

COASTAL MAPPING PROGRAM

**PROJECT HI0001A
COMPLETION REPORT**

HAWAII

Kaula Rock

**A Photogrammetric Survey based
on 2000 Aerial Photographs**

**UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
National Geodetic Survey
Remote Sensing Division**

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COASTAL MAPPING PROGRAM

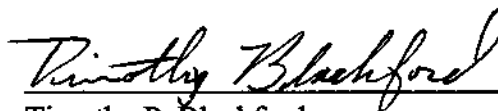
PROJECT HI0001A
COMPLETION REPORT

HAWAII
Kaula Rock

Clearance

This report summarizes the photogrammetric operations related to project completion and is submitted for approval. The project data and this report meet the requirements and standards of the Coastal Mapping Program.

Submitted by,



Timothy P. Blackford
Senior Cartographer
Applications Branch

Approved:



Robert W. Rodkey, Jr.
Chief, Applications Branch
Remote Sensing Division

9/21/01
Date



Captain Jon W. Bailey, NOAA
Chief, Remote Sensing Division
National Geodetic Survey, NOS, NOAA

9/24/01
Date

COASTAL MAPPING PROGRAM

PROJECT HI0001A COMPLETION REPORT

HAWAII
Kaula Rock

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**COASTAL MAPPING PROGRAM
PROJECT HI0001A
SUMMARY**

Introduction

Project HI0001A provides highly accurate digital shoreline data for Kaula Rock, a small uninhabited island in the state of Hawaii. HI0001A is a sub-project of HI0001, part of a larger effort to "Re-position Atolls and Islands on Nautical Charts" for the Northwest Hawaiian Islands.

Successful completion of this project resulted in a densification of the National Spatial Reference System (NSRS), a set of controlled metric quality aerial photographs and companion high resolution digital scans, and digital cartographic feature files of the coastal zone to complement the Nautical Charting Program (NCP) and other geographic information systems.

The project database consists of information measured and extracted from aerial photographs and metadata related to photogrammetric compilation. Base mapping was conducted in a fully digital environment using softcopy stereo photogrammetry and associated cartographic practices. Positional data is referenced to the North American Datum 1983 (NAD83).

Planning

The planning phase of Project HI0001 was accomplished by the Requirements Branch, Remote Sensing Division. Photogrammetric requirements were formulated during project planning and issued as a set of Project Instructions under the heading "HI0001 - Hawaiian Islands." These instructions, included as Appendix A, discuss in detail the following: photographic requirements, flight lines, tide coordination, GPS control requirements, guidelines for static and kinematic data collection and handling, project priority and communication guidelines.

Field Operations

Field operations consisted of the collection of static and kinematic GPS data and the acquisition of aerial photographs. Static GPS data was collected at Honolulu International Airport prior to the photo missions and applied as a local reference point. Kinematic GPS data was collected during the ensuing photo missions, rendering precise camera positions as a means of controlling the photographs. Refer to Appendix B, GPS Processing Report for HI0001A, for detailed information regarding GPS data collection and processing. Aerial photographic survey operations were conducted during April of 2000 by the Cessna Citation II (N52RF) aircraft. Photographic requirements consisted of 1:24,000 scale photography utilizing natural color film. All photos were taken using a Wild RC-30 camera with the NOS "A" lens cone.

Aerotriangulation

Softcopy aerotriangulation methods were applied to establish the network of horizontal and vertical control for mapping and to provide model parameter and orientation elements required for digital compilation. The aerotriangulation task was accomplished by the Applications Branch, Remote Sensing Division, in September 2001. Refer to the Aerotriangulation Report in Appendix C for a complete discussion of this phase of the project, including source photography, geodetic control, hardware and software used, methods employed to derive an analytical solution and overall accuracy achieved. Accompanying diagrams of the project area show geographic coverage, approximate flight lines of the photo mission, and relative accuracy of the solution.

