PHOTOGRAMMETRY-DERIVED HISTORICAL ORTHOIMAGERY FOR HOMER, ALASKA FROM 1951, 1952, 1964, AND 1985

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PHOTOGRAMMETRY-DERIVED HISTORICAL ORTHOIMAGERY FOR HOMER, ALASKA FROM 1951, 1952, 1964, AND 1985

Richard M. Buzard[1]

INTRODUCTION

The State of Alaska Division of Geological & Geophysical Surveys (DGGS) used Structure-from-Motion (SfM) photogrammetry to produce orthoimagery for the City of Homer and surrounding areas from 1951, 1952, 1964, and 1985 imagery (fig. 1). The orthometrically corrected imagery are for assessing coastal hazards and changes. The original photographs were collected by the U.S. Air Force (1951 and 1952), the Bureau of Land Management (BLM; 1964), and the National Aeronautics and Space Administration (NASA; 1985). Data were processed using Agisoft Metashape software. These products are released as a Raw Data File with an open end-user license. All files are available from: https://doi.org/10.14509/30824.

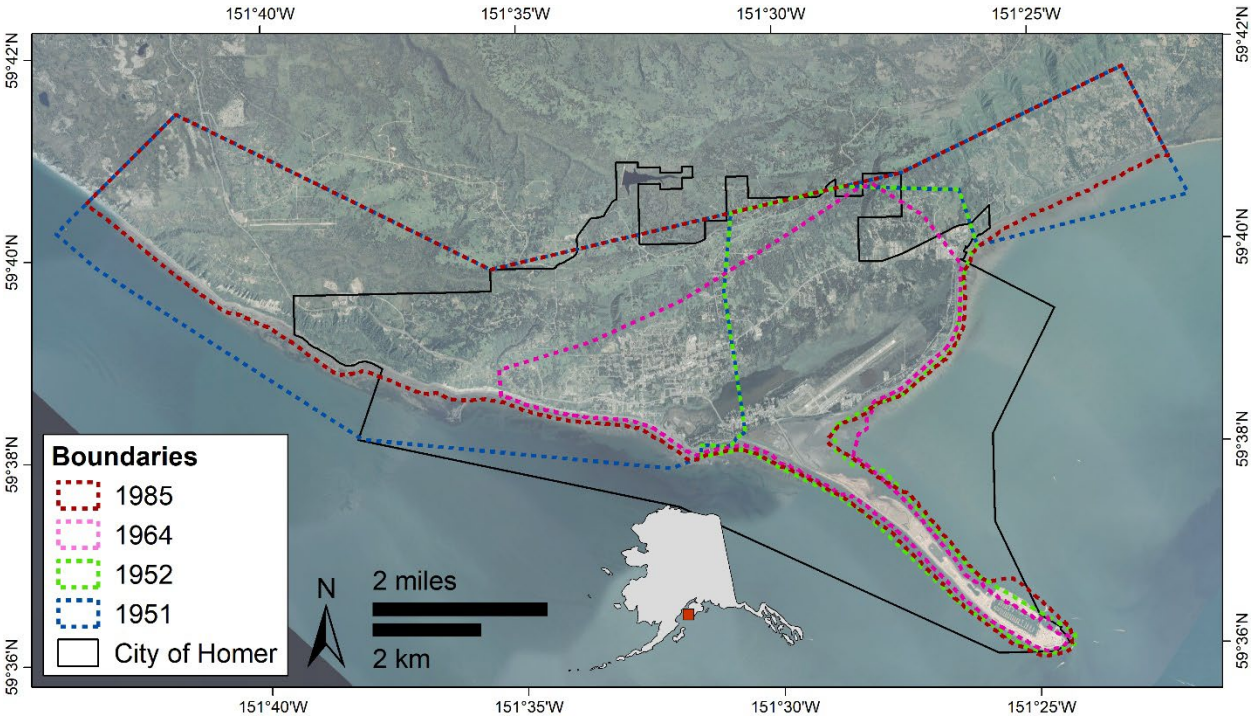

Figure 1. Map of orthoimage product boundaries for the City of Homer and surrounding area.

