Spatial Data Modifications and Enhancements (v1.2)

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Document Version Control

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1.1	8/2005	Original Document	Monica Stanley
1.2	8/2005	Made requested changes to accuracy levels tables. (See original document.)	Monica Stanley

Functional Requirements Document Authorization

We have fully assessed the Functional Requirements Document for the Spatial Data Modifications and Enhancements project. By signing below we acknowledge that we fully accept the changes as needed improvements and authorize initiation of work to proceed. Based on our authority and judgment, the continuation of this project is authorized.

Management Certification – Please check the appropriate statement.

☐ The document is accepted.

☐ The document is accepted pending the changes noted.

☐ The document is not accepted.

Project Sponsor: Manoj Samant	Signature	Date
Dep. Chief, ISD: Janet Burton	Signature	Date
Project Leader: Monica Stanley	Signature	Date

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1 Introduction

1.1 Purpose

The purpose of this document is to establish written communication between the users of the Center for Operational Oceanographic Products and Services (CO-OPS) Data Processing and Acquisition System (DPAS), PORTS Meta Data, Tidebox and Data Management System (DMS) excel window's applications and the Information Systems Division (ISD). This will serve as the official record indicating the needed modifications and enhancements of spatial address data provided by Manoj Samant on behalf of the users. Finally, this will ensure that ISD has correctly interpreted the needs of the users so we can provide a quality product.

1.2 Scope

This document will provide details of the changes that are going to be made to the existing system. It is not intended to provide details on how ISD is going to accomplish these changes. A project plan will follow that will document, in detail, what changes are going to be made.

1.3 Overview

CO-OPS stores meta data about the stations, sensors and other equipment used to collect water level and other environmental data. The portion of the meta data that ISD will focus on in this project are the spatial addresses of the stations and equipment. The spatial address has been referred to as the equipment's location or the equipments position but all three of these terms provide the same data. They are an objects latitude, longitude and elevation (aka altitude) values. These three together make up the x,y,z coordinate value that are used in mapping and navigation.

Currently, spatial data is only being stored for stations, dcp's, and vertical marks. The need for additional space to store spatial data for sensor's and other equipment will also be addressed with this project.

It has been brought to the attention of ISD that while stations do not move their spatial data may change. It has been requested that we track these changes. The spatial data of sensors and other equipment already have the ability to track changes made to the data. As part of this project ISD will be implementing this capability for stations.

The United States Geological Survey (USGS), in conjunction with American National Standards Institute (ANSI), has come up with a standard by which all federal agencies are required to transfer spatial data. As of July 1994 all federal agencies must transmit, not store, spatial data in the format described in the Spatial Data Transfer Standard (SDTS). For ease of transmission and to accommodate future use of this data in Geographic Information System (GIS) applications, ISD is going to adopt this standard for the storage of the spatial data also. For detailed information on the SDTS please visit their web site at http://mcmcweb.er.usgs.gov/sdts/standard.html.

1.4 Goals and Objectives

Please Note: The only changes that will be made are the ones that are outlined in this document. If a requirement has been excluded from this document please bring it to the attention of ISD so we can include it in this document.

Our goals and objectives are listed below.

Modifications:

- Increase the accuracy of the latitude and longitude values that the users can store in the database.
- Modify windows applications to include an integer field for degrees, and integer field for minutes, and a decimal field for the seconds.
- Users should no longer enter the precision. They should enter the accuracy level. Please see section 3.1.2 Accuracy and Validity for more.

Enhancements:

- Store the elevation coordinates of an objects spatial address.
- Add GRS80 (ellipsoid) as reference datum for calculation of elevations. This value should be stored as a station parameter.
- Adapt an acceptable industry standard for the storage of spatial address data.
- Establish CO-OPS specifications for the storage and publication of spatial addresses.
- Allot space for future storage of the spatial address data of sensors and other equipment. Until the fields are populated by the users, the spatial data fields should pull this data from the DCP table by the station id.
- Add the ability to change the elevation values when the reference datum has been changed. Formulas will be provided by Manoj Samant.
- Track spatial data history of stations.

The goals and objectives discussed need to be implemented with minimal impact on the existing appearance of CO-OPS products.

2 Current System Summary

2.1 System Objectives and Current Functionality

The current system stores data in different formats across databases. The dpasman and tidebox databases store this data in three character fields that consists of the latitude, longitude and direction (N, S, E, W). The ports database (npdb) stores the latitude and longitude values as a floating point number.