Compilation

Compilation requirements for Project HI0001A included digital base mapping and the production of cartographic feature files in ESRI shapefile format.

Digital mapping was accomplished by the Applications Branch, Remote Sensing Division, in September 2001, using the SOCET SET Feature Extraction software module on a Digital Photogrammetric Workstation (DPW), which is a configuration of computer hardware, SOCET SET modular software components and other associated peripheral devices.

Cartographic features were compiled using the aerotriangulated 1:24,000 scale natural color photographs and digital stereo compilation methods. The source photographs used to compile cartographic features are described in Appendix D, Compilation Sources.

Features were compiled to meet 5.8 meters horizontal accuracy at a 95% confidence level. This predicted accuracy of compiled well-defined points is a deductive estimate based on triangulation statistics. Feature identification and the assignment of cartographic codes were based on the interpretation of these photographs and the NOS nautical chart.

Final Review

Final review evaluation tasks were initiated in September 2001. The digital cartographic feature files were evaluated for completeness and adherence to the Coastal Mapping Program (CMP) requirements and established NOS accuracy standards. Discrete point data for Project HI0001A was compared with the USCG Light List and the nautical chart for consistency. Cartographic feature codes conform with the CMP's Coastal Cartographic Object Attribute Source Table (C-COAST). Nomenclature was assigned to cartographic features which required further description.

A page-size plot of the digital cartographic feature files is included in Appendix E.

Project Final Data and Products

Agency Archive:

- Original Project Completion Report (PCR)

Remote Sensing Division Electronic Data Library:

- Project Data Base
- Digital Cartographic Feature Files for GC-10502
- Copies of Digital Cartographic Feature Files in ESRI shapefile format

OCS Marine Chart Division:

- Digital Cartographic Feature Files in ESRI shapefile format
- Abbreviated copy of PCR

APPENDIX A

HI0001
Hawaiian Islands

1.0. General:

1.1. Introduction: Aerial survey HI0001 is a survey to provide high resolution controlled photographic coverage of an area that covers the Hawaiian Islands (Oahu, Maui, Molokai, Niihau, Kahoolawe, Kauai, Lanai, Hawaii and Kaula). Aerial survey HI0001 will be conducted in conjunction with two research projects. The lead person for one is Grady Tuell and the other is headed by John Klein. However, survey HI0001 has priority.

1.2. Coverage: These instructions cover the photographic flights of the designated survey area.

1.3. Scope: Ninety-four(94) flight lines at a scale of 1:24,000 are required to provide adequate photographic coverage. Control for aerotriangulation will be provided by kinematic GPS data. Only natural color photography is required along the flight lines configured. Color photography will be required to satisfy standing requirements for photobathymetric mapping. There are no tides coordinated requirements. The sun angle requirements are outlined in section 2.7. Concurrent with color photography, remotely sensed imagery will be attempted using the Hyperspectral Imaging System(HSI). An on sight representative of the contractor will be the contact person for the operations of the APT1 system. Refer to the listing of contacts under section 11.

2.0. Photographic Requirements:

2.1. All exposures will be taken along the flight lines indicated on the accompanying flight maps and way point files.

2.2. All flight lines will be flown at an altitude that produces nominal photographic scale of 1:24,000.

2.3. Expose all images so that they have a nominal end lap and side lap of 60 percent.

- 2.4. All flight lines are to be flown using color negative film (standard NOS emulsion film type) and the HSI system when the HSI system arrives.
- 2.5. All flight lines will be navigated using GPS and the Universal Flight Management System.
 - 2.5.1. Flight lines may be patched when GPS navigation is used, and kinematic data are acquired for both sides of the split flight line.
- 2.6. Begin the second portion of a patched flight line at least two photographs before where the break was made.
- 2.7. Color negative imagery and the HSI system data will be collected concurrently when the sun angle is between 10-30 degrees. The water clarity conditions will be provided daily by John Klein; he will relay this information to the mission commander the evening before overflights. Information for contacting John Klein is in section 11.
- 2.8. The HSI system may also be flown on selected test sites at a lower altitude. These way points and altitudes will be provided by this office. When flying these lines collect color negative photography in conjunction with the HSI system.
- 3.0. Flight Line Priority:

