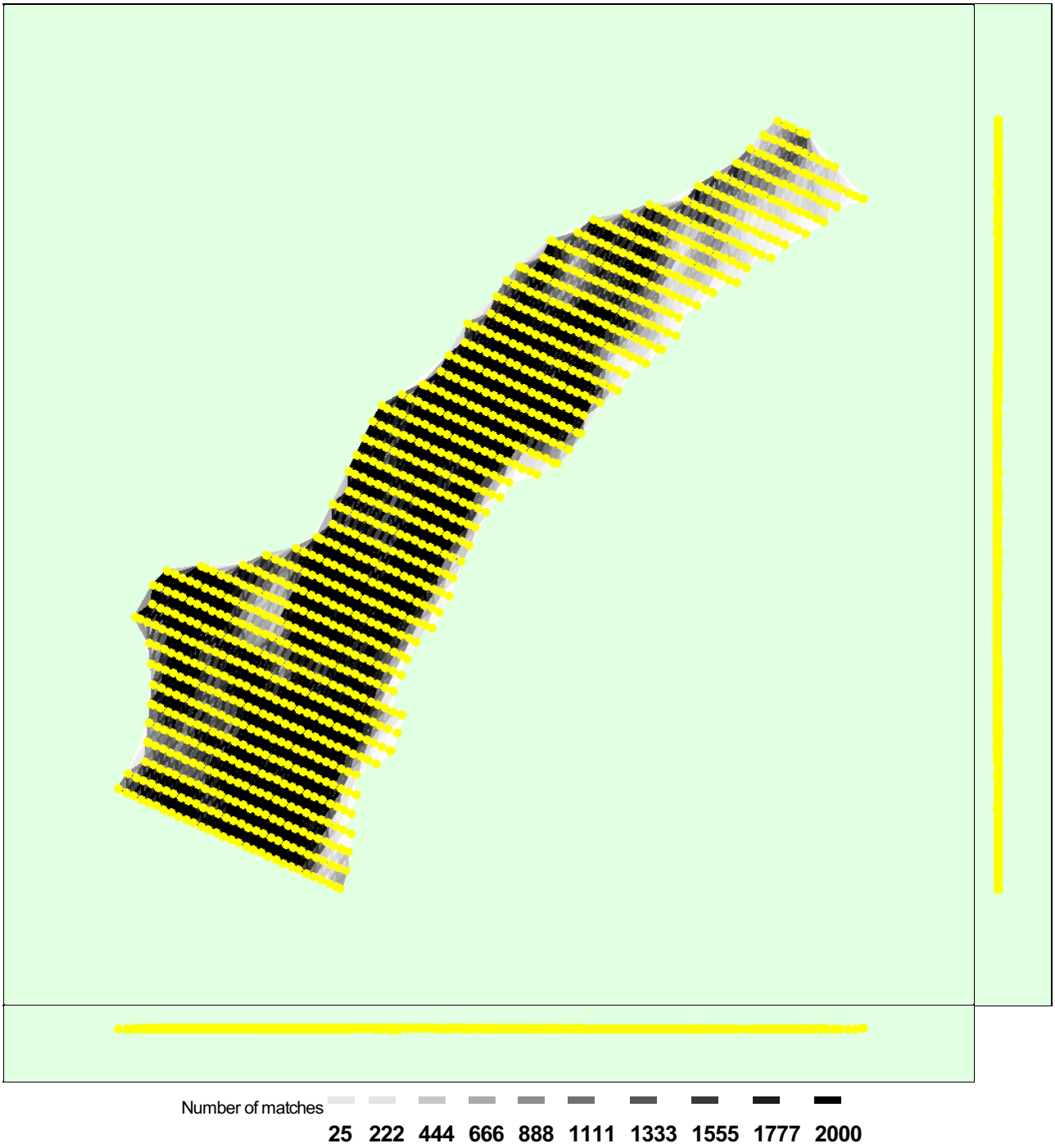



**Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images.**

# Geolocation Details

### Ground Control Points

| GCP Name | Accuracy XY/Z [US survey foot] | Error X [US survey foot] | Error Y [US survey foot] | Error Z [US survey foot] | Projection Error [pixel] | Verified/Marked |
|---|---|---|---|---|---|---|
| 1 (3D) | 0.020/ 0.020 | -0.003 | -0.015 | -0.011 | 0.330 | 15 / 15 |
| 2 (3D) | 0.020/ 0.020 | 0.019 | 0.013 | 0.010 | 0.216 | 15 / 15 |
| 7 (3D) | 0.020/ 0.020 | 0.011 | -0.009 | 0.010 | 0.178 | 15 / 15 |
| 8 (3D) | 0.020/ 0.020 | 0.005 | 0.013 | 0.002 | 0.169 | 18 / 18 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 9 (3D) | 0.020/ 0.020 | -0.002 | 0.005 | -0.021 | 0.225 | 6 / 6 |
| 10 (3D) | 0.020/ 0.020 | -0.000 | 0.000 | 0.010 | 0.167 | 7 / 7 |
| 11 (3D) | 0.020/ 0.020 | -0.002 | -0.010 | -0.003 | 0.235 | 15 / 15 |
| 12 (3D) | 0.020/ 0.020 | -0.021 | 0.005 | 0.000 | 0.228 | 19 / 19 |
| 14 (3D) | 0.020/ 0.020 | -0.007 | 0.005 | 0.007 | 0.124 | 12 / 12 |
| 15 (3D) | 0.020/ 0.020 | 0.002 | 0.013 | 0.001 | 0.376 | 14 / 14 |
| 16 (3D) | 0.020/ 0.020 | -0.001 | 0.001 | -0.010 | 0.195 | 10 / 10 |
| 18 (3D) | 0.020/ 0.020 | 0.003 | 0.026 | -0.001 | 0.173 | 20 / 20 |
| 20 (3D) | 0.020/ 0.020 | 0.001 | -0.008 | -0.002 | 0.229 | 17 / 17 |
| 23 (3D) | 0.020/ 0.020 | 0.002 | -0.009 | -0.003 | 0.146 | 14 / 14 |
| 24 (3D) | 0.020/ 0.020 | 0.003 | -0.020 | 0.015 | 0.263 | 11 / 11 |
