

**Standards**

**For the**

**Positional Accuracy**

**of**

**Cadastral Surveys**

**When using**

**Global Navigation Satellite Systems (GNSS)**

**February 23, 2009 Version**  
**April 5, 2010**

**Boundary Management**  
**Forest Service**  
**Department of Agriculture**

Standards for the Positional Accuracy of Cadastral Surveys  
When Using Global Navigation Satellite Systems

## Preface

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

In 2001, when I.M. 186 was originally issued, the use of GPS technology, to include Real-Time Kinematic (RTK) GPS technology, while conducting cadastral or other boundary surveys was still in its infancy. I.M. 186 was intended to provide instructional knowledge 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 last few years as GPS/GNSS technological knowledge and methodology has become more ubiquitous throughout the surveying profession, to the point that portions of I.M. 186 are no longer applicable or required.

The positional accuracy standards, identified in I.M. 186, were defined in terms of the 95% 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% 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). The accuracy reporting requirements of this document is 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, brought forth, have been considered in the preparation of this document.

Standards for the Positional Accuracy of Cadastral Surveys  
When Using Global Navigation Satellite Systems

**Standards for Positional Accuracy  
Using GNSS Technology**

The following standards are for Global Navigation Satellite System (GNSS) technology and shall be used to define the minimally acceptable levels of positional accuracy required of any DOA-Forest Service, official land or administrative boundary survey.

**Local Accuracy Standards<sup>1</sup>**

---

<u>Semi-major axis 95% error ellipse</u>	<u>Application</u>
Less than 0.025 (m)	Cadastral Project Control
Less than 0.050 (m)	Cadastral Corner Measurements

---

**Network Accuracy Standards<sup>2</sup>**

---

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

---

---

<sup>1</sup> See Appendix 1, items 3 and 4.

<sup>2</sup> See Appendix 1, items 5 and 6.

Standards for the Positional Accuracy of Cadastral Surveys  
When Using Global Navigation Satellite Systems

Supporting Information

1. The standard is based on the magnitude of the semi-major axis of the 95% 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% 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% 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% 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% confidence level error ellipse is less than or equal to the values in Table 2.
  7. The 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% 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% confidence error ellipse for network accuracy determination for these standards.
-

Standards for the Positional Accuracy of Cadastral Surveys  
When Using Global Navigation Satellite Systems

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** – Is a value that represents the uncertainty at the 95% 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% confidence level relative to the NSRS as determined in the survey.

**OPUS-RS** – An internet located positioning program developed and supported by the National Geodetic Survey (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.

Standards for the Positional Accuracy of Cadastral Surveys  
When Using Global Navigation Satellite Systems

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 United States Forest Service when establishing or reestablishing boundaries, control networks, or other segregation lines necessary to meet boundary management needs.

*/s/ Greg Asher*

---

Greg Asher,  
Chief Land Surveyor,  
Department of Agriculture,  
United States Forest Service

---