STATE OF HAWAII

DEPARTMENT OF TRANSPORTATION

AIRPORTS DIVISION

GPS DATA COLLECTION STANDARDS

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State of Hawaii, Department of Transportation – Airports Division

GPS Data Collection Standards

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1.0 Introduction

The State of Hawaii, Department of Transportation, Airports Division (DOTA) maintains a Geographic Information System (GIS) for use by the DOTA for the storage and analysis of cartographic and related environmental, property, and regulatory database information. The data in the DOTA's GIS database has been used by DOTA staff for over ten years for map-based decision support and for searching engineering project drawings.

Data produced by and for the DOTA's GIS must adhere to guidelines set forth by DOTA's GIS Development Team. Data must also be documented with Federal Geographic Data Committee (FGDC) standard metadata (https://www.fgdc.gov/metadata).

The use of Global Positioning System (GPS) receivers for accurately and efficiently collecting and storing mapped feature locations and descriptive attributes has become a widely accepted method for capturing data for GIS applications. With the continuing decline of costs in GPS hardware that provide greater accuracy, users of this technology can cost-effectively collect highly accurate GIS data.

The procedures outlined in this document must be applied to GPS work performed by or for DOTA.

2.0 GPS Receiver Hardware and Data Processing Software Requirements

There are three general classes of GPS receivers: Recreation Grade, Mapping Grade, or Survey Grade.

Recreation Grade or Sports Receivers - This receiver is not designed for mapping and GIS applications, but more for basic navigation use by drivers of automobiles, boaters,

hikers, etc. Generally, these do not have data collection capabilities beyond the storing of waypoints (points you wish to navigate to) and routes (also called tracks - sets of linked waypoints). With this class of receiver, users can expect determined position fixes to be accurate to within 10 meters with a 95% confidence under ideal conditions (GPS signals of sufficient strength, and favorable satellite geometry).

Mapping Grade Receivers -These are specifically designed for storing mapped features that include feature coordinates and attributes. Positions determined by these receivers are generally in the 1 to 3 meter accuracy range after differential correction, though more advanced receivers are capable of sub-meter and sub-foot accuracies. These receivers generally perform better in less GPS friendly environments. These receivers can operate in real time differential correction mode using WAAS, or other real time differential correction solutions (that usually require additional hardware and/or service subscriptions).

GPS data post processing software is necessary in order to perform differential corrections and other data processing tasks. The GPS data differential correction software includes utilities to enable GPS field data file transfer to a PC, perform corrections, allow analysis/edit of data, and enable the export of collected data to a GIS file format. The mapping grade GPS receiver is the most acceptable grade for GIS data collection within the DOTA.

Survey Grade Receivers - Designed for applications that require extremely high accuracy. Positions determined by these receivers can be accurate to within less than a centimeter. These receivers are more sensitive to surrounding environmental conditions that cause signal blockage than mapping grade receivers. In GIS applications, these receivers are used most often for establishing the geodetic control base for study areas, and for data collection projects that require higher accuracies.

2.1 GPS Receiver Requirements

The GPS receiver must operate in a 3D mode, where the receiver requires signals from a minimum of four satellites to determine a 3D (latitude, longitude, and elevation) location (a fix).

The GPS receiver must allow the storage of position fixes for features. When mapping point features, the receiver must be able to store a sample of position fixes (the minimum number depending on the quality of the receiver) for the feature. The receiver should have enough data storage capacity for a typical day's worth of data collection.

2.2 Feature Accuracy

Features collected for the Federal Aviation Administration (FAA) electronic airport layout plan (eALP) must adhere to FAA data collection standards and accuracy requirements as defined by FAA. See https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/74204.

FAA requirements in the document referenced above state that:

"The accuracy for geospatial vector airport features (taxiway, aprons, ramps, buildings, etc.) is typically mapping grade accuracy, nominally within 3 feet horizontally and 5 feet vertically" and,

"Specific runway, stopway and navigational aid data accuracies are nominally within 1 foot horizontal and 0.25 feet vertically. Accuracy requirements for geospatial features used for geographic orientation (major highways and roads, lakes, rivers, coastline, and other items of landmark value) are usually 20 feet horizontally and 10 feet vertically relative to the NSRS. Derived elevations must be within 10 feet vertically."