| 25 (3D) | 0.020/ 0.020 | 0.002 | 0.007 | -0.013 | 0.288 | 13 / 13 |
| 26 (3D) | 0.020/ 0.020 | -0.001 | -0.010 | -0.016 | 0.174 | 15 / 15 |
| 27 (3D) | 0.020/ 0.020 | 0.006 | -0.000 | 0.024 | 0.176 | 20 / 20 |
| 29 (3D) | 0.020/ 0.020 | 0.013 | 0.012 | -0.019 | 0.253 | 17 / 17 |
| 31 (3D) | 0.020/ 0.020 | 0.001 | -0.001 | -0.001 | 0.215 | 15 / 15 |
| 32 (3D) | 0.020/ 0.020 | -0.003 | 0.001 | 0.000 | 0.183 | 18 / 18 |
| 33 (3D) | 0.020/ 0.020 | 0.007 | -0.001 | -0.001 | 0.235 | 15 / 15 |
| 34 (3D) | 0.020/ 0.020 | -0.000 | -0.001 | 0.005 | 0.253 | 16 / 16 |
| 36 (3D) | 0.020/ 0.020 | 0.013 | -0.008 | 0.023 | 0.132 | 6 / 6 |
| 37 (3D) | 0.020/ 0.020 | -0.009 | -0.007 | -0.004 | 0.315 | 11 / 11 |
| 38 (3D) | 0.020/ 0.020 | -0.004 | -0.002 | -0.020 | 0.211 | 9 / 9 |
| 39 (3D) | 0.020/ 0.020 | 0.000 | 0.002 | 0.010 | 0.193 | 13 / 13 |
| 40 (3D) | 0.020/ 0.020 | -0.012 | 0.012 | 0.012 | 0.167 | 10 / 10 |
| 42 (3D) | 0.020/ 0.020 | -0.002 | -0.006 | 0.007 | 0.207 | 15 / 15 |
| 43 (3D) | 0.020/ 0.020 | -0.032 | -0.034 | -0.025 | 0.160 | 14 / 14 |
| 44 (3D) | 0.020/ 0.020 | 0.004 | 0.006 | -0.008 | 0.139 | 15 / 15 |
| 46 (3D) | 0.020/ 0.020 | 0.004 | 0.014 | -0.000 | 0.227 | 18 / 18 |
| 47 (3D) | 0.020/ 0.020 | 0.006 | -0.005 | -0.006 | 0.251 | 14 / 14 |
| **Mean [US survey foot]** | | 0.000067 | -0.000322 | -0.000767 | | |
| **Sigma [US survey foot]** | | 0.009285 | 0.011291 | 0.011817 | | |
| **RMS Error [US survey foot]** | | 0.009285 | 0.011296 | 0.011842 | | |