Currently the precision field is used to retrieve the level of accuracy for the stored latitude and longitude value. According to ERSI, this is not the correct usage for the precision in the GIS environment. There is no storage of spatial data for sensors and other equipment used to collect data in the existing database. There is no storage of the elevation values either.

Currently, the DCP and sensor data is already tracking history. We will only need to make accommodations for the tracking of the station's spatial data.

2.2 Current Methods and Procedures

2.2.1 Equipment Being Used

Spatial data is being collected with GPS equipment. This equipment takes more accurate readings as the quality of the equipment gets better and technologies change.

2.2.2 Input and Output

Inputs:

- In DPAS – integer degrees and decimal minutes with the direction stored as a character and an integer precision value.
- In PORTS Meta Data – decimal degrees with no storage of direction or precision value. There are a few values that are store as degrees and minutes because there are no restrictions on what can be entered into this character field. This allows users to enter data in the wrong formats.
- In Tidebox – integer degrees and decimal minutes with the director stored as a character and no precision value.

Outputs:

All products are published in integer degrees and decimal minutes format with the direction displayed as a character.

2.2.3 Deficiencies

Deficiencies in the current system include but are not limited to:

- The lack of ability to store latitude and longitude values to an appropriate level of accuracy.
- The npdb and tidebox databases do not record the level of accuracy of the stored longitude and latitude values.
- The Lack of the ability to store the ellipsoid value for use as a reference when calculating elevation values.
- CO-OPS has not adopted any standards for storing or publishing data. The storage of data lacks unity across databases.
- Measurements are taken in meters and feet. Users input these measurements in meters and feet but the npdb database does not record whether the depth/elevation values are stored in meters or feet.

3 Proposed Methods and Procedures

3.1 Summary of Improvements

In order to accomplish the goals, ISD is proposing to change the way we store data across all three databases to make them uniform. The dpasman, tidebox and npdb databases should all be storing latitude and longitude values as decimal degrees. The precision needs to be determined by ISD. The users will be asked to enter the accuracy level instead. A space needs be created to store a new ellipsoid datum value as well as an elevation value. ISD has determined that the ellipsoid value should be stored as a station parameter. The direction (N, S, E, W) should be represented by the existence or absence of a minus sign (-). A minus preceding the degrees should represent south latitude and west longitude. The absence of a minus sign or a plus (+) sign should represent north latitude and east longitude. Some tables are storing a value for the depth. This should be replaced with elevation. In the PORTS Meta Data and TIDEBOX interfaces the depth field will continue to appear but this data should be stored in the elevation field. Please see the glossary for the definition of elevation in the GIS environment.

In order to track the history of the spatial data for stations, ISD will need to add a new table to the database. This table would only contain data pertaining to a station's location. For initial begin and end dates ISD will use the station's establish date as the begin date and leave the end date null. When a user needs to change a station's spatial data they would be required to enter the end date for existing values. If no end date is provided, the system will default to the date the change was made. New data will not be saved to the database without first entering an end date for the old data.

3.1.1 Inputs and Outputs

Inputs:

- Latitude and longitude need to be input as decimal degrees across all databases.
- Elevation values need to be added and input as a decimal number across all databases.
- Accuracy level of the latitude, longitude and elevation values need to be stored as an integer.
- Precision of the stored decimal degree value needs to be stored as an integer.
- A new station parameter needs to be added called the GRS80. The GRS80 is the ellipsoid value for a station. It will be used to calculate the elevation.
- Elevation fields can be null.
- A begin date and an end date for any changes made to a station's spatial data

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Outputs:

- No requests have been made to modify the output of our products; therefore they should be modified to display exactly as they are currently unless a change is requested through the helpdesk.
- For the internal users, they should see the data displayed in the new format with integer degrees and minutes with decimal seconds.
- Internal users should also see new fields for the elevation, reference datum of the elevation.
- When the reference datum of the elevation is changed the elevation value will change.

3.1.2 Accuracy and Validity

When a decimal number is stored in the database ISD has no control over how many digits are stored in the database. To ensure the accuracy and validity of the data two fields should be incorporated in to the new table designs. An integer field for the precision should keep a record of how many significant decimal places of the original decimal degree number. Another field should be added to keep a record of the measurements level of the original data as the user entered it. For example it should record whether the data was entered in degrees and minutes or degrees and tenth of a minute or degrees, minutes and seconds, etc.

The tables below describe the levels of accuracy that should be stored in the database.