Specific accuracy requirements for each feature type will be provided to data collectors prior to project initiation or in the request for proposals (RFP) for outside contractors. In general, data collectors will be required to achieve 1 meter or sub-meter accuracy for most feature types.

2.3 GPS Processing Software Requirements

The GPS data processing software must adhere to the following requirements:

Post-processing software must be capable of performing differential corrections. The GPS processing software will provide quality control information about, or summary reports on, satellite residuals, standard deviations of point features, Dilution of Precision (DOP), files processed, critical receiver setting parameters (collection mode, elevation mask, Position Dilution of Precision (PDOP) mask, signal to noise ratio mas, etc.) The ability to detect and remove bad satellite data or positions is also preferable.

The GPS processing software must be capable of exporting data to a GIS or CAD file format. Final submission to DOTA must be consistent with approved export formats, coordinate system, datum, and units as specified below.

3.0 GPS Field Data Collection

GPS field work must be performed by staff that has had training in the operation of a GPS receiver and GIS or has a surveying or mapping background. Field staff must have a thorough understanding of GPS basic concepts, and receiver operation. The staff must also have familiarity with the types of features to be located and must be able to recognize/interpret features in the field. To achieve the DOTA's target accuracy, all collected GPS data must be differentially corrected, either in real time or in a post process step.

3.1 GPS Collection Parameter Settings

Each GPS receiver parameter setting should be set to the manufacturer's recommendation that would, at a minimum, allow the GPS data collected to meet the accuracy requirement for the specific feature.

All position fixes must be determined with 4 or more satellites. 2D fixes (using only 3 satellites) are not acceptable. 3D positions generated from 2D fixes supplemented with user entered elevations are also not acceptable. Solutions based on a single fix are not acceptable.

Intervals for point features should be 1 or 5 seconds. Intervals for line and area features depend on the velocity at which the receiver will be traveling and the nature of the feature and the operating environment. Under normal circumstances (i.e., when the user is walking with the receiver) the interval for line and area features will be set to 5 seconds. If the receiver allows, this parameter setting will be set to allow the logging of DOP data along with position fixes.

3.2 Field Notes

Field notes must be maintained for each feature collected. The notes should document the following:

Project name
Site name
Feature description
Begin data logging time

PDOP value
Name of receiver operator
Brand & Model of GPS receiver
Date of collection
Feature number (permit #, well #, etc.)
GPS file name
End data logging time
Number of position fixes
Difficulties/Comments
Any additional hardware (if applicable)

Depending on the project, additional project specific information may also be recorded.

4.0 Processing of GPS Field Data and Coordinate Systems

All GPS data collected for DOTA must undergo post processing steps using GPS processing software before the data can be used to generate a GIS layer. The GPS processing software must be able to download GPS data files from the GPS receiver, and perform differential corrections. In addition, it must allow exporting the corrected data to a DOTA approved export GIS format, in the correct coordinate system, as specified below for each island/airport.

For Kauai Airports (LIH, PAK):

NAD 1983 HARN StatePlane Hawaii 4 FIPS 5104 Feet

WKID: 102464 Authority: Esri

Projection: Transverse_Mercator
False_Easting: 1640416.666666667
False_Northing: 0.0
Central_Meridian: -159.5
Scale_Factor: 0.99999
Latitude_Of_Origin: 21.83333333333333
Linear Unit: Foot_US (0.3048006096012192)

For Oahu (HNL, HDH, JRF)

NAD 1983 HARN StatePlane Hawaii 3 FIPS 5103 Feet

WKID: 3760 Authority: EPSG
Projection: Transverse_Mercator
False_Easting: 1640416.666666667
False_Northing: 0.0
Central_Meridian: -158.0
Scale_Factor: 0.99999
Latitude_Of_Origin: 21.16666666666667
Linear Unit: Foot_US (0.3048006096012192)