First priority shall be to acquire color imagery. However, as soon as the HSI arrives in HI collect photography concurrently with HSI data.
- 3.1. The Hawaiian Islands diagrams will be furnished to the flight mission. The islands have been labeled in numerical order (I thru VII) in the order of importance. There are also two islands that are labeled N/A which are the least important. For tracking and reporting purposes the islands have been assigned serial numbers 24-100's thru 24-400's.

In the 24-100's series (Kauai, Niihau, Kaula) there are twenty-four(24) lines; 24-200's series (Oahu) there are sixteen(16) lines, 24-300's (Molokai, Maui, Lanai, Kahoolawe) there are 32 lines and 24-400's series (Hawaii) there are 22 lines.
- 4.0. Tide Coordination:

None.

5.0. GPS Control for Aerotriangulation:

- 5.1. Kinematic GPS data are required for all imagery acquired in completion of this project.
- 5.2. GPS and EDI files are required for all color negative imagery.
- 5.3. All flight lines may be flown without a bank angle restriction. However, caution must be observed when banking so that all satellites being tracked remain locked. (See GPS SOP Section X. for further operational instructions.)
- 5.4. No support from the NGS Field Operations Branch is required for this aerial survey.

6.0. GPS Reference Receivers:

- 6.1. Primary Reference Receiver: Establish a GPS primary reference receiver station over a known, monumented NOS control station at the airport you choose as your base of operations.
 - 6.1.1. Control is available at the following airports within the operating area of the aerial survey (Honolulu, Molokai, Kailua-Kona, Lanai, Kahului, Lihue).
 - 6.2. If preexisting control is not of first order or better, or conveniently located, set a PK nail in a convenient spot.
 - 6.3. Observe two(2) static GPS surveys over the PK nail, following standard GPS procedures given in GPS Controlled Photogrammetry Field Operations Manual, Section 5.2.
 - 6.3.1. If the nearest Continuously Operated Reference Station (CORS) is less than 50KM away, observe two(2) static surveys of two(2) hours duration each.
 - 6.3.2. If the nearest CORS is greater than 50KM away, observe two(2) static surveys of four(4) hours duration each.
 - 6.4. Send the static GPS survey data to Tim Blackford via e-mail, the post office, or courier.
- 7.0. Project Schedule/Priority:

- 7.1. This survey is scheduled to be begin April 1, 2000. Based on clear weather predictions, it is estimated that operations will continue until about June 20, 2000. However, weekly progress will be evaluated and a completion date may be modified.
- 7.2. The contractor will provide personnel to operate the APTI.
- 7.3. The Chief, Remote Sensing Division may alter or eliminate this priority.
- 8.0. Data Recording/Handling:
- 8.1. Record all photographic data as provided for in the Photo Mission Standard Operating Procedures.
- 8.2. Record and handle all GPS data as provided for in the GPS Controlled Photogrammetry Field Operation Manual.
- 8.3. Send one (1) copy of the kinematic GPS data from the aircraft and static data and station logs from the reference receiver to Tim Blackford, Applications Branch N/NGS33 weekly, unless otherwise requested.
- 8.3.1. You will be notified by Tim Blackford when further in-house copies of the data have been made, at which time you may eliminate your copy.
- 8.4. Send EDI files to the Systems & Quality Assurance Branch with the exposed roll.
- 8.5. Fax a copy of the photographer's flight report for each roll of exposed film to the Requirements Branch(RB), RSD. Ship film and the original report to the contract photo laboratory for processing.
- 8.6. Film for this project must be reviewed quickly. Image quality is important for coral reef interpretation, therefore, if reflays are necessary this information must be sent to the field crew asap. Futhermore, Steve Rohman must be contacted when CN film arrives in S&QA.
- 9.0. General Guidelines for Aircraft GPS Operations:
- 9.1. It is advised that the Mission Commander download GPS satellite ephemeris and health data from the Arinc web site daily to ensure that the satellite constellation is adequate for kinematic operations. Their URL is: WWW.ARINC.COM/PRODUCTS_SERVICES/GPSSTAT.HTML. Download