Lat/Lon Value	Level #	Accuracy Level
98° 7’	0	Kilometer
98° 16.5’	1	Approx. 100 meter (Pre-conversion value)
98° 16’ 30”	2	10 m or Decameter (Post-conversion value)
98° 16’ 30.1”	3	Meter
98° 16’ 30.12”	4	Decimeter
98° 16’ 30.123”	5	Centimeter
98° 16’ 30.1234”	6	Millimeter
98° 16’ 30.12345”	7	Tenth of a Millimeter

Elevation Value	Level #	Accuracy Level
98	0	Meter
98.7	1	Decimeter
98.76	2	Centimeter
98.765	3	Millimeter
98.7654	4	Tenth of a millimeter

3.2 Summary of Impacts

These changes should have little to no impact on the users. ISD will take care of any conversions of data on the back end of the data processing. The only changes that the users should see are the addition of the extra field for the seconds on the windows interfaces. They should have additional fields to collect elevation data.

There is an exception with the PORTS data. Since there is no record of whether the depth is stored as meters or feet one of the users will have to research and update the database. A standard needs to be decided upon, storing in feet or meters, and all data needs to be converted accordingly.

4 Interface Requirements

4.1 User Interfaces

Only three of the four windows applications will need modifications to the user interface. The DMS Excel application is not used to enter spatial data. It is only used for processing data. There are some modifications that need to be made to DMS that will not affect the user interface. The other applications will be modified as listed below.

4.1.1 DPAS

- Should be modified to include a seconds field and the precision field should be changed to an accuracy field.
- Should be adding fields for the input of spatial data for sensors and other equipment.
- Should be adding a new reference datum called the ellipsoid.
- Should be adding fields for the elevation value and the reference datum associated with it.
- Location data (x,y,z) should be added to enter spatial data for sensors.
- Add space for the user to enter a begin date and an end date for the station's spatial data.

4.1.2 PORT Meta Data

- Users should be prevented from entering spatial data that is not in decimal format. A column for the direction field should be added.
- In the overview section of the PORTS applications the number should be converted from the decimal degree number to display integer degree and minutes with decimal seconds.
- Both of these sections should be enhanced to include the elevation and the reference datum associated with it.

4.1.3 Tidebox

- Should be modified to include a seconds field and the precision field should be changed to an accuracy field.

- Should be adding fields for the input of spatial data for sensors and other equipment.
- Should be adding fields for the elevation value and the reference datum associated with it.

4.1.4 DMS Excel

- No changes need to be made to the user interface in this application.

4.2 Software Interfaces

The software that requests spatial data from the database should access the data through the use of stored procedures and c code. New stored procedures will need to be created. They should be used exclusively for retrieving and storing the spatial data. These stored procedures should call upon other stored procedures that would convert the values to and from the decimal degree formats that are stored in the database. Much of the software being referred to in this section is what creates CO-OPS products. As stated earlier the look of the products would not be changed. ISD would modify the software to use the new stored procedures and c code to retrieve the data in its original display format.

5 Design Considerations

This section will provide a few details of what needs to happen in order to implement this request. These changes will be made to the development database first. After successful testing these steps will then be duplicated on the production server. No products will be affected during the design changes. During the implementation of these changes ISD would add new tables to the database, remove and add new columns to existing tables, create new stored procedures to store and retrieve the data and modify the windows and UNIX applications. This document will not provide the same level of detail that the project plan will. Another version of the project plan will follow this document. It will include the addition of elevation data that the original project plan did not address.

5.1 System Description

Currently the NWLON system stores x,y coordinate values of station and equipment. It now needs to store x,y,z coordinate values. The x,y,z coordinates consist of the latitude, longitude and elevation (altitude) values.

The new system will include keeping a history of all changes made to a station's spatial data. To achieve this ISD may need to remove this data from the original tables and put them in a new table. The new tables will be designed specifically for keeping track of changes and the keeping a record of the person who made the change. This will only be done with the sensor and station tables. Should ISD find that it will not be necessary to create new tables; new tables will not be created.

5.2 System Functions

All conversion of the spatial data will take place behind the scenes. The system will store latitude and longitude values in decimal degree format. We will keep track of the level of accuracy (how the data was originally stored), and the precision (number of significant digits following the decimal point). In addition to the longitude and latitude values we will add columns to hold the elevation value and a column to hold the reference datum that was used to calculate the elevation value.

6 Assumptions and Constraints

6.1 Assumptions

- Since no requests were made to change the way the products display spatial data ISD will assume that it should not change.
- There are no directions listed for latitude and longitude in the NPDB. We are assuming that, currently, all latitude and longitude values are north latitude and west longitude.
- Since the addition of a begin date and an end date for a station's spatial data is new, ISD will be assuming that the establish date of the station is the begin date for that station's location.