LIST OF DELIVERABLES

- Orthoimagery
- Metadata

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MISSION PLAN

Aerial Photogrammetric Survey Details

Various agencies collected aerial photographs intended for photogrammetric applications (table 1). Each photo set was collected using a 9 X 9 in (229 X 229 mm) frame lens camera pointed nadir (vertical towards the ground). The collectors maintained flight lines and altitude to allow sufficient overlap (≥ 60 percent) for photogrammetry. Photos have fiducial marks. The photos were scanned to digital images with 1,000 pixels-per-inch resolution. Panchromatic photos (black and white [BW]) were scanned with one 8-bit band. Color-infrared photos (CIR, sometimes called "false color") were scanned with three 8-bit color bands in red, green, and blue (RGB). The resulting RGB image bands are roughly equal to infrared, red, and green, respectively. The scanned images are hosted by the U.S. Geological Survey (USGS) at www.earthexplorer.gov.

Table 1. Source imagery specifications. Image types are color-infrared (CIR) and black and white (BW).

Date	Source	Type	Image scale	Flight height (m)	Focal length (mm)
1985 AUG 27	NASA	CIR	1:65,000	19,813	304.68
1964 APR 11	BLM	BW	1:17,000	1,524	88.20
1952 AUG 15	Air Force	BW	1:40,000	6,096	152.00
1951 JUN 25	Air Force	BW	1:40,702	6,095	153.79

Weather and Photo Conditions

Overall, the photos are in adequate condition to process using structure-from-motion (SFM) techniques. The photos have less than 10 percent cloud cover. Some photos in the 1951 and 1952 collections have tears that are repaired with clear tape. The water and forests in the 1964 photos are much darker than previous BW collections. These factors reduced image matching options but did not impede orthomosaic creation. The CIR film experienced degradation before being scanned, causing the images to have a blue tint.

PROCESSING REPORT

Photogrammetric Dataset Processing

Images were processed in Agisoft Metashape Professional software (version 1.6.3 build 10732). The images do not have high-precision camera/aircraft attitude or coordinate data common to modern aerial surveys. We identified the fiducial marks and input frame camera dimensions (size and focal length). The cameras are considered precalibrated. We masked out areas that hinder the SFM process, including the black photo border, text stamped on the photo, and large water bodies, especially with waves and sun glint. We did not use ground control points for the SFM process. After the initial alignment, we removed statistical outliers and artifacts from the sparse point cloud that are often found in water bodies and near study site borders. We optimized the bundle block adjustment, created the dense point cloud, and removed artifacts as needed near the coastline. The dense cloud

was converted to triangular irregular network geometry, which was used to orthorectify and mosaic the imagery. These methods produced orthorectified imagery with no spatial coordinates.

We georeferenced (first order: shift, scale, and rotate) each orthoimage to the Best Data Layer (BDL) in ArcMap (Alaska Geospatial Council, 2021). Georeferencing was prioritized only in the study area. Initially, we selected images beyond the study area because there is always insufficient sidelap at survey boundaries. At this stage we clipped the orthoimages to the study area.

Our coastal hazard study required only one image set from the early 1950s. The 1951 collection has greater contrast and focus at the coastline than the 1952 collection. However, the 1951 collection did not cover the Homer Spit or Kachemak Drive region. We used the 1952 image where the 1951 image has no coverage.

Orthoimagery

The orthoimagery is a single-band (for BW) or three-band (for CIR), 16-bit unsigned GeoTIFF file. The ground sample distance (GSD) varies per collection (table 2). The "No Data" value is set to 256.

SURVEY REPORT

Ground Survey Details

On July 22, 2020, DGGS conducted a post-processing kinematic global navigation satellite system (PPK-GNSS) survey. The Trimble R10 receiver base station was installed over a benchmark at the Homer Ferry Terminal on the Homer Spit (National Geodetic Survey, 2021). With the Trimble R8s as a rover, DGGS collected three ground control points from the Homer Spit to Bluff Point. The root mean sum of squares (RMS) error for rover points is 0.006 m horizontal.

Coordinate System

All data were processed and delivered in NAD83 (2011) UTM Zone 5N.

