GPS DATA COLLECTION AND DELIVERY STANDARDS

Port of Tacoma

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Preface

The Port of Tacoma (Port) is developing an Enterprise Geographic Information System (GIS) for use by the Port for the storage and analysis of cartographic (mapped) data and related tables (including scientific and regulatory database information). Geographic data produced for the Port must adhere to guidelines set forth by the Port's GIS Data Standards.

The use of the Global Positioning System (GPS) for accurately and efficiently storing mappable feature locations and attributes has become a widely accepted method for collecting GIS data. With many now having the ability to use this technology to collect GIS data, it is imperative that the Port adopts GPS data collection standards to insure data quality and consistency. This document provides both Port staff and the private sector the standards and guidelines for collecting GIS data with GPS for the Port's Enterprise GIS.

The GPS Data Collection and Delivery Standard does not define threshold accuracy values nor define the minimum accuracy required for a given data theme or application. The data steward or application manager is responsible for deciding the accuracy values that are acceptable on a theme-by-theme basis.

The standards and procedures in this document have been developed to meet or, in most cases, exceed this accuracy standard. This accuracy standard will meet the requirements for most GIS mapping applications such as point generation (wellheads, signs, utility meters), line generation (rail lines, ditches, roads), and polygon generation (area boundaries). Specific projects undertaken for the Port may have more stringent accuracy requirements that may require significant modifications to the procedures outlined.

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Chapter 1 – Explanation

1.0 Purpose

The purpose of this document is to establish the minimum GPS standards to be used by Port of Tacoma personnel involved in mapping activities as well as individuals and groups submitting digital data to the Port.

1.1 Scope

The following addresses only ground collected data and does not apply to aerial GPS procedures. The standards apply to current technology and are subject to revision as GPS equipment develops.

Chapter 2 – GPS Data Collection and Delivery Standards

2.1 GPS Receiver

To ensure that the appropriate type of GPS receiver is matched to the mapping application, an understanding of receiver capabilities and limitations is required. There are basically three classes of GPS receivers:

- Recreational Grade
  These have an accuracy within five to twenty meters. These GPS receivers usually do not have the ability to "post-process" collected data, but usually have the ability to perform real time correction using Wide Area Augmentation System (WAAS). GPS receivers can be used to navigate to a specific area and/or compile uncorrected GPS data, using associated third party software to convert the collected data directly into GIS supported data formats.

  Most modern “smart phones/tablets” fall into this category.

- Mapping Grade
  These have an accuracy from sub-meter to five meters. These GPS receivers have the ability to log raw GPS data, enabling these GPS-collected data to be post-processed utilizing desktop GPS software and allowing locations to be refined or corrected to a higher level of precision than inherent in the raw data. This category of GPS receiver also has the ability to communicate with a base station, store attributes of features, use a data dictionary and upload data from the GPS device to a PC.

- Survey or High Accuracy Grade
  These include instruments with associated software that can achieve one centimeter relative accuracy. These are used by land surveyors primarily for boundary, topographic, and geodetic surveys, photogrammetry, and other activities requiring high accuracy. Specialized training is needed to use this equipment.

The GPS receiver used to collect data for the Port of Tacoma must be of **Mapping Grade** or better. It must:

- Routinely achieve 1 meter or better horizontal accuracy, using either real time or post processed differential corrections.

- 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).

- Allow the storage of position fixes for features that are being mapped. 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 must have enough data storage capacity for a typical day's worth of data collection.

- Be user configurable for critical settings, including DOP, SNR, elevation mask, and logging rate.

- Produce and store data in a format compatible with the base station data used to perform the differential corrections or have the capability to receive real-time corrections from the base station.

2.2 Field Data Collection Parameters

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

Along with the following parameters, the Port suggests standing at a collection location for 5-10 seconds to evaluate the quality of signal (PDOP and number of satellites) before gathering points.

