Standards

For the

Positional Accuracy

of

Cadastral Surveys

When Using

Global Navigation Satellite Systems (GNSS)

February 23, 2009

Cadastral Survey
Bureau of Land Management
Department of the Interior

Attachment 1-1

Preface

These *Standards for the Positional Accuracy of Cadastral Surveys When Using Global Navigation Satellite Systems* (Standards) were developed as an update to the positional standards originally defined in *IM 2001-186, Standards and Guidelines for Cadastral Surveys Using Global Positioning System Methods*, and are a product of a joint venture between the United States Forest Service and the Bureau of Land Management. The positional standards outlined in this updated document are intended to apply to all boundary surveys conducted under the authority of official Special Instructions or other survey-related instructions issued by the Bureau of Land Management (Cadastral Survey) when Global Navigation Satellite Systems (GNSS) technology is used. In addition to the positional standards, this document also describes how survey accuracies will be defined and computed. These positional accuracy standards are consistent with the current edition of the *Manual of Surveying Instructions*.

In 2001, when IM 2001-186 was originally issued, the use of Real-Time Kinematic (RTK) global positioning system (GPS) technology while conducting cadastral or other boundary surveys was still in its infancy. IM 2001-186 was intended to provide instructions on the use of these technologies as well as provide guidance on the accuracy levels necessary to achieve acceptable results comparable to conventional terrestrial surveys. In the past few years, use of GPS/GNSS technological knowledge and methodology have become universal throughout the surveying profession making portions of IM 2001-186 no longer applicable or required.

The positional accuracy standards identified in IM 2001-186 were defined in terms of the 95 percent confidence error "circle" as called for in the Federal Geographic Data Committee's (FGDC) document FGDC-STD-007.1-1998**,** *Geospatial Positioning Accuracy Standards Part 1: Reporting Methodology***.** However, this methodology has not been widely adopted or accepted and, as such, has proven difficult to implement. In this document the positional accuracy standards are defined in terms of the 95 percent confidence error "ellipse," which can easily be computed using any contemporary GNSS software suite.

Cadastral Surveys are an important part of the National Spatial Data Infrastructure (NSDI), and the accuracy reporting requirements of this document are in accordance with accuracy reporting requirements of the FGDC *Geospatial Positioning Accuracy Standards, July 1997*. These standards do not require that cadastral surveys be performed to the higher accuracy and methodology required of geodetic control surveys. They are intended to provide sufficient observational, positional, and occupational redundancies to detect blunders and quantitatively demonstrate the stated accuracy of a survey has been achieved to ensure a certain level of acceptability and positional confidence.

The positional standards set forth in this document have undergone both internal and external review and scrutiny. All issues, comments, and concerns have been considered in the preparation of this document.

Standards for Positional Accuracy Using GNSS Technology

The following standards are for Global Navigation Satellite System (GNSS) technology and will be used to define the minimally acceptable levels of positional accuracy required of any Department of the Interior, Bureau of Land Management, official cadastral or administrative boundary survey.

Local Accuracy Standards[1]

Semi-major axis 95 percent error ellipse	Application
Less than 0.025 (m)	Cadastral Project Control
Less than 0.050 (m)	Cadastral Corner Measurements

Network Accuracy Standards[2]

Semi-major axis 95 percent error ellipse	Application
Less than 0.050 (m)	Cadastral Project Control
Less than 0.100 (m)	Cadastral Corner Measurements

[1] See Appendix 1, items 3 and 4.
[2] See Appendix 1, items 5 and 6.

Appendix 1

Supporting Information

1. The standard is based on the magnitude of the semi-major axis of the 95 percent confidence level error ellipse.

2. A least squares adjustment or other multiple baseline data analysis should be used to verify that the required level of positional accuracy has been achieved.

3. The local accuracy of a control point established as part of a static GNSS project control network can be determined by performing a minimally constrained least squares analysis of the network and ensuring the magnitude of the semi-major axis of the 95 percent confidence level error ellipse is less than or equal to the values in Table 1.

4. The local accuracy of a cadastral corner measurement can be determined by performing a minimally constrained least squares analysis of the network and ensuring the magnitude of the semi-major axis of the 95 percent confidence level error ellipse is less than or equal to the values in Table 1.

5. The network accuracy of a control point established as part of a static GNSS project control network can be determined by performing a fully constrained least squares analysis of the network and ensuring the magnitude of the semi-major axis of the 95 percent confidence level error ellipse is less than or equal to the values in Table 2.

6. The network accuracy of a cadastral corner measurement point established by real time kinematic, fast static, or kinematic methods which meet the manufacturer's specifications may be determined by performing a fully constrained least squares analysis of the network and ensuring the magnitude of the semi-major axis of the 95 percent confidence level error ellipse is less than or equal to the values in Table 2.

7. The National Geodetic Survey (NGS) program "OPUS – Static" (http://www.ngs.noaa.gov/OPUS/) returns the maximum peak-to peak separation for each component of the computed position. The maximum peak-to-peak separation of the computed position will be used to estimate the semi-major axis of the 95 percent confidence error ellipse for network accuracy determination for these standards.

8. The NGS program "OPUS – RS" (http://www.ngs.noaa.gov/OPUS/) returns the standard deviation for each component of the computed position. Two times the largest position component standard deviation will be used to estimate the semi-major axis of the 95 percent confidence error ellipse for network accuracy determination for these standards.

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Appendix 2

Glossary

Cadastral Corner Measurements - The measurements used to define the location of Public Land Survey System (PLSS) corners and boundaries. Cadastral Corner Measurements are based on the Cadastral Project Control coordinates or direct ties to the National Spatial Reference System (NSRS).

Cadastral Project Control - A network or series of the GPS/GNSS of control points that are tied to the NSRS, which is created to control all subsequent GPS cadastral corner measurements. The Cadastral Project Control is adjusted independently of other cadastral measurements

Fully Constrained Least Squares Adjustment - For the purpose of this document, a least squares adjustment performed by holding the horizontal coordinates of all control points and a minimum of one vertical control coordinate fixed and allowing all other points to be adjusted.

Local Accuracy - A value that represents the uncertainty at the 95 percent confidence level in the coordinates of a measured point relative to the coordinates of other directly connected and adjacent points in the survey.

Minimally Constrained Least Squares Adjustment - For the purpose of this document, a least squares adjustment performed by holding the coordinates of one control point fixed and allowing all other points to be adjusted.

Network Accuracy - A value that represents the uncertainty in the coordinates of a measured point at the 95 percent confidence level relative to the NSRS as determined in the survey.

OPUS-RS - An internet-located positioning program developed and supported by the NGS. This program allows the user to submit 15 minutes to 2 hours of GPS data to NGS. NGS will then compute and return, via email, the calculated coordinates of the position.

OPUS-Static - An internet-located positioning program developed and supported by the NGS. This program allows the user to submit a minimum of 2 hours of GPS data to NGS. NGS will then compute and return, via email, the calculated coordinates of the position.

Appendix 3

CERTIFICATE OF APPROVAL AND ACCEPTANCE

These Standards for the Positional Accuracy of Cadastral Surveys When Using Global Navigation Satellite Systems have been properly vetted and, THEREFORE, are considered approved for use within the Bureau of Land Management when establishing or reestablishing boundaries, control networks, or other segregation lines necessary to meet realty needs.

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