For Molokai (MKK, LUP)

NAD 1983 HARN StatePlane Hawaii 2 FIPS 5102 Feet
WKID: 102462 Authority: Esri

Projection: Transverse_Mercator
False_Easting: 1640416.666666667
False_Northing: 0.0
Central_Meridian: -156.6666666666667
Scale_Factor: 0.9999666666666667
Latitude_Of_Origin: 20.33333333333333
Linear Unit: Foot_US (0.3048006096012192)

For Maui and Lanai Airports (OGG, HNM, JHM, LNY)

NAD 1983 HARN StatePlane Hawaii 2 FIPS 5102 Feet
WKID: 102462 Authority: Esri

Projection: Transverse_Mercator
False_Easting: 1640416.666666667
False_Northing: 0.0
Central_Meridian: -156.6666666666667
Scale_Factor: 0.9999666666666667
Latitude_Of_Origin: 20.33333333333333
Linear Unit: Foot_US (0.3048006096012192)

For Hawaii Airports (ITO, KOA, MUE, UPP)

NAD 1983 HARN StatePlane Hawaii 1 FIPS 5101 Feet
WKID: 102461 Authority: Esri

Projection: Transverse_Mercator
False_Easting: 1640416.666666667
False_Northing: 0.0
Central_Meridian: -155.5
Scale_Factor: 0.9999666666666667
Latitude_Of_Origin: 18.83333333333333
Linear Unit: Foot_US (0.3048006096012192)

A list of airports, IATA Code and State Plane Zone is show below for additional reference.

ISLAND	COUNTY	STATE PLANE ZONE	IATA CODE	AIRPORT NAME
OAHU	HONOLULU	3	HDH	Dillingham Airfield
OAHU	HONOLULU	3	HNL	Daniel K. Inouye International Airport
OAHU	HONOLULU	3	JRF	Kalaeloa Airport
HAWAII	HAWAII	1	ITO	Hilo International Airport
HAWAII	HAWAII	1	KOA	Ellison Onizuka Kona International Airport at Keahole
HAWAII	HAWAII	1	MUE	Waimea-Kohala Airport
HAWAII	HAWAII	1	UPP	Upolu Airport
LANAI	MAUI	2	LNY	Lanai Airport
MAUI	MAUI	2	HNM	Hana Airport
MAUI	MAUI	2	JHM	Kapalua West Maui Airport
MAUI	MAUI	2	OGG	Kahului Airport
MOLOKAI	MAUI	2	LUP	Kalaupapa Airport
MOLOKAI	MAUI	2	MKK	Molokai Airport
KAUAI	KAUAI	4	LIH	Lihue Airport
KAUAI	KAUAI	4	PAK	Port Allen Airport

4.1 GPS Base Stations for Differential Corrections

For post processed differential corrections, resources exist for GPS base station data in Hawaii. This base data is typically freely available via the web. Differential correction routines in GPS data post processing software can often identify what time frame correction files are necessary and provide the user the ability to select the files from a preferred base station (usually closest to the field data site).

For the latest on CORS GPS base data availability in Hawaii, check the NGS web site at https://www.ngs.noaa.gov/CORS/.

4.2 Analysis and Edit

After GPS field data is differentially corrected, it must be inspected for errors and analyzed for precision. For point features, at least 95% of the position fixes making up the feature should be within the required accuracy of the feature's true position. Outlier fixes that are obviously in error may be edited (or deleted) from the sample of position fixes for a point feature. For line and area features, the standard is the same. At least 95% of the fixes making up a line feature or area boundary should be within the required accuracy of truth. Fixes that show significant deviation from what should be a relatively straight or smooth line or curve may be deleted.

4.3 Export to GIS

DOTA prefers GIS data submittals to be consistent with the approved GIS formats. Coordinate data must be in the correct Hawaii State Plane Coordinate System for the specified airport. The preferred unit of measure is the US Survey Feet.

