HIGH RESOLUTION ELEVATION DATA (HRE) SPECIFICATION OVERVIEW

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ABSTRACT

For decades, the National Geospatial-Intelligence Agency (NGA)'s only standard product specification for digital elevation model (DEM) data has been Digital Terrain Elevation Data (DTED®). The DTED® specification was defined for wide area elevation coverage at relatively coarse resolutions (~30m). Recently there has been an increase in the number and types of sensors that can collect high resolution elevation data with a denser sampling rate and better accuracy than DTED®. However, NGA has not had a specification to define the required characteristics (accuracy, data content, etc…) of these products. NGA is currently developing the High Resolution Elevation (HRE) specification, which is intended to provide a product specification for the high resolution elevation datasets stored by the National System for Geospatial- Intelligence (NSG). The purpose of this paper is to introduce the HRE product specification. The paper will address the formatting and metadata associated with HRE datasets. The post spacing and accuracy requirements for various HRE levels will be introduced. Finally, the development, storage, and exploitation of the extended error data will be explored.

Key words: Digital Elevation Model, High Resolution Terrain Information, HRTI, Error propagation

INTRODUCTION

For decades, the National Geospatial-Intelligence Agency (NGA)'s only standard product specification for digital elevation model (DEM) data has been for a product line called Digital Terrain Elevation Data (DTED®), specifically Levels 0, 1 and 2. The DTED® specification was defined for wide area elevation coverage at relatively coarse resolutions (~30m). Additionally, DTED® only provides a few summary accuracy statistics to indicate data quality of the entire dataset to the user.

There has been a relatively recent increase in the number and types of sensors that can collect high resolution elevation data. These datasets contain elevation data with a much denser sampling rate and better accuracy than DTED®. As the availability of these datasets has increased, new uses have been developed for the datasets with ever more stringent requirements. However, to date, NGA has not had a specification to define the required characteristics (accuracy, data content, etc…) of these products.

NGA is currently developing the High Resolution Elevation (HRE) specification, which is intended to provide a product specification for the high resolution elevation datasets stored as raster grids by the National System for Geospatial- Intelligence (NSG). The specification builds upon existing US and international standards and formats, but also proposes new concepts in the storage of extended error predictions associated with elevation data. The purpose of this paper is to provide a broad overview of the HRE product specification.

OVERVIEW OF HRE

The High Resolution Elevation (HRE) product specification was developed by the National-Geospatial Intelligence Agency (NGA) to provide high resolution elevation products in a standardized format with predefined characteristics.

File Format

HRE is designed to store standardized raster digital elevation products. The file is stored using the National Imagery Transmission Format (NITF) version 2.1. Each HRE NITF file contains the following:

- File Header
- Extended Header Data to include the PIAPRD Tagged Record Extension (TRE)
- Image Subheader for DEM Height Data
- DEM Height Data
- XML Metadata Data Extension Segment
- Accuracy summary statistics
- Optional error propagation data

One image segment containing the elevation data is always present in an HRE NITF file. Optionally the NITF file may contain extended error data associated with the elevation data. This extended error data will be described in more detail later in the paper. However, for each of these error data types the NITF file will contain:

- Image Subheader for Error Data type
- Error Data

A graphical representation of the HRE file format is shown in figure 1.