the three files that pertain to the daily and monthly ephemeris and satellite health data. These will all run under the same SEM program that has been previously used.

- 9.2. Run satellite visibility plots and PDOP predictions daily.
- 9.3. Base daily operations on the most current satellite ephemeris.
- 9.4. Standard operating Procedures for conducting a kinematic airborne GPS Survey are found in GPS Controlled Photogrammetry Field Operations Manual, Section 5.
- 9.5. Imaging operations will be conducted within approximately 325km of the primary reference receiver.
- 10.0. Satellite Lock:
- 10.1. Receiver lock on a minimum of four(4) satellites are required at all times during photographic operations for this project.
- 10.2. Receiver lock on satellites shall be in accordance with the specifications for kinematic GPS operations contained in the GPS SOP Section X.
- 10.3. If loss of lock occurs while flying any lines, follow the procedures outlined in the GPS SOP Section X, (Reestablish lock and re-fly the entire line where lock was lost.)
- 11.0. Contacts/Communications:
- 11.1. E-mail, FAX, or phone a project status or situation report to the Requirements Branch daily, even if there has been no change in project status or progress. A report of "no progress" or "no change" is preferable to no report at all. See attached E-mail list.
- 11.2. Check your E-mail box frequently; Requirements Branch personnel will forward any project changes or other pertinent data to e-mail address: Photo1@Earthlink.net.
- 11.3. For questions or information regarding the operational aspect of this project contact:

Edward Allen (Requirements Branch)
Phone: (w) 301-713-2674, ext. 176
home 703-313-9166
home (beach) 804-435-3488
Internet: eallen@ngs.noaa.gov

- 11.4. For questions or information regarding the operational or theoretical GPS aspect of this project or in the event of total GPS failure or for questions or information regarding aircraft operations contact:

Jon Bailey
Phone: (w) 301-713-2663, ext. 160
(h) 301-990-8578
(Cell) 240-305-4041
(Fax) 301-713-4572
Internet: jbailey@ngs.noaa.gov

- 11.4.1 For questions or information regarding the operation of the APXI contact:

John Klein
Phone: (Cell) 410-340-6443

- 11.5. For questions regarding aerial camera maintenance or repair contact:

Steve Nicklas
Phone: (w) 301-713-2671
(h) 301-365-3221

- 11.6. When communicating with anyone outside the RB about any aspect of this project a copy of the communication must be forwarded to the RB. This includes notifying the RB that data have been sent.

12.0. Data provided with these Instructions:

One copy of the original Project Layout Diagram
Four copies of the flight maps

One floppy disk containing the files:

HI0001.wpt - waypoint input to flight management system
 HI0001.xls - Microsoft Excel format of flight line input
 HI0001.txt - Text version of way point input

Two copies of these instructions

One copy of the listing of other geodetic control in the area.