In addition to feature coordinate and field entered attribute data, some GPS processing software packages are capable of automatically generating metadata for exported features. This metadata can provide users of the GIS data an indication as to the quality of the GPS position fixes that were used to generate the features. If the GPS processing software allows, the following generated attributes must be produced as metadata for exported features:

Automatically Generated Metadata Attributes
Line and Area Features
plus:
Standard deviation
Average horizontal precision

Data file name
Total positions
Filtered positions

4.4 Elevation Data

If elevation data is required by the project, it will be referenced to the North American Vertical Datum of 1988 (NAVD 88) vertical geodetic datum. Elevations must be generated as orthometric heights (relative to mean sea level) determined using the GEOID03 (CONUS) or later geoid conversion model.

5.0 Deliverables

The following are guidelines for acceptable GPS data collected by an outside agency.

5.1 GPS and GIS Data Files

Final deliverables to DOTA must be consistent with the approved formats, and will include the following GPS and GIS files:

l) All GPS field data files, both uncorrected and corrected versions, must be submitted.

If field data was collected in real time differential mode, then there will not be uncorrected files, and only the real time corrected files are necessary. If edits are made to corrected files (i.e., fixes deleted or offset), copies of both edited and unedited are to be submitted.

2) All GPS to GIS export files.

3) All GPS processing log files pertaining to differential correction and GIS export (if produced by the GPS processing software).

4) GPS Data dictionary files, defined for project attribute storage.

5) GIS feature classes (points, lines, and polygons) in either ESRI personal geodatabase (.mdb) or File Geodatabase format.

These files should all be in a compressed format and be organized into a logical directory structure. For example, the files could be organized by date of data collection,

and in subdirectories for Data and Export. Uncorrected, corrected field data files, post process differential correction log files, and data dictionary files should reside in the Data subdirectory. GIS export files and associated export log files would reside in the Export subdirectory.

Final GIS files should reside in a separate GIS directory.

6) GIS Feature Class Metadata following FGDC standards:

- Layer & Coverage Name
- Layer Type
- Status
- Geog. Extent
- Projection
- Datum
- Description
- Source
- History
- Attributes
- Contact Info.

7) All Aerial & Satellite Imagery shall be in .tif (TIFF), JPEG2000, or .sid(Mr SID) formats (in order of preference). Images that require georeferencing should include a projection file according to the above standards. (i.e. World File .tfw).

8) All other images (photographs, etc.) shall be in either .tif (TIFF) or .jpg (JPEG) format at minimum 400 dpi.

5.2 Project Report

The contractor must submit a project report that includes the following information:

1) An introduction describing the project. This would include the project name, the names of DOTA programs involved, the purpose and goals of the project, the project's study area, and data collection (including accuracy) requirements.

2) A project time line depicting significant milestones or achievements during the course of the project. Examples might include: awarding of contract, meetings with DOTA staff, GPS field data collection/processing phase, significant delays, interim

deliverables and status reports, final deliverables and status report; etc.).

3) Names of contractor staff performing project work.

4) A list of GPS hardware and processing software used for the GPS data collection/processing phase of the project. The hardware listing will include GPS receiver models (including firmware version), data loggers, antennas, external sensors, laser offset measuring devices, etc. The GPS processing software, mapping software, and any related data management software will be listed, along with version number.

5) A list of GPS base stations used for the project. If local base stations (stations other than US EPA, or CORS) were used, the setup procedure must be described in detail, along with the operation, collection parameter settings, and what steps were used to establish the reference position.

6) A project overview documenting the plan for carrying out the field data collection, the methods and techniques used for the GPS field data collection, how the data was processed. The handling of special circumstances and problems must also be documented.

7) A description of the deliverables including naming conventions, file formats, media, etc.

8) A listing of all the project's mapped features organized by date of collection.

9) Field notes (either in digital or paper form) that were produced during the data collection process.

6.0 DOTA Review

DOTA personnel will review all deliverables for completeness and accuracy according to the project specifications. Any omissions or data inaccuracies will be discussed with the contractor to determine cause and/or rationale, and resolution. The contractor will be held responsible to answer any questions on the deliverables, and also to provide any requested corrections based on the DOTA review.