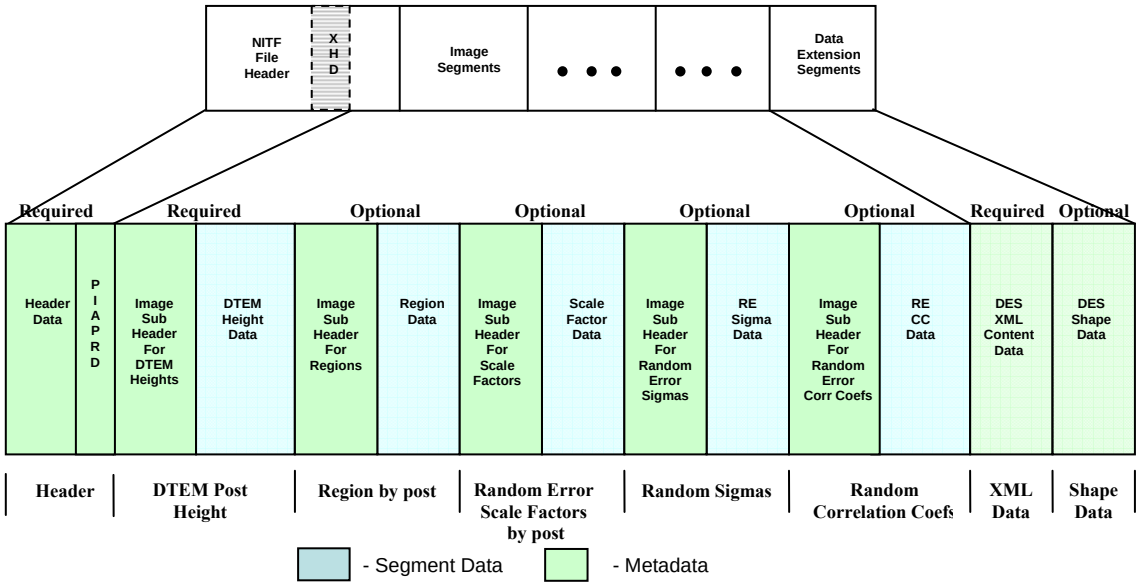

Figure 1. HRE NITF File Structure.

HRE Data Levels

The specification defines eight standard HRE data levels. An HRE level is defined by a post spacing and a set of accuracy thresholds. For HRE, there are thresholds defined for random horizontal error, random vertical error, relative horizontal error, and relative vertical error. In addition to these threshold accuracy values, HRE also provides both horizontal and vertical absolute accuracy objectives. The HRE levels and associated properties are illustrated in table 1 below.

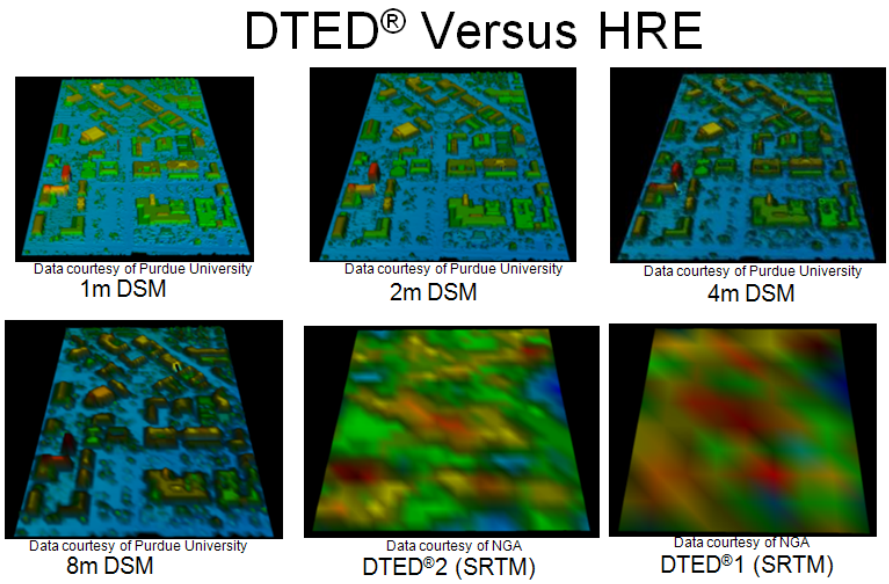

Figure 2. Comparison of HRE and DTED Dataset.