Approved _____ Date _____
 Edward Allen, Chief of RB

Approved _____ Date _____
 Robert Rodkey, Chief of AB

Approved _____ Date _____
 Steve Matula, Chief of S&QA

Approved _____ Date _____
 CDR Jonathan Bailey
 Chief, Remote Sensing Division

cc: J. Bailey
 R. Rodkey
 S. Matula
 E. Allen

*NOTE: Signed original copy of the
 was not available
 time of PCR assembly
 R. Bailey
 10/2/01*

E-MAIL LIST

APPENDIX B

HI0001A

Kaula Rock

Hawaii

GPS Processing Report

September 2001

INTRODUCTION

The Global Positioning System (GPS) data referred to in this report was processed to provide precise positions of camera centers, to be used as photogrammetric control in the aerotriangulation phase of the Coastal Mapping Program project HI0001A - Kaula Rock. The datasets processed and the aerial photos covered by those datasets are listed in the table below:

Dataset	Date	Project(s)	Description / Flight Lines
00HNL102.s	4/11/00	HI0001	Static Data for reference station (PHNL)
00HNL111	4/20/00	HI0001	24-101, 102, 111, 121, 122, 124

DATA COLLECTION

GPS data was collected in April 2000, as detailed in the table above. The procedures followed are described in the GPS Controlled Photogrammetry Field Operations Manual, of Oct. 25, 1999. All data was collected using Trimble 4000SSi geodetic receivers. Before the first session, a PK-nail was set in a convenient location at Honolulu International Airport (HNL) in Honolulu, HI. A Trimble Compact L1/L2 antenna with Ground Plane was set up on a 2 meter fixed height tripod over a the PK-nail, which was given the designation PHNL. Four hours of static data were collected.

The next session was a kinematic survey with the rover receiver in the NOAA Cessna Citation II (N52RF) aircraft, and the reference receiver set up over PHNL. This session was of about 3 hours 16 minutes duration with a measurement interval of 1 second. Six flight lines were flown, and 79 photo events were recorded. No problems were reported by the field personnel in the observation log.

All observed data was downloaded from the receivers to a portable computer. At the end of each week the data files were copied to zip disks and forwarded to headquarters for processing. Upon receipt in the office, the datasets were backed up to optical disk and project folders were created for each session. As it became available, additional data was downloaded from the network for use in the processing stage. This supplementary data included NGS precise ephemeris files for each session, NGS CORS data, and the FIF file for the film roll.

REFERENCE RECEIVER POSITIONING

Static GPS data from the two nearest CORS stations, Kokole Point (KOK1) and Upolu Point (UPO1), and static data collected over the PK-nail, PHNL, were processed using Trimble GPSurvey (ver. 2.35) software. Baseline solutions were computed from both CORS stations to PHNL, and then adjusted in a network to produce the final coordinates in NAD83:

Latitude:	21° 19' 18.02382"
Longitude:	157° 54' 36.17781"
Ellipsoidal Height:	18.453 m

KINEMATIC PROCESSING

The airborne kinematic GPS dataset, 00HNL111, was processed in July 2001 using Trimble GPSurvey (ver. 2.35), and utilizing the NGS computed precise satellite ephemeris, and standard meteorologic data. A continuous kinematic iono-free phase solution was obtained. The RMS of the phase residuals had spikes to almost 4 cm near the beginning and end of the session, but generally ranged from 0.5-2 cm for most of the time. The average iono-free RMS for the session was 1.0 cm. The RDOP value varied between 1.5 and 2.8 throughout the session. The product, RMS x RDOP (which is a reasonable estimate of the mean square positional error), generally varied between 1 and 5 cm, with its highest peaks during the survey remaining below 9 cm. The session folder (HI0001 Day 111) on file in the RSD GPS Archive contains the GPSurvey Detailed Kinematic Solution Summary report including plots of RMS and RDOP and a solution diagram (network map).

APPENDIX C

AEROTRIANGULATION REPORT

HI0001A

Kaula Rock, Hawaii

September, 2001

Area Covered

Project HI0001A covers the island of Kaula Rock in the Hawaiian Islands at approximately 21° 38' N latitude and 160° 33' W longitude. The project area is west of Kauai, the westernmost of the major islands of Hawaii. The project area is shown in the accompanying diagram, "HI0001 - Hawaiian Islands."