Horizontal Accuracy

We calculated horizontal accuracy of orthoimagery by comparing the locations of checkpoints: photo-identifiable objects or landmarks that did not change between the image acquisition date and the control image (BDL). This method quantifies the error of comparisons between images, but the BDL itself has horizontal error. Therefore, we report two errors: the total relative error and the total absolute error (table 2). The total relative error is the root-mean-square (RMS) error of the X and Y offsets between the orthoimage and the BDL. This represents the accuracy of the orthoimage relative to the BDL. The total absolute error is the root sum of squares (RSS) error of the orthoimage RMS error and the control RMS error. This represents the accuracy of each orthoimage relative to the coordinate system. For example, one might find the edge of a building between the orthoimage and BDL is offset by 1 m (relative error), but the BDL coordinate of that edge is 2 m from the coordinate measured with survey-grade GPS equipment (absolute error).

We calculated the BDL error using horizontal offsets to the 2019 image collection by Office for Coastal Management Partners (2021). The 2019 image only covers the coastline from the Homer Spit to Diamond Creek, so it could not be used as the control image. Using ground control points from the PPK-GNSS survey, we calculated a total absolute error of 0.09 m (n = 3) for the 2019 image. We compared checkpoints between the BDL and 2019 orthoimage to find a relative error of 1.26 m (n =

20). The total absolute error of the BDL (RSS of the relative error and 2019 total absolute error) was 1.27 m. See the appendix for tables of checkpoint comparisons.

Table 2. Orthoimage product specifications.

Date	Type	Orthoimage GSD (m)	Area (sq. km)	Total relative error (m)	Total absolute error (m)
1985 AUG 27	CIR	1.88	64.44	3.05	3.30
1964 APR 11	BW	0.55	25.80	0.89	1.55
1952 AUG 15	BW	1.14	21.76	2.68	2.97
1951 JUN 25	BW	1.14	53.76	2.68	2.97

Data Consistency and Completeness

The orthoimagery data have been visually inspected for errors such as shifts, seamline mismatches, and water noise overlapping land. The coastal bluffs were priority areas for correcting these errors. Other areas, even coastal areas like Homer Spit, were not prioritized but some corrections were made. Some issues may be inherent to the source imagery (like clear tape on tears in the photo). The SfM method often introduces artifacts, especially near water bodies, forests, and high-angle features like buildings and bluffs. We recommend accounting for this and determining an appropriate additional error value if delineating the instantaneous water line on these images. If artifacts from the orthorectification process obfuscate an area of interest, consider downloading the original imagery from www.earthexplorer.gov. Keep in mind image limitations and common sources of confusion when examining and comparing imagery. For example, some images have greater sensitivity to bright features like roads and the brightness bleeds to neighboring pixels, causing these features to appear larger than they are. When toggling between images, the difference in brightness and shadow angle between image sets can cause illusions that the images are not aligned properly.