6.2 Constraints

- All of the current databases lack referential integrity.
- The database limits ISD in the number of significant decimal places we can store.

7 Appendices

7.1 Appendix A (Acronyms)

Acronyms Listing

Acronym	Meaning
CO-OPS	Center for Operational Oceanographic Products and Services
NGS	National Geodic Survey
USGS	United States Geological Survey
ISD	Information Systems Division
RDD	Requirements and Development Division
PSD	Products and Services Division
SDTS	Spatial Data Transfer Standard
ANSI	American National Standards Institute

7.2 Appendix B (Glossary)

[1]Glossary of Terms

Term	Definition
Spatial	1. Related to or existing within space.
Term	**Definition**
Spatial Data	1. Information about the locations and shapes of geographic features and the relationships between them, usually stored as coordinates and topology. 2. Any data that can be mapped.
Term	**Definition**
Spatial Data Transfer Standard (SDTS)	1. A data exchange format for transferring different databases between dissimilar computing systems, preserving meaning and minimizing the amount of external information needed to describe the data. All federal agencies are required to make their digital map data available in SDTS format upon request, and the standard is widely used in other sectors.
Term	**Definition**
Precision	1. The closeness of a repeated set of observations of the same quantity to one another. It is a measure of the control over random error. Assessment of the quality of a surveyor's work is based in part on the precision of their measured values. 2. *The number of significant digits used to store numbers, particularly coordinate values.* Precision is important for accurate feature representation, analysis, and mapping. 3. A statistical measure of repeatability, usually expressed as the variance of repeated measures about the mean.
Term	**Definition**
Dataset Precision	1. The mathematical exactness or detail with which a value is stored within the dataset, based on the number of significant digits that can be stored for each coordinate. In a geodatabase, the precision of the dataset is the number of internal storage units that are allocated to each of the linear units of a coordinate system.
Term	**Definition**

[1] Technical Staff, Environmental Systems Research Institute (ERSI); (accessed 20 May 2005); available from http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.gateway; Internet

Term	Definition
Accuracy	1. The degree to which a measured value conforms to true or accepted values. Accuracy is a measure of correctness. It is distinguished from precision, which measures exactness.
Term	Definition
Global Positioning System	1. A constellation of radio-emitting satellites deployed by the U.S. Department of Defense and used to determine location on the earth's surface. The orbiting satellites transmit signals that allow a GPS receiver anywhere on earth to calculate its own location through triangulation. The system is used in navigation, mapping, surveying, and other applications in which precise positioning is necessary.
Term	Definition
x,y coordinates	1. A pair of values that represents the distance from an origin (0,0) along two axes, a horizontal axis (x) representing east–west, and a vertical axis (y) representing north–south. On a map, x,y coordinates are used to represent features at the location they are found on the earth's spherical surface.
x,y,z coordinates	1. In a planar coordinate system, three coordinates that locate a point by its distance from an origin (0,0,0) where three orthogonal axes cross. Usually, the x-coordinate is measured along the east–west axis, the y-coordinate is measured along the north–south axis, and the z-coordinate measures height or elevation.
Term	Definition
Ellipsoid	1. A three-dimensional, closed geometric shape, all planar sections of which are ellipses or circles. An ellipsoid has three independent axes, and is usually specified by the lengths a,b,c of the three semi-axes. If an ellipsoid is made by rotating an ellipse about one of its axes, then two axes of the ellipsoid are the same, and it is called an ellipsoid of revolution, or spheroid. If the lengths of all three of its axes are the same, it is a sphere. 2. When used to represent the earth, an oblate ellipsoid of revolution, made by rotating an ellipse about its minor axis.
Term	Definition

Term	Definition
Spheroid	1. A three-dimensional shape obtained by rotating an ellipse about its minor axis, resulting in an oblate spheroid, or about its major axis, resulting in a prolate spheroid. 2. When used to represent the earth, a spheroid as defined above, but with dimensions that either approximates the earth as a whole, or with a part that approximates the corresponding portion of the geoid.
Term	Definition
Elevation	1. The vertical distance of a point or object above or below a reference surface or datum (generally mean sea level). Used especially in reference to vertical height on land.
Term	Definition
Reference Datum	1. A datum that is used in calculating a value. In this document the reference datum refers to the ellipsoid (GRS80) value used to calculate the elevation.

7.3 *Appendix C (Proposed Specifications)*

7.3.1 Storage

Center For Operational Oceanographic Products and Services

Specifications for Storage of Spatial Address

Definition

The spatial address is information about the locations of geographic features and the relationships between them, usually stored as coordinates. It consists of the latitude, longitude and elevation values.