Position Mode	All position fixes must be determined with 4 or more satellites. Manual 3D or overdetermined 3D (5 satellites minimum) modes are acceptable. 2D fixes (using only 3 satellites) are not acceptable. 3D positions generated from 2D fixes supplemented with user entered elevations are also not acceptable.
Elevation Mask	15 degrees above horizon.
PDOP Mask	Max PDOP = 8
Signal to Noise Ratio Mask (SNR)	If this parameter setting exists, set it to 39.0
Minimum Positions	If this parameter setting exists, set it to the manufacturer's

for Point Features	recommendation that would, at a minimum, allow the GPS data collected to achieve the Port's 1 meter standard or the accuracy specified for the dataset. Solutions based on a single fix are not acceptable.
Logging Intervals	Intervals for point features will be 1 second. 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 1 second.
Logging of DOP	If the receiver allows, this parameter setting will be set to allow the logging of DOP data along with position fixes.

2.3 Data Dictionaries

For many data themes, the Port has created data dictionaries for use in GPS data collection. A data dictionary is a list of attributes to be collected, the field characteristics for each attribute, and acceptable values (if appropriate). If a data dictionary exists for a data theme, the Port requires that it be used for data collection. This will ensure that data collected will be compatible with existing data in the same theme and will be easily added to the existing dataset. Please contact the GIS Coordinator for a current list of data dictionaries.

2.4 Processing of GPS Field Data

All GPS data collected for the Port must undergo some 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 Port GIS compatible format (File Geodatabase or Shapefile), in the correct coordinate system. Refer to the section below for specific information on the required coordinate system. See the Port of Tacoma's Geospatial Data Delivery Standards for more information on data requirements for File Geodatabases and Shapefiles.

2.4.1 GPS Base Stations for Post Processed Differential Corrections

For post processed differential corrections, several resources exist for GPS base station data in Washington. The nearest operating base station with the highest integrity rating should be

used. For the Tacoma Tideflats, the Port averages two base stations when possible, and uses Washington State Reference Network – Tacoma and UNAVCO Steilacoom, Washington (pcol).

2.4.2 Output to GIS

As stated previously, the Port prefers GIS data submittals to be in either Esri File Geodatabase or Shapefile formats. The GPS processing software must allow for exporting to one of these formats. Refer to the section below for specific information on the required coordinate system. See the Port of Tacoma's Geospatial Data Delivery Standards for more information on data requirements for File Geodatabases and Shapefiles.

In addition to feature coordinate and field entered attribute data, some GPS processing software packages are capable of automatically generating attribute information for exported features. This information 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 for exported features:

Point Features	**Line and Polygon Features**
Maximum PDOP	Maximum PDOP
Receiver type	Receiver type
Correction status	Correction status
Date of collection	Date of collection
Time of collection	Time of collection
Data file name	Data file name
Total positions	Total positions
Filtered positions	Filtered positions
Standard deviation	Average horizontal precision
Horizontal Precision	Worst horizontal precision
*Elevation (MSL in feet)	*Average vertical precision
*Vertical Position	*Worst vertical precision

*Only necessary if elevation data is required by project

2.4.3 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 GEOID99 (Continental US) geoid conversion model. Conversions from other geoid conversion models are not acceptable.

2.5 Naming Convention

It is important that GPS and GIS data and attribute field names in said data delivered to the Port of Tacoma Enterprise GIS follow the same naming convention already applied to all existing data. Not all of the following rules may apply to all datasets, for example, if the delivery is for a singular dataset, but it is important to understand the geospatial naming convention already in place to alleviate any confusion or added work upon delivery of the data.

2.5.1 Start data and field names with alphabetical characters

Many processing workflows that GIS data are subjected to are unable to handle objects that start with numbers or special characters. Avoiding names starting with a number also helps to better sort the display of objects in the Enterprise GIS.

2.5.2 Do not include spaces, dashes, underscores or other special characters

Many GIS software processes cannot handle spaces or any kind of special character in the file names and/or in field names. Avoid causing problems for the data later down the line by eliminating any special characters. Underscores, however, do not cause problems and can be used in the place of dashes and/or spaces.