Table 1. HRE Levels and associated error statistics

Proposed HRE Product	**Required Post Spacing**	**Random Horizontal Error per Post (σh)**	**Relative Horizontal Accuracy Between Points (Rh)**	**Random Vertical Error per Post (σv)**	**Relative Vertical Accuracy Between Points (Rv)**	**Desired: Absolute Horizontal Accuracy CE90**	**Desired: Absolute Vertical Accuracy LE90**
DTED®1	3 arc-sec ~90 m	N/A	N/A	N/A	20 m	50 m	30 m
DTED®2	1 arc-sec ~30 m	N/A	N/A	N/A	12 m	23 m	18 m
HREG	0.4 arc-sec ~12 m	0.14 arc-sec ~4.4 m	0.4 arc-sec ~12.4 m	2.2 m	6.2 m	0.4 arc-sec ~15 m	12.4 m
HRE08	8 m	2.83 m	8 m	1.41 m	4 m	10 m	8 m
HRE04	4 m	1.41 m	4 m	0.71 m	2 m	5 m	4 m
HRE02	2 m	0.71 m	2 m	0.35 m	1 m	3 m	2 m
HRE01	1 m	0.35 m	1 m	0.18 m	0.5 m	2 m	1 m
HRE50	0.5 m	0.18 m	0.5 m	0.09 m	0.25 m	1 m	0.5 m
HRE25	0.25 m	0.09 m	0.25 m	0.04 m	0.12 m	0.5 m	0.25 m
HRE12	0.125 m	0.04 m	0.125 m	0.02 m	0.06 m	0.25 m	0.12 m

HRE Metadata

HRE provides for the storage of extensive metadata that is compliant with international standards. Since HRE utilizes the NITF file format, it leverages the NITF Tagged Record Extensions (TRE) for much of its metadata. HRE also uses International Standards Organization (ISO) compliant XML metadata to store much of the information on the product. This XML data is then stored within a NITF Data Extension Segment (DES) so that all data and metadata is stored within a single file.

HRE stores the metadata that is required by the NSG for data discovery. However, HRE also allows for the storage of extensive error data and metadata. This data will allow the user to calculate a predicted absolute accuracy for any post in the DEM and also allow for the computation of the relative error between points in the DEM. The metadata required to support such calculations in HRE include error propagation region point-by-point values, error propagation random error point-by-point scale factor values, error propagation random error point-by-point covariance values, and error propagation random error point-by-point correlation coefficient values. Regions in HRE are defined as areas in the dataset with similar systematic (low frequency) error characteristics. A detailed description of the HRE metadata will not be provided within this overview document. However, detailed information on the generation, use, and exploitation of this data was presented at the ASPRS conference held in Baltimore in 2009.

Exploitation

The goal of the HRE product specification is to make high resolution terrain information available to NSG partners in a format that can be exploited. Since HRE uses a NITF format, it is being provided in a format that NSG partners are accustomed to working with. There will be some modifications required to handle specific aspects of the HRE data. Included in these are modifications required to read the XML data out of the NITF DES. However, there is a trend to move toward XML metadata stored in a DES for other products, so these changes are not HRE specific. HRE carries the metadata that will make it discoverable and the extended error data will support precise geopositioning and rigorous data adjustment techniques that have not been used historically with elevation data.

DISCUSSION

As described above, the HRE product specification provides for the storage of predicted error data at a much finer scale than what has been incorporated in past elevation datasets. As the resolution and quality of elevation data continues to improve, the proposed uses for such datasets continue to increase. As these datasets work their way into more geopositioning scenarios, this advanced error data will be required. This paper will help assist data vendors in understanding what constitutes HRE data.

CONCLUSION

The community has shown increased interest in high resolution elevation data and there is a need for NGA to make this type of data available to the NSG partners. The High Resolution Elevation (HRE) Product Specification is being developed by NGA to provide a storage method for this type of data. Key aspects of HRE are that it is being developed to support high resolution raster grid datasets, it is built on existing standards (NITF and XML), it uses both Geographic and UTM coordinates, and it provides ability to store detailed predicted error values to assist in advanced data exploitation. The High Resolution Elevation (HRE) Product Specification will help NGA to meet the current and future needs of the NSG community.

ACKNOWLEDGEMENTS

- The members of the HRTI Tiger Team and the HRE development team
- The members of the Sensor Geopositioning Center who have helped in the development of these concepts

REFERENCES

NGA High Resolution Elevation (HRE) Product Specification version 098_04102009.