Photography

Two strips of color photography (24-121 and 24-122), consisting of 6 individual exposures, were bridged during the aerotriangulation phase of this project. See the diagram referenced above for position and orientation of the flight lines. Photos were acquired on 4/20/00 using a Wild RC-30 camera with the NOS "A" lens cone at an altitude of approximately 3,600 meters, for a nominal scale of 1:24,000. Photographic coverage, resolution, overlap, and metric quality were adequate for the performance of the aerotriangulation phase.

Adequacy of Control

During acquisition of the color photography, kinematic GPS control of the camera stations was employed allowing for GPS determined photo center points. The GPS controlled camera stations provided adequate horizontal and vertical control for an acceptable solution.

Method

The photographs were bridged using a softcopy 3D stereo photogrammetric system to establish the network of control required for the compilation phase. All measurements were made using the ORIMA aerotriangulation module within SOCET SET in a Windows NT environment, on a Digital Photogrammetric Workstation (DPW). Photos were scanned and converted into 25 micron resolution digital images in VITec format, and subsequently imported into SOCET SET. The GPS controlled images were then measured manually and the Combined Adjustment Program (CAP-A) was run to derive an initial adjustment. After subsequent processing, analysis and refinement, a final analytical adjustment was performed.

The RMS of the standard deviations of the residuals for each triangulated ground point was calculated using the ORIMA software triangulation module. These values were used to compute a predicted horizontal circular error of 2.9 meters for the entire project based on a 95% confidence level.

Visualization tools within ORIMA were used for evaluation of the triangulation adjustment, providing a graphic display of the horizontal and vertical standard deviations and residuals of measured points in the least squares solution. The attached diagram entitled "Horizontal Error Ellipses" shows the ellipses as computed in ORIMA.

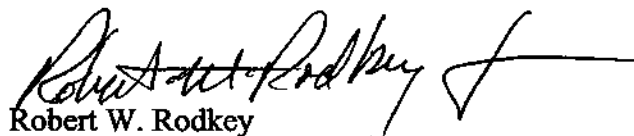
Project Database

Upon completion of the aerotriangulation phase, a project database was created under the reference number HI0001A and includes the following:

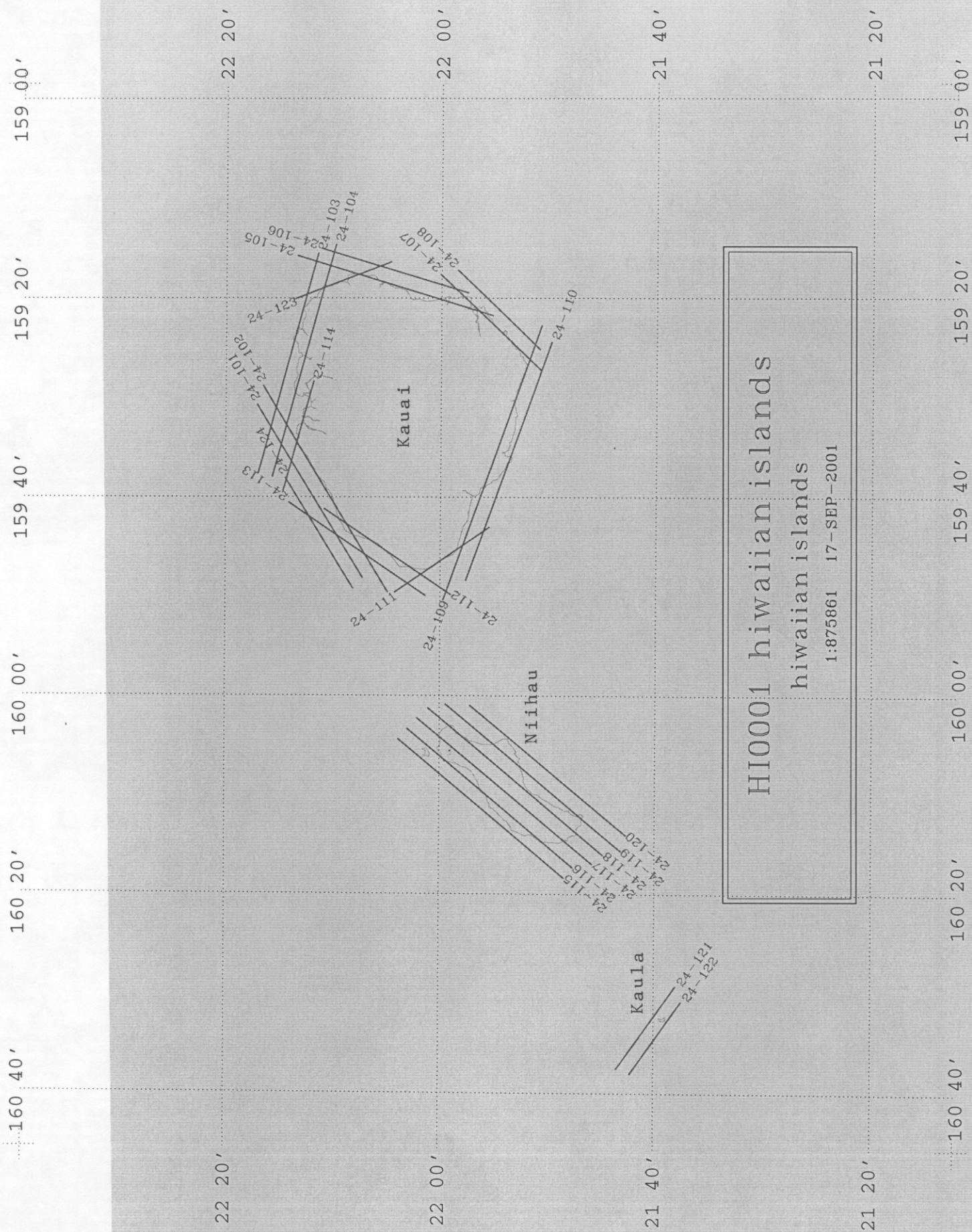
- General Project Parameters
- Camera Calibration Data
- Image Interior Orientations
- Airborne GPS Antenna Position and Offset Data
- Adjusted Exterior Orientation Parameters
- Positional Listing of All Measured Points Used in the Project

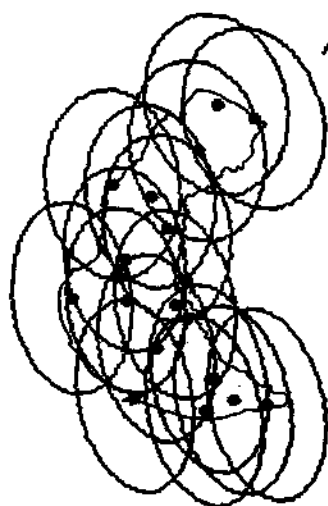
Select models from each strip of photography were examined in SOCET SET to insure the horizontal and vertical integrity of the adjustment, and to verify the suitability of the database for use in the compilation phase. Positional data is based on the North American Datum of 1983 (NAD83), and is referenced to UTM Zone 4.

Approved and Forwarded,



Robert W. Rodkey
Chief, Applications Branch





H10001A
Kaula Rock, HI
Horizontal Error Ellipses

APPENDIX D

Compilation Sources

Project: HI0001A

Photography:

DATE	TIME	ROLL / FRAMES	SCALE	TIDE LEVEL
04-20-00	03:02-03:10	00 ACN-08 #1465-1482	1:24,000	0.54

Tide levels are given in Meters above MLLW and are based on actual observations recorded by the NOS gauge at **Nawiliwili Harbor, Kauai Island, HI**, at the time of photography. Times shown are on UTC (GMT).

The elevation of the MHW tidal datum at the Nawiliwili Tide Gauge is equal to 0.43 meters above MLLW.

APPENDIX E

