



## **2016 AERIAL TRIANGULATION FINAL REPORT**

*Submitted to:*

**City of Lubbock, TX**

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# 1. INTRODUCTION

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Bohannon Huston, Inc. (BHI) (Contractor) is as a deliverable item in project 2016 City of Lubbock Digital Orthophotography has developed this report of the employed aerial triangulation process and specifications. This report is developed according to SOW task descriptions with the purpose of outlining the technical approach designed to fulfill the requirements of the SOW and contract.

## 1.1 ISAT Aerial Triangulation

BHI performed analytical aerial triangulation of the captured aerial photography within the Hexagon Photogrammetry Suite; ImageStation Orientations 2016 (ISAT). The ISAT specific version is Version 16.00.0000 Build 347. Aerial triangulation setup, measurement, orientations, and absolute adjustment were performed by Juan Ridout, Senior Geospatial Analyst and Photogrammetric Technician. A review and analysis of the final aerial triangulation absolute adjustment was performed by Dennis Sandin, Principal in Charge, Registered Professional Photogrammetrist.

### 1. Triangulation Constraints and Methods

- 1.1. This triangulation was established for aerial photography in units of US Survey Feet. Angular units are specified as decimal degrees. Project coordinates were adjusted to a control system defined as **NAD 1983\_StatePlane\_Texas\_North\_Central\_FIPS\_4202\_Feet** with vertical datum of NAVD88 corrected to orthometric heights via Geoid12a. Both Atmospheric Refraction and Earth Curvature refinements were enabled during the measurement/adjustment process.
- 1.2. Interior Orientation (IO) were not applicable as the imagery was captured with a digital camera sensor – the Microsoft UltraCAM Eagle.
- 1.3. Relative Orientation was performed for each stereo model and for the entire project block. Individual pass and tie points were automatically derived with ISAT pixel matching algorithms. The project was divided into quarters and merged back together when pixel matching was completed. Initially, statistical review of overall point measurement quality was used to eliminate problematic measurement results. Manual measurement was used to provide additional results as determined by the photogrammetric technician.
- 1.4. Absolute Orientation was performed after a final relative orientation was established. Airborne GPS (ABGPS) and Inertial Measurement Unit (INS) were enabled along with linear shift calculations by line for both the ABGPS and INS. Paneled control points were individually measured by the photogrammetric technician in all photographs were they were imaged. No

corrections were necessary to any of the previously measured points in this step. Final project-wide relative and absolute orientation results are shown below:

*Adjustment Mode* : *Absolute*  
*Precision Computation* : *Enabled*  
*Error Detection* : *Enabled*  
*Camera Calibration* : *Disabled*  
*Self-Calibration* : *Disabled*  
*Given EO* : *Enabled*  
*Antenna Offsets* : *Disabled*  
*GPS Shift/Drift Correction* : *Enabled*  
*GPS XY Shift/Drift Correction Type*: *Linear Shift/Drift*  
*GPS Z Shift/Drift Correction Type*: *Linear Shift/Drift*  
*INS Shift/Drift Correction* : *Disabled*  
*Max EO Delta (position,attitude[deg])*: *(0.0001; 0.0000)*.

*Max Obj. Delta (XY,Z)*: *(0.0000; 0.0001)*.

*Computing residuals...*

***Sigma: 0.000901.***

*Final number of gross outliers*: *0*.

*Final number of robust blunders*: *0*.

*Computing covariances...*

*Mean of image residuals in um (Vx,Vy)* = *( -0.000003; 0.000019 )*.

*RMS of image residuals in um (RMSx,RMSy)* = *( 0.7; 0.7 )*.

*RMS ctrl XY*: *1.9504e-002 in Lsq solution*.

*RMS ctrl Z: 1.2247e-004 in Lsq solution.*

*RMS of photo XYZ residuals (RMSx,RMSy,RMSz) = ( 0.006; 0.005; 0.025).*

*Number of total control points: 45*

*Number of full control points: 45*

*Number of control points in X: 45*

*Number of control points in Y: 45*

*Number of iterations: 9*

*Number of DOF: 198486*

*Sigma naught: 0.900833*

*Mean of std dev X: 0.030568*

*Mean of std dev Y: 0.029048*

*Mean of std dev Z: 0.102714*

*Number of measured points: 152805*

- 1.5. Stereo AT Review showed neat model matching between flight lines and between frames within a strip. Several areas were evaluated distributed throughout the project coverage. Additionally, each paneled control point was visited in stereo and evaluated both horizontally and vertically for correspondence with the 3d vector point representation. There were no inconsistencies discovered during the Stereo AT Review
- 1.6. Final AT peer review was performed to double check the integrity of the aerial triangulation process and to serve as a workflow gate before commencing subsequent mapping tasks. A BHI registered photogrammetrist reviewed the aerial triangulation setup, selected parameters, final orientation statistics, and brief stereo visitation of the paneled ground control. No errors were encountered and the AT was deemed final and ready for subsequent mapping operations.

## 2. Derivative Products

2.1. Included in the digital delivery are rich text format reports for the following information:

- project parameters
- camera model
- refined exterior orientations
- control parameters
- PAT-B importable file of photo measurements.