ACKNOWLEDGEMENTS

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APPENDIX: CHECKPOINTS

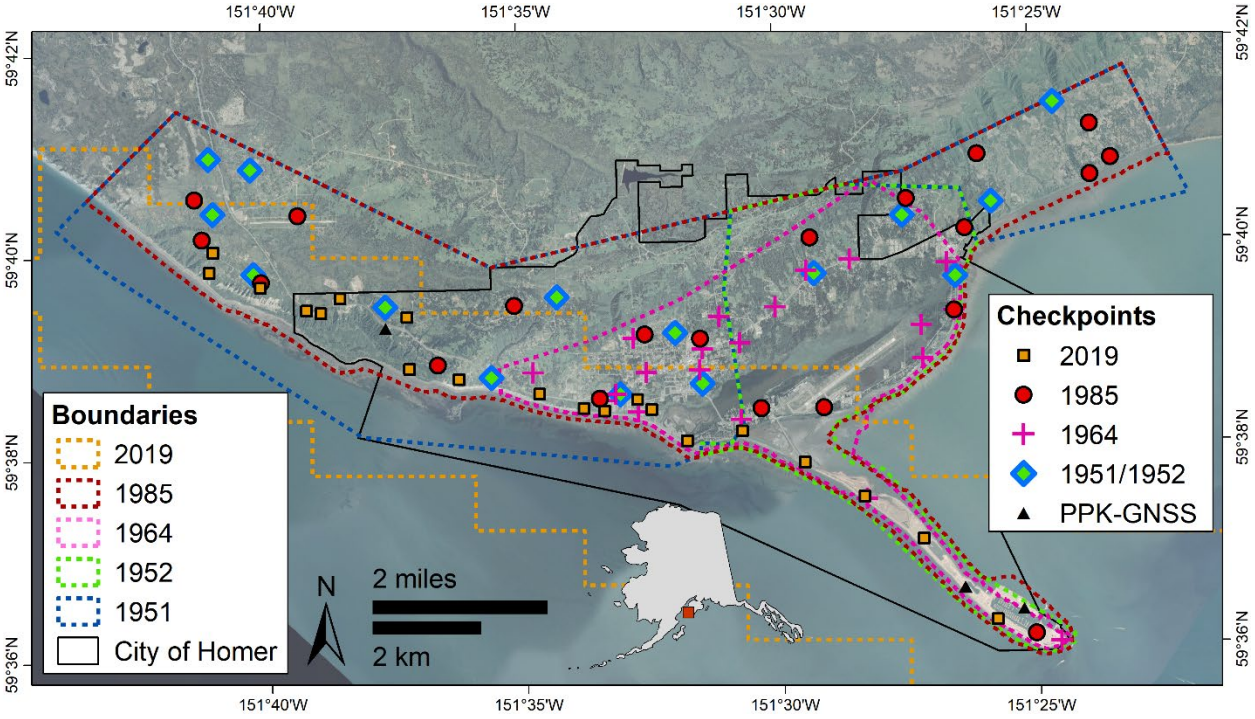

Figure A1. Map of checkpoint locations for orthoimages. Checkpoints are all compared to the best data layer, which covers the entire area. PPK-GNSS points are used to determine the total absolute error of the 2019 image. No reliable checkpoints were found for 1952 at the Homer Spit.

Table A1. Checkpoints and accuracy statistics for the 2019 orthoimage (OCM Partners, 2021) and the DGGS PPK-GNSS survey.

Checkpoint	Easting (m)	Northing (m)	Easting Offset (m)	Northing Offset (m)
1	577341.09	6613707.87	-0.03	-0.13
2	587993.92	6608975.82	0.00	-0.07
3	589076.19	6608588.59	0.03	-0.03
		Mean	0.00	-0.08
		Standard Deviation	0.03	0.05
		Range	0.06	0.09
		Root Mean Square Error	0.03	0.09
		Total Absolute Error	**0.09**	

Table A2. Checkpoints and accuracy statistics for the best data layer compared to the 2019 orthoimage (OCM Partners, 2021).

Checkpoint	Easting (m)	Northing (m)	Easting Offset (m)	Northing Offset (m)
1	574169.78	6615097.55	0.22	-0.13
2	575040.39	6614447.69	-0.90	0.37
3	575888.31	6614031.33	-0.42	0.28
4	576504.54	6614253.94	0.13	-0.01
5	577730.86	6613917.33	0.33	-0.21
6	578692.55	6612776.97	-0.92	0.09
7	580171.83	6612509.66	-0.42	1.20
8	581962.81	6612410.69	1.80	0.04
9	581356.69	6612198.54	-0.14	0.17
10	582229.20	6612229.38	0.97	0.42
11	583893.19	6611834.30	-0.42	-2.38
12	585044.93	6611263.15	1.67	-0.82
13	586143.94	6610641.46	0.16	0.34
14	587229.55	6609868.75	0.20	0.51
15	588588.10	6608392.10	0.98	-0.28
16	580982.48	6612244.91	1.31	1.83
17	576150.37	6613984.64	0.04	0.52
18	577777.72	6612964.93	0.64	0.58
19	574098.67	6614724.25	-0.66	1.63
20	582880.86	6611653.10	0.40	-1.89
		Mean	0.25	0.11
		Standard Deviation	0.79	0.99
		Range	2.72	4.22
		Root Mean Square Error	0.81	0.97
		Total Relative Error	**1.26**	
		Total Absolute Error	**1.27**	

Table A3. Checkpoints and accuracy statistics for 1951/1952 orthoimage.