2.5.3 Do not use prefix or suffix for data type

Do not use prefixes like ‘tbl’ for tables, nor ‘fc’ for feature classes. This is redundant as tables and feature classes are symbolized differently in the Enterprise GIS.

2.5.4 Do not use geometry type as suffix

The Port of Tacoma Enterprise GIS provides a preview of the geometry type for each GIS dataset. Therefore adding a feature type indicator in the name is generally unnecessary. However data may occasionally be represented in alternative forms such as showing a feature as a polygon and as a point. In such a case, the data with the most logical shape should take

on the base name without a geometry type, while the data with the alternative type should be augmented with a feature type suffix separated by an underscore (Point, Poly, Line, Anno), e.g., “Buildings” and “Buildings_Point”

2.5.5 Avoid using reserved words

Using reserved words for the underlying DBMS could easily result in unexplained errors. Avoid using words like Order, File, Range, etc., on their own. Using plurals for feature class names reduces this risk.

2.5.6 Limit names to 10 characters of less (Shapefile only)

Shapefiles do not support names for the shapefile nor attribute field names longer than 10 characters; otherwise, they are truncated and the true name can be misunderstood.

2.5.7 Always provide alias names for fields

Setting an alias for field names, especially field names that are cryptic or abbreviated, is the best way to maintain useful information and provide benefits in multiple areas. As the shapefile format does not support field name aliases, for data delivered to the Port of Tacoma in that format, be sure to include field aliases as a part of the metadata. This is a required element of metadata.

2.6 Spatial Reference

The Port of Tacoma prefers all GPS data be delivered in the Port’s standard Spatial Reference as noted below. However, the Port will accept GPS data in a standard table format collected directly in decimal degrees if collected at a minimum of 8 significant digits (for example, -121.363469, 37.948884). See the Delivery Format section for further information regarding acceptable forms of GPS data in tables.

a. *Projection*: State Plane
b. *Zone*: Washington South, FIPS Zone 4602
c. *Units*: US Survey Feet
d. *Horizontal Datum*: North American Datum (NAD) 1983 adjusted to the High Accuracy Reference Network (HARN)
e. *Vertical Datum*: North American Vertical Datum (NAVD) 1988

2.7 Deliverables

If GPS data collection work is being performed by an outside agency, final deliverables will include:

1. 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, using Washington State Plane South Coordinates, in the NAD 83 (HARN) horizontal geodetic datum, in US survey feet units, in either Esri File Geodatabase or Shapefile.

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

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

5. Metadata. Refer to the next section and see the Port of Tacoma Metadata Standards for more information.

6. Project Report. The contractor must submit a project report that includes the following information. The agency may be excused from including report items indicated with an asterisk with prior consent of the Port of Tacoma GIS Manager prior to delivery.

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

    b. A project time line depicting significant milestones or achievements during the course of the project. Examples might include: awarding of contract, meetings with Port staff, GPS field data collection/processing phase, significant delays, interim deliverables and status reports, final deliverables and status report; etc.).*

    c. Profiles on contractor staff performing project work, including level of education, degrees held, GPS qualifications and/or certifications, and prior GPS work experience.*

    d. 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), dataloggers, 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.

    e. A list of GPS base stations used for the project. If local base stations (stations other than CORS) were used, the setup procedure must be described in detail, along with then

operation, collection parameter settings, and what steps were used to establish the reference position.

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

2.8 Metadata

All GPS and GIS data must have Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM) as defined by the Port of Tacoma Metadata Standards document. Refer to that document for more information.

Additionally, avoid using fields in the database to store metadata about the feature class, e.g. a Date Loaded field. Such information is required in the metadata and therefore superfluous in the attribute table. Only exceptions are to either capture row specific metadata, e.g., Modified By, where each record may have different values, or where the origin source of the individual features may vary and need to be tracked. In the second case, the metadata should also document the fact that there are multiple data origins.

Any exemption requests from any part of the metadata requirement must be submitted to the Port of Tacoma GIS Coordinator for decision before delivery.