Description

Latitude and longitude are ellipsoidal coordinate representations that show locations on the surface of the earth using the earth's equator and the prime meridian (Greenwich, England) as the respective latitudinal and longitudinal origins. Elevation is the coordinate representation that shows the location above or below a specified datum (i.e. GRS80 – ellipsoid).

Type

Latitude, Longitude and Elevation – Real number with 8 decimal places reserved
Precision and Accuracy Levels – Integer

Syntax

Latitude: ±dd.dddddddd
Longitude: ±ddd.dddddddd

Field Names

Latitude:	LATITUDE
Precision:	LAT_PREC
Accuracy level:	LAT_ACC_LEVEL
Longitude:	LONGITUDE
Precision:	LON_PREC
Accuracy level:	LON_ACC_LEVEL
Elevation:	ELEVATION
Precision/Accuracy:	ELE_PREC

Precision

The precision fields will be used to store the number of significant decimal places. When the number is stored in the database ISD has no control over how many digits are stored. This will keep track of the number of decimal digits entered by the user so we can retrieve the data based on that number.

Accuracy Level

The accuracy level does not really apply when storing the actual latitude, longitude and elevation values. This is because this field only applies when the data has been converted to its DD, MM, SS.SSSS values and it only applies to the second's field. We are storing this number because when this data is retrieved, we need to display the data as it was entered. Also, this number can be changed to view the data at smaller levels of accuracy but can not be updated in the database.

References

These specifications came from the industry standard created by the U.S. Geological Survey. Guidelines for these specifications can be found, quickly, in Annex D of the Spatial Data Transfer Standard. A copy of this standard can be viewed at: *http://mcmcweb.er.usgs.gov/sdts/standard.html*.

Use Instructions

Should this data need to be transferred it is in the format that conforms to the SDTS. This data can also be used in GIS applications and other mapping software.
Approval Date
10/7/2005

7.3.2 Publications

Center For Operational Oceanographic Products and Services

Specifications for Publication of Spatial Address

Definition

The spatial address is information about the locations of geographic features and the relationships between them, usually stored as coordinates. It consists of the latitude, longitude and elevation values.

Description

Latitude and longitude are ellipsoidal coordinate representations that show locations on the surface of the earth using the earth's equator and the prime meridian (Greenwich, England) as the respective latitudinal and longitudinal origins. Elevation is the coordinate representation that shows the location above or below a specified datum (i.e. GRS80 – ellipsoid).

Type

- Latitude and longitude degrees will be restricted to ±90 and ±180, respectively.
- Latitude and longitude minutes will be restricted to 2 digit integers between 0 and 59.
- Latitude and longitude seconds well be restricted to 2 digit integers between 0 and 59 with no more than 8 decimal places.
- Elevation values (in meters) will be in decimal format.

Syntax

Latitude: DD° MM' SS.SSSSS"
Longitude: DDD° MM' SS.SSSSS"
Elevation: EE.EEEE
The number of decimal places in the second's value will default to the level of accuracy entered with the latitude and longitude values. Optional: Users may select the level of accuracy they wish displayed. This will not be stored.

Accuracy Levels

Latitude and Longitude
- 0 = Kilometer
- 1 = 100 meter
- 2 = 10 m or Decameter level accuracy [Seconds level = 101 feet (31m)]
- 3 = Meter level accuracy [tenth of a Second level = 10 feet (3m)]
- 4 = Decimeter level accuracy [hundredth of a Second level = 1 foot (0.3m)]
- 5 = Centimeter level accuracy [thousandth of a Second level = 0.1 foot (0.03m)]
- 6 = Millimeter level accuracy [ten thousandth of a Second level = 0.01 foot (0.003m)]
- 7 = Tenth of a millimeter level accuracy [hundred thousandth of a Second level = 0.001 foot (0.0003m)]

Elevation
- 0 = the elevation is accurate to meters
- 1 = the elevation is accurate to decimeters
- 2 = the elevation is accurate to centimeters
- 3 = the elevation is accurate to millimeters
- 4 = the elevation is accurate to tenth of a millimeters

References

These specifications were provided through email and various meeting held between ISD and RDD. They were designed to be parallel with the specifications of NGS.

Use Instructions

These data elements will be used in CO-OPS current and any future products. These formats are strictly for displaying this data to the public. ISD will not store data this way in the databases. Please see the specifications for storing data on the previous page.

Approval Date
10/7/2005