Checkpoint	Easting (m)	Northing (m)	Easting Offset (m)	Northing Offset (m)
1	583164.56	6612708.80	0.85	-3.18
2	581653.07	6612504.38	-0.09	0.62
3	582658.88	6613633.05	0.57	-0.44
4	580482.63	6614285.22	0.11	3.18
5	577333.37	6614096.13	0.21	-0.78
6	574078.37	6616805.94	-3.18	-0.92
7	574159.72	6615797.26	2.12	-2.68
8	574908.58	6614695.56	0.71	3.35
9	574844.97	6616612.98	0.42	0.64
10	579282.73	6612807.40	0.21	-3.28
11	588457.43	6616059.88	-0.88	-1.94
12	589573.54	6617895.94	1.59	-2.12
13	587800.89	6614700.66	0.32	-3.07
14	586816.40	6615803.54	1.06	-1.06
15	585199.08	6614735.84	3.70	-1.59
		Mean	0.51	-0.88
		Standard Deviation	1.48	2.09
		Range	6.88	6.63
		Root Mean Square Error	1.52	2.21
		Total Relative Error	**2.68**	
		Total Absolute Error	**2.97**	

Table A4. Checkpoints and accuracy statistics for 1964 orthoimage.

Checkpoint	Easting (m)	Northing (m)	Easting Offset (m)	Northing Offset (m)
1	581578.44	6612501.63	-0.19	0.40
2	581996.37	6612180.39	-1.01	0.32
3	583883.25	6612046.75	-0.35	1.06
4	587213.52	6613179.54	0.74	-1.16
5	587782.72	6614066.44	-0.04	-0.35
6	587649.59	6614940.63	0.42	-0.90
7	585862.67	6614992.84	0.37	-0.11
8	585059.41	6614788.44	0.64	-0.74
9	584495.09	6614116.57	1.06	-0.18
10	583467.05	6613931.69	0.34	0.32
11	581893.09	6613533.43	-0.56	0.32
12	589771.96	6607999.99	0.74	0.39
13	586195.50	6610602.72	0.90	-1.38
14	583118.80	6612949.41	-0.26	0.53
15	580053.06	6612895.34	-0.02	0.71
16	583164.15	6613340.93	0.18	-0.21
17	581347.45	6612387.71	-0.38	0.38
18	582135.60	6612904.97	-0.49	0.42
19	587182.61	6613792.26	0.88	-0.44
20	583848.75	6613451.75	1.13	-0.14
		Mean	0.20	-0.04
		Standard Deviation	0.61	0.64
		Range	2.13	2.43
		Root Mean Square Error	0.63	0.63
		Total Relative Error	**0.89**	
		Total Absolute Error	**1.55**	

Table A5. Checkpoints and accuracy statistics for 1985 orthoimage.

Checkpoint	Easting (m)	Northing (m)	Easting Offset (m)	Northing Offset (m)
1	573822.85	6616055.16	3.25	3.01
2	573965.27	6615327.71	-1.68	-3.84
3	575048.90	6614548.52	2.85	-3.62
4	578306.15	6613032.31	-3.80	-1.65
5	579704.36	6614126.19	-3.71	0.67
6	582100.25	6613606.94	0.04	-2.10
7	581276.70	6612423.30	1.51	-2.95
8	584247.25	6612253.52	-0.78	-1.51
9	589310.80	6608134.31	-2.63	1.33
10	585397.53	6612270.32	-1.13	-2.40
11	585132.05	6615385.17	-2.75	-0.65
12	587972.18	6615572.73	1.54	-1.23
13	586899.22	6616108.52	-2.95	0.37
14	590270.45	6616567.38	-1.38	-1.94
15	590642.86	6616878.52	1.81	-1.01
16	583116.93	6613527.12	-0.32	-0.23
17	587782.36	6614066.49	0.21	-3.25
18	575720.12	6615768.34	2.91	1.39
19	588197.80	6616931.60	-0.24	1.56
20	590256.61	6617490.82	1.25	2.50
		Mean	-0.30	-0.78
		Standard Deviation	2.21	2.04
		Range	7.05	6.85
		Root Mean Square Error	2.18	2.13
		Total Relative Error	**3.05**	
		Total Absolute Error	**3.30**	