**0 out of 9 check points have been labeled as inaccurate.**

| Check Point Name | Accuracy XY/Z [US survey foot] | Error X [US survey foot] | Error Y [US survey foot] | Error Z [US survey foot] | Projection Error [pixel] | Verified/Marked |
|---|---|---|---|---|---|---|
| 13 | | -0.0306 | -0.0195 | 0.0486 | 0.1850 | 18 / 18 |
| 17 | | 0.0046 | 0.0354 | -0.2111 | 0.1603 | 19 / 19 |
| 19 | | -0.0084 | 0.0191 | -0.2273 | 0.1743 | 15 / 15 |
| 21 | | 0.0008 | -0.0202 | -0.1446 | 0.3510 | 15 / 15 |
| 22 | | -0.0072 | -0.0262 | -0.0258 | 0.1987 | 15 / 15 |
| 28 | | -0.0411 | -0.0129 | 0.1237 | 0.2240 | 19 / 19 |
| 35 | | 0.0124 | 0.0575 | 0.0931 | 0.1534 | 19 / 19 |
| 41 | | -0.0255 | -0.0379 | -0.0385 | 0.2862 | 14 / 14 |
| 45 | | -0.0016 | 0.0435 | -0.0383 | 0.3204 | 19 / 19 |
| **Mean [US survey foot]** | | -0.010732 | 0.004315 | -0.046689 | | |
| **Sigma [US survey foot]** | | 0.016793 | 0.032892 | 0.119002 | | |
| **RMS Error [US survey foot]** | | 0.019930 | 0.033174 | 0.127833 | | |

**Localisation accuracy per GCP and mean errors in the three coordinate directions. The last column counts the number of calibrated images where the GCP has been automatically verified vs. manually marked.**

## Absolute Geolocation Variance

| Min Error [US survey foot] | Max Error [US survey foot] | Geolocation Error X [%] | Geolocation Error Y [%] | Geolocation Error Z [%] |
|---|---|---|---|---|
| - | -49.21 | 0.00 | 0.00 | 0.00 |
| -49.21 | -39.37 | 0.00 | 0.00 | 0.00 |
| -39.37 | -29.53 | 0.00 | 0.00 | 0.00 |
| -29.53 | -19.68 | 0.00 | 0.00 | 0.00 |
| -19.68 | -9.84 | 0.28 | 0.00 | 5.72 |
| -9.84 | 0.00 | 49.86 | 51.25 | 48.85 |
| 0.00 | 9.84 | 49.77 | 48.57 | 27.24 |
| 9.84 | 19.69 | 0.09 | 0.18 | 18.19 |
| 19.69 | 29.53 | 0.00 | 0.00 | 0.00 |
| 29.53 | 39.37 | 0.00 | 0.00 | 0.00 |
| 39.37 | 49.21 | 0.00 | 0.00 | 0.00 |
| 49.21 | - | 0.00 | 0.00 | 0.00 |
| **Mean [US survey foot]** | | -16.428566 | 9.386566 | -271.577761 |
| **Sigma [US survey foot]** | | 1.621251 | 2.412261 | 7.587194 |
| **RMS Error [US survey foot]** | | 16.508369 | 9.691575 | 271.683723 |

**Min Error and Max Error represent geolocation error intervals between -1.5 and 1.5 times the maximum accuracy of all the images. Columns X, Y, Z show the percentage of images with geolocation errors within the predefined error intervals. The geolocation error is the difference between the initial and computed image positions. Note that the image geolocation errors do not correspond to the accuracy of the observed 3D points.**

| Geolocation Bias | X | Y | Z |
|---|---|---|---|
| Translation [US survey foot] | -16.428566 | 9.386566 | -271.577761 |

**Bias between image initial and computed geolocation given in output coordinate system.**

### Relative Geolocation Variance

| Relative Geolocation Error | Images X [%] | Images Y [%] | Images Z [%] |
|---|---|---|---|
| [-1.00, 1.00] | 100.00 | 100.00 | 100.00 |
| [-2.00, 2.00] | 100.00 | 100.00 | 100.00 |
| [-3.00, 3.00] | 100.00 | 100.00 | 100.00 |
| **Mean of Geolocation Accuracy [US survey foot]** | 16.404167 | 16.404167 | 32.808333 |
| **Sigma of Geolocation Accuracy [US survey foot]** | 0.000002 | 0.000002 | 0.000004 |

**Images X, Y, Z represent the percentage of images with a relative geolocation error in X, Y, Z.**

| Geolocation Orientational Variance | RMS [degree] |
|---|---|
| Omega | 0.638 |
| Phi | 0.644 |
| Kappa | 3.501 |

**Geolocation RMS error of the orientation angles given by the difference between the initial and computed image orientation angles.**

# Initial Processing Details

### System Information

| | |
|---|---|
| Hardware | CPU: Intel(R) Xeon(R) CPU E5-2630 v4 @ 2.20GHz<br>RAM: 64GB<br>GPU: Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown), Microsoft Remote Display Adapter (Driver: unknown) |
| Operating System | Windows 10 Pro, 64-bit |

### Coordinate Systems

| | |
|---|---|
| Image Coordinate System | WGS 84 (EGM96 Geoid) |
| Ground Control Point (GCP) Coordinate System | NAD_1983_StatePlane_California_I_FIPS_0401_Feet (deprecated) (EGM96 Geoid) |
| Output Coordinate System | NAD_1983_StatePlane_California_I_FIPS_0401_Feet (deprecated) (EGM96 Geoid) |

### Processing Options

| | |
|---|---|
| Detected Template | No Template Available |
| Keypoints Image Scale | Full, Image Scale: 1 |
| Advanced: Matching Image Pairs | Aerial Grid or Corridor |
| Advanced: Matching Strategy | Use Geometrically Verified Matching: no |
| Advanced: Keypoint Extraction | Targeted Number of Keypoints: Automatic |
| Advanced: Calibration | Calibration Method: Standard<br>Internal Parameters Optimization: All<br>External Parameters Optimization: All<br>Rematch: Auto, no |

## Point Cloud Densification details

### Processing Options

| | |
|---|---|
| Image Scale | multiscale, 1/2 (Half image size, Default) |
| Point Density | Optimal |
| Minimum Number of Matches | 3 |
| 3D Textured Mesh Generation | yes |
| 3D Textured Mesh Settings: | Resolution: Medium Resolution (default)<br>Color Balancing: no |
| LOD | Generated: no |
| Advanced: 3D Textured Mesh Settings | Sample Density Divider: 1 |
| Advanced: Image Groups | group1 |
| Advanced: Use Processing Area | yes |
| Advanced: Use Annotations | yes |
| Time for Point Cloud Densification | 01h:47m:15s |
| Time for Point Cloud Classification | 11m:35s |
| Time for 3D Textured Mesh Generation | 26m:32s |

### Results

| | |
|---|---|
| Number of Generated Tiles | 4 |
| Number of 3D Densified Points | 118049578 |
| Average Density (per US survey foot$^3$) | 2.62 |

## DSM, Orthomosaic and Index Details

### Processing Options

| | |
|---|---|
| DSM and Orthomosaic Resolution | 1 x GSD (3.25 [cm/pixel]) |
| DSM Filters | Noise Filtering: yes<br>Surface Smoothing: yes, Type: Sharp |
| Raster DSM | Generated: yes<br>Method: Inverse Distance Weighting<br>Merge Tiles: yes |

| | |
|---|---|
| Orthomosaic | Generated: yes<br>Merge Tiles: yes<br>GeoTIFF Without Transparency: no<br>Google Maps Tiles and KML: yes |
| Raster DTM | Generated: yes<br>Merge Tiles: yes |
| DTM Resolution | 5 x GSD (3.25 [cm/pixel]) |
| Contour Lines Generation | Generated: yes<br>Contour Base [US survey foot]: 0<br>Elevation Interval [US survey foot]: 1<br>Resolution [cm]: 100<br>Minimum Line Size [vertices]: 20 |
| Time for DSM Generation | 46m:39s |
| Time for Orthomosaic Generation | 03h:23m:12s |
| Time for DTM Generation | 02h:04m:20s |
| Time for Contour Lines Generation | 31s |
| Time for Reflectance Map Generation | 00s |
| Time for Index Map Generation | 00s |